DISTRIBUTION, ECOLOGY AND MANAGEMENT OF *CHROMOLAENA ODORATA*

***REPARTITION, ECOLOGIE ET GESTION DE* CHROMOLAENA ODORATA**

Proceedings of the Third International Chromolaena Workshop

Comptes Rendus du Troisieme Atelier International sur Chromolaena

Abidjan, Côte d'Ivoire, November 1993

Agricultural Experiment Station

University of Guam, Mangilao, GUAM, USA

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CHROMOLAENA WORKING GROUP

INTERNATIONAL ORGANIZATION OF BIOLOGICAL CONTROL

AGRICULTURAL EXPERIMENT STATION
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PROCEEDINGS OF THE THIRD INTERNATIONAL WORKSHOP ON BIOLOGICAL CONTROL AND MANAGEMENT OF *CHROMOLAENA ODORATA*

COMPTES RENDUS DU TROISIEME ATELIER INTERNATIONAL SUR LA LUTTE BIOLOGIQUE ET LA GESTION DE CHROMOLAENA ODORATA

(Abidjan, Côte d'Ivoire, November 1993)

Distribution, Ecology and Management of Chromolaena odorata
Répartition, Ecologie et Gestion de Chromolaena odorata

edited by / *édité par*

Usha K. Prasad,
R, Muniappan,
P. Ferrar,
J.P. Aeschliman,
and / *et*
H. de Foresta

Agricultural Experiment Station
University of Guam, Mangilao, GUAM, USA
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PREFACE

The Siam weed, *Chromolaena odorata* was a serious problem in pastures, vacant lands, roadsides and other disturbed areas of the Mariana Islands. A grant for biological control of *C. odorata* was received from the Tropical and Subtropical Agricultural Research Special Grants section of the U.S. Department of Agriculture. This grant was administered by the Pacific Basin Administrative Group. After its introduction, the natural enemy, *Pareuchaetes pseudoinsulata*, successfully established on Guam in 1986; it was also supplied to the other Mariana Islands, Caroline Islands, Thailand, Indonesia, South Africa, Ghana and Ivory Coast.

A result of the successful biocontrol of *C. odorata* effort was the First International Workshop on Biological Control of *Chromolaena odorata*, held in Bangkok, Thailand in 1988, and hosted by Dr. Banpot Napompeth, Executive Director, National Biological Control Research Center. The Second International Workshop on Biological Control of *Chromolaena odorata* was held in BIOTROP, Bogor, Indonesia in 1991. The Third International Workshop on Biological Control and Management of *Chromolaena odorata* was held in Abidjan, Côte d'Iovire, hosted by IDEFOR, La Me, Côte d'Ivoire and the FAO Regional Office, Ghana. During this workshop, an Internal Working Group for Biological Control was formed under the auspices of International Organization for Biological Control.

This publication contains articles on the distribution, adverse and beneficial effects of *C. odorata*, its interaction with other plants, the uses of chemicals, cultural and biological control measures, and insect-plant interactions.

We hope this volume will serve as a source of information for administrators and scientists alike in their efforts to curtail and control the spread of *C. odorata*.

We wish to express our sincere appreciation to Dr. H. de Foresta for arranging with ORSTOM for publication of this volume. We also thank Mr. Terrence Conklin for his assistance in preparing this manuscript.

Usha K. Prasad et R. Muniappan
Agricultural Experiment Station
University of Guam
Mangilao, GU 96923

Jean Paul Aeschliman
CSIRO Unitè de Lutte Biologique
Campus de Baillarguet, 34982
Montferrier, France

Paul Ferrar
ACIAR, P.O. Box 1571
Canberra, ACT 2601
Australia

Hubert de Foresta
ORSTOM, antenne ORSTOM a l'ICRAF,
P.O. Box 161, Bogor, 16001
Indonesia

PREFACE

L'herbe du Siam, *Chromolaena odorata*, était considérée comme un sérieux problème dans les pâturages, les terres inoccupées, les bords de route et autres zones perturbées des îles Marianes. Un financement pour la lutte biologique contre *C. odorata* fût accordé par la section des Fonds Spéciaux pour la Recherche en Agriculture Tropicale et Subtropicale du Ministère de l'Agriculture des Etats-Unis. Ce financement était géré par le Groupe Administratif du Bassin Pacifique. Après son introduction, l'ennemi naturel Pareuchaetes pseudoinsulata s'est établi avec succés à Guam en 1986; cet insecte fût aussi envoyé aux autres îles Marianes, aux îles Carolines, en Thailande, en Indonésie, en Afrique du Sud, au Ghana et en Côte d'Ivoire.

A la suite de cette tentative réussie de lutte biologique, le Premier Atelier International sur le Contrôle Biologique de *Chromolaena odorata*, s'est tenu à Bangkok, Thaïlande en 1988, accueilli par le Dr. Banpot Napompeth, Directeur Exécutif du Centre National de Recherche sur la Lutte Biologique. Le Deuxième Atelier International sur le Contrôle Biologique de *Chromolaena odorata* s'est déroulé au BIOTROP, à Bogor, Indonésie en 1991. Enfin, le Troisième Atelier International sur le Contrôle Biologique et la Gestion de *Chromolaena odorata* s'est tenu à Abidjan, Côte d'Ivoire, sous le patronage de l'IDEFOR, La Me, Côte d'Ivoire et du bureau régional de la FAO au Ghana. Pendant cet atelier s'est formé un Groupe de Travail Interne sur la Lutte Biologique, sous les auspices de l'Organisation Internationale de Lutte Biologique.

Cet ouvrage contient des articles sur la répartition de *C. odorata*, sur ses effets négatifs et bénéfiques, sur ses interactions avec les insectes ainsi qu'avec les autres plantes, et sur l'emploi de méthodes de lutte chimiques, biologiques et culturales.

Nous espérons que ce volume servira de source d'informations tant pour les administrateurs que pour les scientifiques dans leurs efforts pour limiter et contrôler l'expansion de *C. odorata*.

Nous tenons à remercier M. Terrence Conklin pour son assistance dans la préparation de ce manuscrit. Enfin, nous désirons exprimer notre sincère gratitude à l'Institut Francais de Recherches pour le Développement en Coopération, l'ORSTOM, qui a accepté de se charger de la publication de ce volume.

Usha K. Prasad et R. Muniappan
Agricultural Experiment Station
University of Guam
Mangilao, GU 96923

Jean Paul Aeschliman
CSIRO Unité de Lutte Biologique
Campus de Baillarguet, 34982
Montferrier, France

Paul Ferrar
ACIAR, P.O. Box 1571
Canberra, ACT 2601
Australia

Hubert de Foresta
ORSTOM, antenne ORSTOM à l'ICRAF,
P.O. Box 161, Bogor, 16001
Indonésie

The Status of *Chromolaena odorata* (L.) R. M. King and H. Robinson in West and Central Africa.

(Le Statut de *Chromolaena odorata* (L.) R. M. King et H. Robinson en Afrique Centrale et Occidentale)

R. Hoevers and S.S. M'boob
FAO Regional Office for Africa
Accra, Ghana

Résumé- C'est à la fin des années 1930 que l'arbuste *Chromolaena odorata* (L.) R. M. King et H. Robinson a été introduit en Afrique de l'Ouest pour la première fois. Depuis, il s'est largement propagé dans toute l'Afrique Occidentale et Centrale, de la Guinée jusqu'au nord de l'Angola et au centre du Zaire. *C. odorata* est devenue une adventice problématique dans les espaces ouverts, les clairières aux alentours des villages, dans la phase initiale des successions secondaires, dans les pâturages et les cultures, ainsi que dans les jeunes plantations d'arbres. *C. odorata* est maintenant une espèce dominante dans toute la zone humide et sub-humide de l'Afrique du Centre et de l'Ouest, fournissant abri et espace de reproduction à des insectes nuisibles comme le criquet puant, *Zonocerus variegatus*.Les noms locaux attribués à *C. Odorata* soulignent et la réussite de son implantation et la nature des ravages qu'elle cause. On lui reconnait également des propriétés utiles puisqu'elle peut contribuer à l'élaboration de la matière organique du sol, intervenir dans le contrôle de l'érosion et être utilisée à des fins médicales. La lutte biologique est considérée comme étant l'approche à long terme la plus réaliste pour le contrôle et la gestion de *C. odorata*. En Afrique de l'Ouest et du Centre, les travaux dans ce domaine sont encore limités à la Côte d'Ivoire et au Ghana. Peu d'attention a été accordée à l'élaboration de stratégies efficaces de contrôle et de gestion de *C. odorata* pour les paysans les plus démunis d'Afrique.

Introduction

The perennial shrub *Chromolaena odorata* (L.) R.M. King and H. Robinson, was first introduced into West Africa in the late 1930s. It has since spread rapidly throughout West and Central Africa, from Guinea to northern Angola and central Zaire. *C. odorata* has become a troublesome weed in open spaces, clearings around human settlements, in early secondary succession, crop and pasture lands, and in young tree crop plantations. *C.*

odorata is now a dominant species throughout the humid and sub-humid zones of West and Central Africa, providing shelter and breeding spaces for harmful insects such as the variegated grasshopper, *Zonocerus variegatus*.

The local names given to *C. odorata* signify how established the weed has become and what havoc it causes. The plant is also reported to have some useful properties since it may contribute to the build-up of organic matter and serve as erosion control, and it is used for medicinal purposes.

Biological control is considered to be the most feasible long term approach for the control and management of C. *odorata* but work in this area has so far been restricted to Côte d'Ivoire and Ghana, in West and Central Africa. Little attention has been given to the development of effective strategies for the control and management of *C. odorata* in the resource-poor farming situations in Africa.

Origin and Distribution

C. odorata is a perennial woody shrub native to the Caribbean and Latin America. In its native habitat, *C. odorata* occurs naturally over a wide area, from southern Florida to northern Argentina, where it is generally not considered an important weed. This species has a role in the early succession of the forest vegetation after clearing. In Asia, *C. odorata* was introduced in the mid or late 1800s, and has now spread throughout South-east and South Asia and parts of the Pacific.

C. odorata was first introduced into West Africa in the late 1930s, and is now estimated to be distributed from 12°W - 23°E, to 10°N - 10°S; this area extends from eastern Guinea to central Zaire and Central African Republic, southwards to northern Angola. *C. odorata* has also spread to the Natal coastal region of South Africa and has become a dominant weed in the humid and sub-humid zone of West and Central Africa.

C. odorata was first introduced into Nigeria, West Africa, around 1937 through contaminated seed lots of *Gmelina arborea*. *G. arborea* is a tree species which was imported from Sri Lanka for reforestation purposes. The first observations of *C. odorata* were made in the early 1940s from Enugu in the central part of Nigeria. Other introductions of *C. odorata* into West Africa have taken place in Côte d'Ivoire, in the sous-préfecture Bingerville around 1950, and near Accra in southeastern Ghana in the early 1960s. *C. odorata* also occurred near Durban, South Africa in the 1940s.

By 1960, *C. odorata* had occupied the southeastern states of Nigeria, from where it spread into Cameroon and southern Côte d'Ivoire. By 1965, it was establishing itself in the western forest zone of Ghana. Southern Côte d'Ivoire, southern Ghana, southern and central Nigeria, and western and central-southern Cameroon were widely infested with *C. odorata* by 1970. It had probably also reached Togo, western Central African Republic, Gabon, and Congo. By 1980, it had become a common weed of road and railway sidings, young tree crop plantations, crop and pasture lands and clearings around villages. It was also being found in southern and central parts of Cameroon, Congo, Côte d'Ivoire, Ghana and Nigeria, southern Togo and Benin, northern Zaire, and the southwestern part of the Central African Republic. Although observations were dated back to 1980, the first recording of *C. odorata* in Sierra Leone was in 1987.

The primary mechanism by which *C. odorata* spreads is human activity. Such activities include road construction and the maintenance of dirt roads and railways, which are reported to be of major importance in Côte d'Ivoire, Liberia, Congo and Zaire. Nomadic livestock also appear to contribute significantly to the spread of *C. odorata* in the Central African Republic.

Several reports mention that the geographical distribution of *C. odorata* in Africa includes areas with an annual rainfall exceeding 1200 mm, and altitudes of less than 1000 m. However, surveys carried out since 1991 show its geographical distribution is only within areas having a rainfall of 800 to 900 mm and above. While *C. odorata* does not occur on the Adamaoua Plateau or higher plateaus in the North-West Province and Mount Cameroon, it has been observed around Garoua in the Northern Province, which is located at 9-9.5°N, 13°E. Garoua has an erratic rainfall pattern averaging 900 mm and maximum temperatures of 45°C at the beginning of the rainy season. *C. odorata* is also widespread on the West African coastal savannas of Ghana, Togo and Benin.

The Problem of *Chromolaena odorata*

C. odorata is a typical pioneer species of secondary forest succession with a strong heliophilic character and vigorous vegetative development. Also, some allelopathic effects are reported from Nigeria. Initially *C. odorata* spreads by seed, but after establishment it may also reproduce vegetatively from lateral branches; regrowth occurs after slashing and burning. It flowers at the end of the rainy season and after flowering the leaves fall and the stems die back. The ripe seeds are wind dispersed, although adherence to the fur of animals, clothes and machinery, and the contamination of planting material are also important mechanisms for seed dispersal over large distances. *C. odorata* may easily invade open spaces. In heavily disturbed environments, it competes effectively with other plants and crops, and may become the dominant species.

C. odorata is a major weed in young tree crop plantations (such as rubber, oil palm, coffee, cacao, and fruit trees), cassava, yams, banana and plantain. It is considerably less important as a weed in cereal and legume plantations. Due to its abundant vegetative development, *C. odorata* may overgrow the young trees. Due to competition and possibly its allelopathic effects it leads to poor crop establishment. During the dry season, it constitutes a real fire hazard, particularly in areas with prolonged dry seasons. In sparsely populated forest areas where farming systems with long fallow periods are practiced, *C. odorata* usually does not become a problem until the third or fourth year of cultivation.

The invasion of pasture lands by *C. odorata* causes cattle to avoid these lands, and subsequently to overgraze non-infested lands. This is particularly a problem for nomadic and semi-nomadic livestock systems where free grazing is practiced around the settlements during the rainy season.

Roadsides and the open places around human settlements are often overgrown by dense bushes of *C. odorata*. The weed is also a nuisance to traffic. Its abundant biomass constitutes a large quantity of combustible plant material during prolonged dry seasons, thereby creating a threat of bush fires that can endanger villages. Many tree crop plantations and villages have already been destroyed by bush fires which have been facilitated by the dense and dry *C. odorata* populations.

An important aspect of the *C. odorata* problem in African agriculture is the high labor required for its control, and the increased pressure on lands that are free of or only slightly infested by established bushes of this plant. In secondary succession after clearing of forests, *C. odorata* may slow down the regeneration process by overgrowing and shading equally heliophilic secondary forest trees. The weed is also known to harbor harmful insects. The variegated grasshopper, *Zonocerus variegatus*, breeds in *C. odorata* stands. From there *Z. variegatus* moves to cassava fields, feeding on the leaves and causing important yield losses.

Useful Aspects of *C. odorata*

Farmers observed that fields colonized by *C. odorata* produce better yields of maize and groundnut. There are indications that leaves of *C. odorata* contain insect repellent compounds, and that root exudates may have nematicidal effects. It is, however, obvious that with its abundant biomass production, *C. odorata* contributes significantly to the build-up of organic matter and leads to an increase of the soil pH on very acid soils.

C. odorata may enhance the regeneration in heavily disturbed forests that are dominated by grasses. This is due to the improved soil conditions that enhance secondary succession as a result of the presence of *C. odorata*. If combined with appropriate tree species, *C. odorata* may be more useful. In Sierra Leone this plant is considered useful for land reclamation in old mining areas.

Reports from various countries indicate that the leaves of *C. odorata* serve useful curative and therapeutic purposes. Fresh leaves are used to cure wounds, and to treat malaria, stomach and eye problems. The leaves also have insect repelling properties.

Perception of the Problem

The information on the distribution and impact of *C. odorata* is largely derived from reports by farmers. This in itself is already an indicator that the presence of *C. odorata* is perceived as a major problem by the farming communities of West and Central Africa. However, considering the relatively short presence of this plant in West and Central Africa, the people have quickly found uses for the plant, as well as have discovered its positive impact on crop production. This has taken place in a period of less than 20 years.

The perception of the problems caused by *C. odorata* is best reflected in the local names given to this species. These names refer in some instances to the period when it became a common weed: 'Herbe d'Indépendance' in Côte d'Ivoire (1960), and 'Acheampong' in Ghana (1972-1978). The local names also refer to (un)popular persons or experiences: 'Sékou Touré' in Côte d'Ivoire, which is also the same term used for the skin irritating weed *Solanum verbascifolium*; 'Bokassa' Cameroon, Central African Republic; 'King-Kong' in Cameroon; and 'Choléra' in Zaire.

Control of *C. odorata*

Current control measures are inefficient and not cost-effective under the prevailing resource-poor farming circumstances in sub-Saharan Africa. Slash and burning followed by frequent hoeing and uprooting controls *C. odorata,* but these activities are tedious and very labor intensive.

Several herbicides have been applied but these generally fail to give season-long control. Also these herbicides require repeated applications with high dosages, particularly in young tree crop plantations. Therefore, most herbicide based control procedures are not cost effective under the resource-poor farming circumstances. In addition, many farmers do not have the adequate facilities, training and financial resources for the safe use and storage of the herbicides; these aspects are often forgotten in the partial budget analysis of the efficiency of control measures. Also many of the commonly used, cheap herbicides are hazardous to humans and the environment.

C. odorata is an extremely heliophilic plant and if shaded, the plant is etiolated. It therefore does not occur in tree crop plantations with established crown covers, such as rubber crops that are older than 5 years. In young tree crop plantations, particularly rubber and oil palm, cover crops are commonly used. Aggressive cover crops such as *Pueraria phaseoloides* are able to overgrow *C. odorata*. However, around the trees the cover crop should be regularly pruned to avoid overgrowth.

Biological control is generally considered the most feasible long term approach to controlling *C. odorata*; it is also relatively cheap. Substantial international attention has been given to the use of the leaf feeding moth *Pareuchaetes pseudoinsulata*, which suppressed *C. odorata* in Guam. In West and Central Africa the development of control measures is however still largely confined to the testing of herbicides. Meaningful research on biological control in West and Central Africa is restricted to IRHO-CI Côte d'Ivoire, La Me, and CRI, Kumasi of Ghana. The introduction of biological control agents may be a more sustainable approach, but more research needs to be done on the host specificity of these agents.

To control and manage *C. odorata* in West and Central Africa, it is necessary to formulate effective integrated strategies adapted to the reality of the resource-poor farmer circumstances. The link between research, extension and farmer, should therefore, be strengthened to enable effective testing of these strategies.

A Survey of the Introduction, Distribution and Spread of *Chromolaena odorata* in Ghana.

(Etude sur l'Introduction, la Distribution et la Diffusion de *Chromolaena odorata* au Ghana)

J. A. Timbilla and H. Braimah
Crops Research Institute, Kumasi, Ghana

Résumé - *Chromolaena odorata* (L.) R. M. King et H. Robinson (*Eupatorium odoratum*), aussi connue sous le nom d'herbe du Siam, est une espèce introduite au Ghana. Elle a été observée pour la première fois au jardin botanique de Legon en 1969. Il existe cinq écoles de pensées en ce qui concerne les causes de son introduction. Une étude menée en Novembre-Décembre 1991 a montré que l'adventice s'est propagée jusqu'a une latitude de 8°15'N, et qu'elle est présente dans près des deux tiers du pays. Son importance a donné naissance à de nombreux noms communs. Elle est abondante tant dans les cultures vivrières que dans les plantations, mais pose surtout des problèmes aux paysans des zones forestières. Il existe une incertitude quant à son statut d'adventice dans la zone de transition en raison de son arrivée récente. *C. odorata* est complètement absente de la région des savanes Soudaniennes mais apparaît en bosquets isolés dans les savanes de la Côte et de l'Intérieur. Malgré son statut d'adventice et son rôle potentiel dans la création des feux de brousse, *C. odorata* possède tout de même de nombreux usages dans les foyers Ghanéens.

Abstract-*Chromolaena odorata* (L.) R.M. King and H. Robinson (*Eupatorium odoratum*), also known as Siam weed, is an introduced weed in Ghana. It was first observed at the Legon Botanical Gardens in 1969. There are five schools of thought about the weed's introduction. A survey conducted in November-December 1991, indicated the weed had spread as far as latitude 8°15'N, covering about two-thirds of the country. The importance of the weed has given rise to various common names. The weed is important in both arable and plantation crops in Ghana. It is particularly a problem for farmers in the forest regions. In the transition zone, there is an apparent conflict about its weed status due to its recent introduction into the area. The weed is completely absent from the Sudan-savanna region but occurs in isolated stands and tufts in the Interior and Coastal-savanna zones. *C. odorata*, despite its weed status and potential in causing bush fires, was found to be of use in many Ghanian homes.

Introduction

Chromolaena odorata (L.) R.M. King and H. Robinson (*Eupatorium odoratum)* also known as siam weed, is a perennial scrambling shrub native to Central and South America, and the Caribbean. It has become a major weed in parts of Asia and West, Central and South Africa (Muniappan 1988). Its occurrence is said to be limited to latitudes 30°N and 30°S, and in altitudes up to 1000 m in locations where rainfall amounts to 2000 mm (Muniappan & Marutani 1988).

The weed spread to the old world via ballasts in ships from the West Indies that landed in Singapore and Malaysia in the 1920s (Bennett & Rao 1968). It was introduced to Nigeria in the 1940's, and by the late 1960s, *C. odorata* had become an important weed. It has since spread to Ghana, Cote d'Ivoire and Cameroon (Cruttwell 1988). In Ghana, the weed was first discovered in February 1969, in old abandoned experimental plots in the Legon Botanical Gardens (Hall *et al.* 1972); by 1972 it had spread to the Greater Accra, Central and Western regions.

This report presents local views on the history of introduction, distribution, damage and benefits of *C. odorata* to the agricultural sector of Ghana. The report is based on a survey conducted in Ghana under sponsorship of the FAO. Research policy at the national level and potential sources of funds for *C. odorata* control programs are also discussed.

Methods

For the purpose of the survey, sixteen degree zones were identified in Ghana (Fig. 1). This was followed by a selection of towns and villages based on these ecological

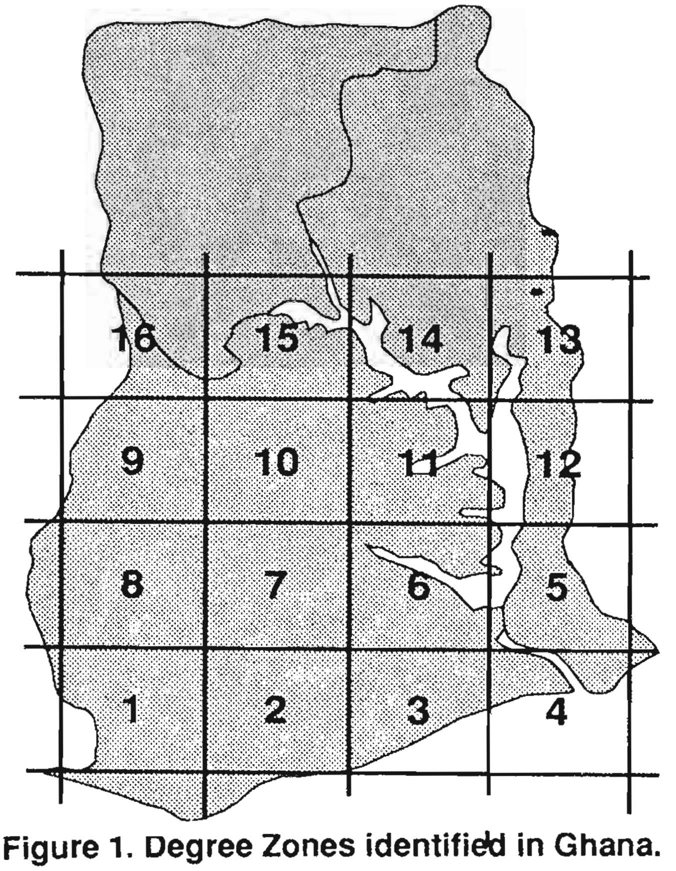

Figure 1. Degree Zones identified in Ghana.

zones, road accessibility, and distributions of selected locations within each degree zone. The survey was conducted using a questionnaire prepared according to FAO guidelines. Farmers and agricultural extension officers were interviewed. Two to four candidates were interviewed at a time, in two separate locations in each town or village. Also, *C. odorata* infested fields were visited at select locations for inspection, confirmation of the information obtained, and to identify the fauna associated with *C. odorata*. The survey was limited to 9°N, the northernmost point, using results from an informal survey conducted by Braimah and Timbilla as a guide (Braimah & Timbilla 1990).

Results

Hypotheses on the introduction of *C. odorata* into Ghana

The survey revealed five schools of thought regarding the introduction of *C. odorata* to Ghana. Until now, only two hypotheses existed. These were: (1) the weed was introduced by Ghanaian residents of Nigeria for its medicinal properties; and (2) *C. odorata* was intentionally introduced during construction of the Akosombo Dam between 1962 and 1966, to suppress weeds along the electricity grid. The latter indicates that seeds were sprayed along the grid by an aircraft. These hypotheses were recorded in a previous survey by Braimah and Timbilla (1990).

New discoveries made during the survey indicate three other possibilities. First, the Government of the First Republic brought the weed into Ghana through Israeli experts, to suppress grasses in the interior savanna zone. This speculation is based on the weed's inability to establish in the North, and because northeast tradewinds carried seeds to the Brong Ahafo region where *C. odorata* became a weed in areas with adequate rainfall. The second hypothesis is *C. odorata* was introduced to the Accra plains around 1973 by a Ghanaian traveler, to suppress grasses which are serious weeds in the area. The last hypothesis is the seeds were accidentally introduced through contaminated rice imported from South Africa. These varied hypotheses place the introduction of *C. odorata* between the late sixties to early seventies. The hypothesis relating the Akosombo Hydro electricity project to the weed's introduction seems to be the most plausible explanation.

Hall *et al.* (1972) reported it coincidental that outbreaks of *C. odorata* in the Legon campus and central/western regions occurred almost simultaneously since *C. odorata* appeared to be absent from the intervening areas. It is more likely that the western outbreak resulted by spreading from Cote d'Ivoire. This indicates that introduction of the weed to Ghana could have been from several sources. The weed may have first been introduced by the Volta River Authority (VRA) in high rainfall areas of the Western region to suppress fast growing trees and shrubs.

In summary, *C. odorata* has now become a weed by spreading through wind, humans, animals, runoff from rain, and vehicles carrying materials from one region to another.

Common names of *C. odorata* in Ghana

There are several local names of *C. odorata* in Ghana. However, one, 'Acheampong', is most commonly used in areas where it occurs. This is probably because the weed became prominent during the military regime (1972-78) of General I.K. Acheampong. It is also known as 'Busia' especially in the Western and Central regions. Dr. K.A. Busia, was a head of state in Ghana around 1969, when the weed was first discovered at Legon Botanical Gardens. The weed is also known by nine other names in various parts of the country where it occurs (Tab. 1).

Table 1. Local names given to *C. odorata* in Ghana.

Name	Region	Meaning/Significance of name
Acheampong	Central, Eastern, Greater Accra, Western, Ashanti, Brong Ahafo, Northern and Volta.	Name of Head of State
Topaye	Central/Western	Spreader
Krawuni	Western/Brong Ahafo	Send for your mother
Abaafo	Western	New entrant
Bompowder	Western/Central	Powder me up (reference to seed spread mechanism)
Sukusuku	Western	Unknown
Woafa me fuo	Brong Ahafo	You have taken my farm
Adiawuo	Brong Ahafo	Killer
Wo amma me gye	Brong Ahafo	I am taking over if you are are not coming
Alisi	Western	Name of a church
Busia	Western/Central	Name of Head of State

Distribution of *C. odorata* in Ghana

Geographically, Ghana is located between 4°45′ and 11°N latitude and 3°15′W,1° 15′E longitude, and has an area of 270, 500 km^2. The highest point is 886 meters above sea level and rainfall varies between 1750-2800 mm in the High Rainforest zone, to 700-1040 mm in the Sudan Savanna zone (Fig. 2). Ghana is divided into ten administrative regions, with six different ecological zones. These are the Sudan Savanna, Interior Savanna, Forest Savanna Transitional zone, Coastal Savanna, Semi-Deciduous Rainforest, and the High Rainfall zones (Fig. 2).

This survey revealed that *C. odorata* has spread over most of southern Ghana, and as far north as latitude 8° 15'N (Fig. 3). These results confirm earlier observations made by Braimah and Timbilla (1990) In this report, the distribution of C. *odorata* will be discussed according to ecological zones.

Sudan Savanna Zone

This is the northernmost vegetation zone in the country. The weed is completely absent in this zone. With the exception of travelers who have been to the south, most people in this zone do not know the weed. Low rainfall (700-1040 mm) and its distribution in this zone could act as ecological barriers to the weed's spread into the area.

Interior (Guinea) Savanna Zone

This is the largest ecological zone and covers approximately half of the land area of Ghana. *C. odorata* was found as far north as latitude 8°15', where it occurs in isolated stands. Beyond this point, *C. odorata* is almost completely absent. This was also reported by Braimah and Timbilla (1990). However, the area above 8°15' has rainfall amounts comparable to the Coastal Savanna zone where *C. odorata* is present. Absence of the weed may be attributed to the single rainfall pattern of this zone, as opposed to the bimodal pattern in the Coastal Savanna zone. Distribution more than the amount of rainfall may influence the establishment and spread of *C. odorata*. Results of the survey are insufficient at this time to draw conclusions about the weed spreading further north.

In the lower parts of this zone where rainfall is relatively higher, i.e. Atebubu, Kwadjokrom and Odonkokrom, *C. odorata* occurs in isolated stands and tufts. The weed in this area has smaller stems than weeds in the Forest regions, and completely dries during the dry season. Seed production in this area is also quite low in comparison to the Forest regions. *C. odorata* is ranked fourth as a weed in this zone. Weeds like *Imperata cylindrica, Pennisetum purpureum* and *Andropogon guyanus* are more serious problems than *C. odorata.* Although its occurrence is low in this zone, farmers and agricultural officers, unhappy about its presence, are anxious to control the weed. An extension officer at Bamboi referred to a report describing its menacing properties, that recommended eradicating the weed from the area. The preference is for grass weeds.

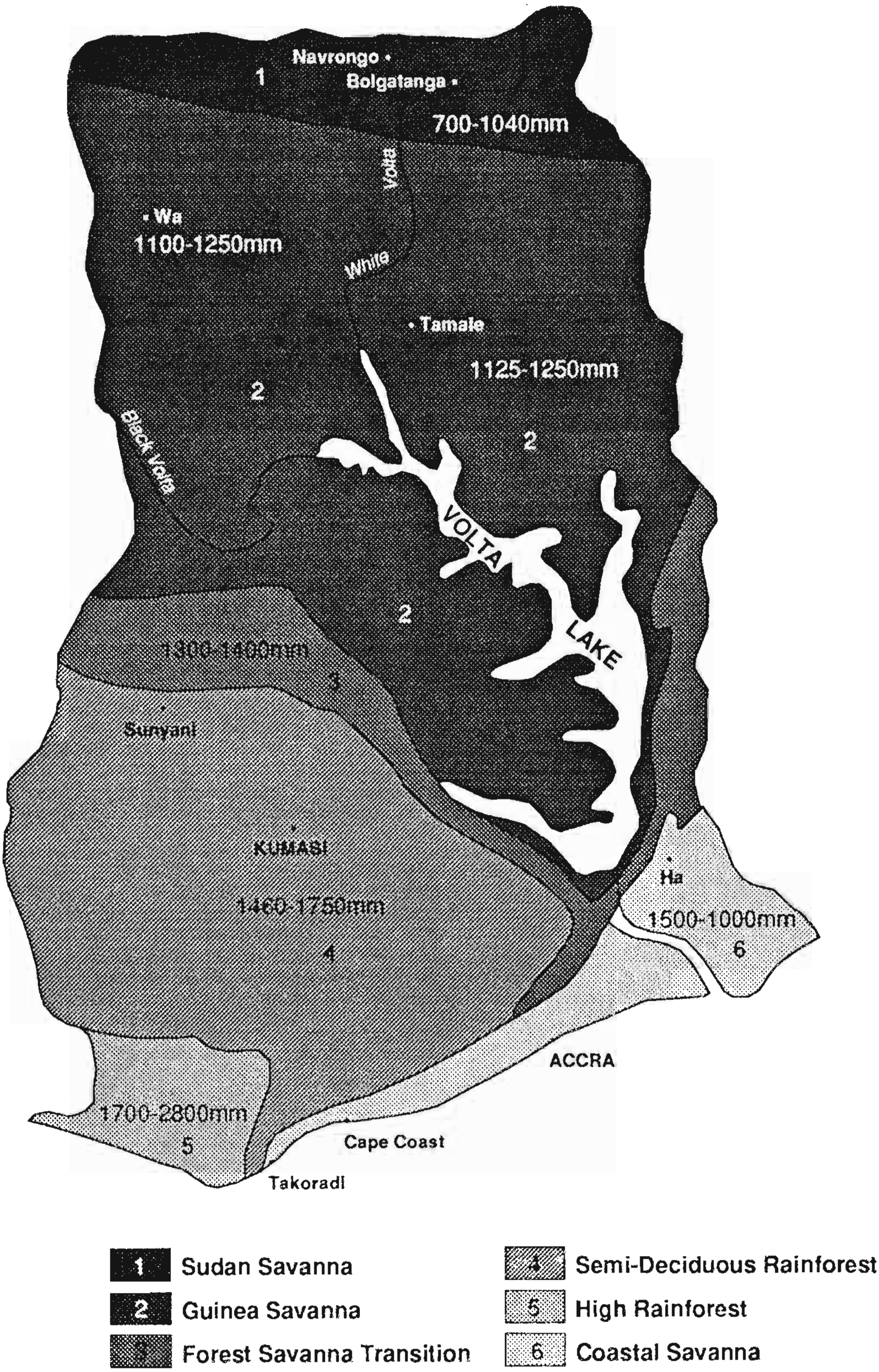

Figure 2. The Six Ecological Zones of Ghana.

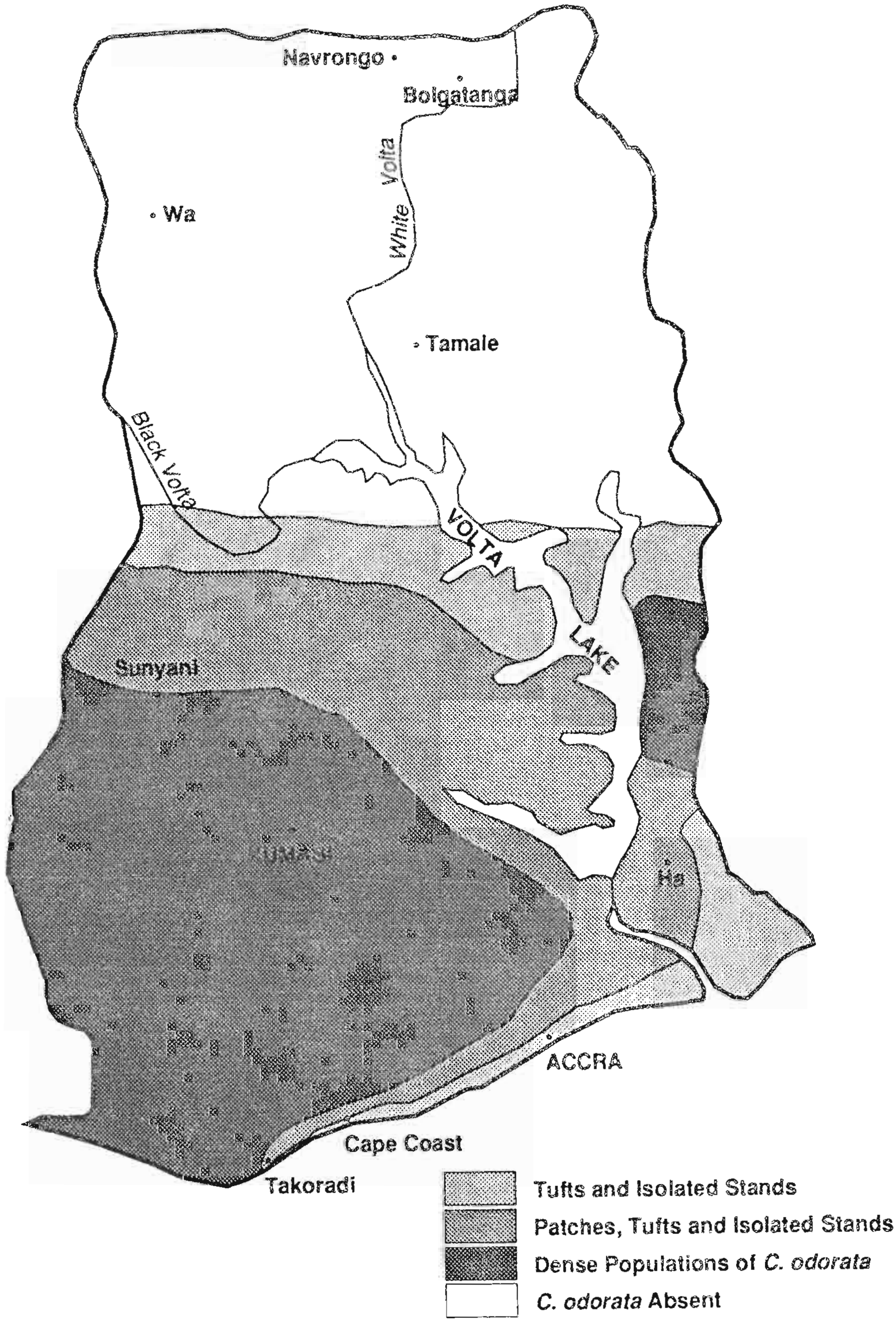

Figure 3. The Distribution of *C. odorata* in Ghana.

The inhabitants of this zone had little knowledge about medicinal values of the weed. Infestation in this zone is mostly found near habitats, fallow lands, roadsides, and areas under bright light that have low agricultural input. Most of this zone is open country. Farmers practice continuous cultivation with short fallow periods in areas with limited availability of land. The weed spreads through runoffs, wind, and human and animal activities. Weeds observed in the area looked healthy though not luxuriant, with a few associated insect species. No insect or other damage was observed on samples inspected.

During this survey, control was mainly by hand hoeing, brushing with cutlasses and accidental burning through bush fires in the dry season. Farmers interviewed about the efficiency of control efforts described them as good in the upper parts and average in the wetter parts of this zone. Due to the cost of chemicals and lack of technical knowledge about use of chemical weedicides, farmers in the area do not use chemical control.

Forest Savanna Transition Zone

This vegetative zone is found in four administrative regions of Ghana, namely Brong Ahafo, Ashanti, Eastern and Volta. The occurrence of *C. odorata* in this zone seems to be transitory. It generally occurs in tufts and single stands in the drier parts, and as patches in the lower, wetter parts. However, around Hohoe in the Volta region, dense populations of *C. odorata* are seen over a considerable area. Farmers in this zone have mixed feelings about the weed status of *C. odorata*. While some farmers see *C. odorata* as a menace rapidly displacing predominant grasses such as *I. cylindrica* and *P. purpureum,* others feel it improves soil organic matter and is easier to clear. Farmers who want the weed have been farming only in this zone, not having used any other area. Farmers having experienced the weed in semi-deciduous and forest zones fear they will encounter similar difficulties in this area.

Coastal Savanna Zone

This zone includes five administrative regions of the country, namely Volta, Eastern, Central, Western and Greater Accra. Rainfall amounts in this zone vary between 500 mm and 1000 mm. The weed was first observed in this zone in 1969; its spread has not been very extensive.

The weed is quite scarce and is found in isolated stands and tufts in open areas. Infestation is mainly noticed along roadsides, around towns and villages, in recent fallows, and in areas with low external input agriculture. The main crops include maize, cassava, vegetables, and plantain in the wetter parts. Even though infestation in this zone is low, C. *odorata* is found as close as 50 m from the seashore. Due to scarcity of land, continuous cropping is the main farming method. It was also observed that existing stands of the weed were well established and healthy.

C. odorata is considered a minor weed in this area since other weeds such as *Euphorbia hirta, Panicum maximum, A. guyanus* and *I. cylindrica* are more menacing. *C. odorata* is considered beneficial in fallow lands since it is believed to improve the soil. Weed control is by hand hoeing or slash and burn. Chemical control of *C. odorata* is not practiced in this area. Farmers interviewed indicated that chemicals are not readily available, and when available are expensive. They also felt the use of chemical weedicides was dangerous.

Semi-Deciduous Rainforest

This zone covers parts of Eastern, Central, Ashanti and the Western Regions of Ghana. The zone experiences a bimodal rainfall pattern with amounts of about 1460 m - 1750 m. *C. odorata* was observed in all parts of the surveyed area, and is believed to have spread by means of wind, running water, and human and animal activities.

The weed occurs very frequently, often being found in open land and dispersed light. Names given such as 'Acheampong, 'Busia', 'Kra wo ni', 'To paye', 'Bompowder' and 'Woamba me gye', give testimony to its population density and importance in this zone. Infestation is common along roadsides, settlements, backyards, uncultivated areas, recent fallow land, and high and low input agricultural areas.

The main farming system practiced is continuous cultivation with short fallows. Generally, *C. odorata* plants grow vigorously with large fresh leaves and thick stumps. Farmers interviewed indicated that litter fall of the weed helps improve soil conditions, especially in cassava and maize cultivation. The most common use of the weed in this zone is as a medicinal plant. Farmers find it to be noxious and welcome effective control methods.

Farmers react to the weed's presence by adopting various methods of control. Control measures included burning, manual clearing using cutlass and hoe, mechanical (tractor) in a few places, and to a lesser extent, use of weedicides such as Grammoxone, Glyphosate and Garlon 2. It was claimed that except for mechanical control which is quite effective, all other methods of control have low efficiency.

High Rainfall Zone

This zone receives the highest amount of rainfall in Ghana. Rainfall ranges from 1750 mm - 2800 mm. The zone is located in the Western Region. *C. odorata* was first reported in the late sixties, believed to be introduced by the Government as an attempt to suppress weeds under the electric grid after construction of the Akosombo Dam. The weed is found in dense populations with thick stems, under full and dispersed light.

The weed can be found along roadsides and settlements in uncultivated areas, in fallow, and high and low input agricultural lands. The farming system is either long or short fallow. Plants observed looked clean with a few associated insects. Spreading is by wind, erosion, animals, and vehicles. The occurrence of *C. odorata* in this area makes subsistence farming very expensive. Farmers attempt to combat it by burning, manual clearing using hoes and cutlasses, and weedicides. Farmers interviewed reported that these methods of control were not very effective. Chemicals used in the control of the weed are Garlon 2, Grammoxone and Glyphosate.

Importance of *C. odorata* to agricultural production in Ghana

Despite its weed status, *C. odorata* was found to be of use in many Ghanaian homes. This strengthens the belief that it was probably brought to the country from neighboring Nigeria and Cote d'Ivoire, for its medicinal properties. The liquid extract is used primarily for treating fresh wounds. It is also said to help blood clotting. Old wounds and boils are also treated with the weed. Another important use of the weed is preservation (embalming) of bodies in the villages. Diseases like malaria and jaundice are also said to be cured by drinking the boiled extract of *C. odorata.* Abdominal pains are said to be treated with liquid extracts of the weed as an enema. The weed is known to be effective in cleaning teeth and treating certain eye problems. It is also claimed that it effects abortion when used as an enema during the early stages of pregnancy, a disadvantage in religious circles.

Fallow lands under *C. odorata* produce higher yields of crops such as maize and cassava. This is probably due to the recycling of nutrients and higher litter fall which improves organic matter and soil structure. This has also been reported in the Philippines (Torres & Paller 1989). Additionally, the weed is said to repel mosquitoes and snakes, and is used to preserve maize from rodents. Farmers welcome the weed in some grassland areas because it suppresses grass growth. Other advantages include using it to prevent soil erosion, as firewood especially in the western and central regions, and as bait for trapping crabs when *C. odorata* leaves are combined with other chemicals. Finally, its ability to suppress other weeds is well known to farmers.

Against this background of benefits, there are also harmful aspects of *C. odorata* in agricultural production. *C. odorata* is easily seen as one of the major causes of bush fires in the dry season (November-March) in forest regions. Cultivated crops, especially young plantations, are easily smothered. Cocoa farmers speculate that if the weed is not eradicated within the next few years, cocoa growing may be seriously hampered. Farmers claim wounds resulting from injury from *C. odorata* stumps easily develop into serious illnesses and sometimes cause paralysis. Death from possible secondary infections has been reported in parts of the Central and Western Regions. The weed is also said to cause skin irritations and rashes in people with allergic reactions.

C. odorata serves as a breeding ground for *Zonocerus variegatus* (Greathead 1989). It is said that *Z. variegatus* acquires its foul smell from feeding on *C. odorata. C. odorata* also harbors rodents and other wild animals, providing a refuge for pests and disease vectors. The weed is also said to cause acute diarrhea if fed on accidentally by cattle and other animals. Some cattle breeders abandon land infested by *C. odorata* after it smothers most of the fodder grasses and shrubs and since it poses a danger to their cattle. Finally, because of its aggressive growth habits, the weed is difficult to suppress and has increased the cost of maintaining infested farms.

Diseases and pests associated with *C. odorata* in Ghana

During the survey, a number of insects and mites were found associated with *C. odorata.* However, fungal and bacterial pathogens were not observed. This may be attributed to the season during which the survey was conducted and not necessarily their complete absence in Ghana. The fauna observed included Lepidoptera, Hymenoptera, Coleoptera, Homoptera, Dictyoptera, Orthoptera, Hemiptera, Thysanoptera and Acarina. Of all these, the orthopteran insect *Z. variegatus* was most common, and is known to cause some damage to *C. odorata* during its nymphal stages. The hymenopteran insects also included some stemborers. The survey did not provide ample opportunity to study the relation of these organisms to *C. odorata.*

Discussion

In Ghana, *C. odorata* was introduced in the late sixties to suppress weeds under the electric grid, and also for its medicinal properties. Establishment has been extensive due to the geographical similarities between its native South/Central America, and Ghana. About two thirds of the total land area of Ghana has been infested by the weed. In the forest regions, the weed occurs in dense populations, whereas it ranges from dense populations to patches and tufts in the transition zone. The coastal and interior savannas are infested in patches and isolated stands.

C. odorata is a weed in both arable and plantation crops, particularly cocoa, oil palm, coffee, rubber, maize and cassava. Other areas include abandoned fields, roadsides, riverbanks and forest margins. Importance of the weed has led to many local names being assigned to it, especially in the forest region. In parts of the transition zone where it has recently been introduced, farmers have mixed feelings about its presence and control. In the forest regions, however, farmers welcome effective control methods because it is a menace to agricultural production.

Weed control is done usually by uprooting, slashing and burning, or by herbicides in some parts of the country. The survey revealed that initial clearings of *C. odorata* are easier to control than grasses and other shrubs. However, its rapid rejuvenation after clearing debris, stumping, and frequent weeding, makes it a more difficult weed to deal with. This makes overall costs of production on infested farms very high. Chemical control using Grammoxone, Glyphosate and Garlon 2 are effective in combating the weed. These, however, are very expensive for most subsistence farmers. Other constraints include unavailability of chemicals in the area in times of need. The potential environmental hazards such as pollution of local water sources, killing off beneficial arthropods and sometimes also of operators, makes chemical use unattractive.

Mechanical control is quite expensive during the first year of weeding. The extensive root system makes mechanical cultivation difficult. In most areas where tractors are used, the land is usually first cleared by cutlass and then burnt. This adds to the cost of land preparation, making the overall costs expensive. If such areas are cultivated continuously, the cost of production decreases in time, reducing the weed problem.

Burning, done intentionally or unintentionally, is not costly. But the consequences of a fire extending to farms, causing destruction to households and increasing environmental pollution, constrains the farmers. There have been instances of whole villages in the forest regions being destroyed by bush fires probably due to *C. odorata.* Its potential as a fire hazard has been reported throughout the country. Similar reports have been made in India (Ambika & Jayachandra 1990), Thailand (Napompeth *et al.* 1988), and the Pacific (Muniappan & Marutani 1988).

The weed serves as an alternative host to nymphs, and as breeding grounds for the adult variegated grasshopper, *Z. variegatus*. *C. odorata* is also suspected as the source of the characteristic foul smell important in deterring predators of *Z. variegatus*.

C. odorata is claimed to have medicinal as well as soil improving properties through recycling of minerals. In spite of its positive and negative effects, farmers interviewed during the survey welcomed an effective control program, using either chemical or mechanical means to lower existing costs. Perhaps a compromise can be reached by implementing classical biological control of the weed. This will suppress the weed below economic injury levels, while also allowing individuals the benefit from its medicinal values. Since it is an exotic weed, this will also maintain a sound ecological balance between *C. odorata* and its natural enemies.

Biological control of *C. odorata* has been attempted in most places where it occurs as a weed. Successful control was achieved in Guam in 1984, as well as in other Pacific Islands. Variable degrees of success have also been obtained in India, Sri Lanka and Malaysia. In Ghana and Nigeria, failure to control the weed by releasing *Pareuchaetes pseudoinsulata* in the 1970s has been attributed to a lack of sustained effort (Greathead 1989).

Local efforts to control *C. odorata*

The Crops Research Institute (CRI) of the Council for Scientific and Industrial Research (CSIR) in Ghana has a research program for weed control. This was initiated in 1989 in collaboration with R. Muniappan of the Agricultural Research Station, University of Guam. Two officers, J.A. Timbilla and H. Braimah, of the Biological Control Division of the CRI are involved. Research programs include pre and post release studies of the arctiid moth *P. pseudoinsulata*. Research is also done on factors that militate against mass rearing and establishment of *P. pseudoinsulata* in the laboratory and field, respectively. These programs do not receive any international assistance; however, the Institute has been receiving free cultures of the control agents from Guam since 1989.

Conclusion

C. odorata is a weed in the forest regions of Ghana where it occurs in dense populations. Farmers in this region welcome suggestions for control. The full impact of *C. odorata* as a weed is yet to be established in the forest savanna transition zone. As a result, there are conflicting views on its importance as a plant vs. the need to control it as a weed. Biological control may provide the most viable solution since it would use the weed's natural enemies.

Acknowledgments

This report is a contribution to an F.A.O. sponsored program on a study of the distribution and spread of *C. odorata* in Africa. It covers a survey conducted in Ghana by J.A. Timbilla and H. Braimah (Consultants), and S.S. M'boob (FAO Senior Regional Plant

Protection Officer). The survey team and FAO are very grateful to the farmers and extension officers interviewed. Special thanks also go to S.A. Yeboah of Crops Research Institute for his clerical assistance.

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Résultats d'Enquête sur *Chromolaena odorata* (L.) R.M. King and H. Robinson (*Eupatorium odoratum* L.) au Bénin.

(A Survey of *Chromolaena odorata* in Benin)

A. Yehouenou
N'Dali, Bénin

Abstract-*Chromolaena odorata* is a problem for crop and livestock farmers in Benin. Its presence in western Africa is threatening large areas of Southern Benin. This report presents the results of a survey conducted for the FAO, using a questionnaire to assess local problems. The objectives and location of the survey were determined after discussions with authorities of Agriculture Development (CARDER) from Atlantic, Quevre, Mono and Zou in Southern Benin. The survey team investigated fields, fallow lands, and plantations at 5 km intervals. Results indicate the weed was introduced to Quevre county in the southeast around 1970. All of South Benin, up to latitude 8°N, is infested by *C. odorata*. The national highway, Colonou - Parakori, divides Southern Benin into 2 zones. Of these, the eastern zone is largely affected and the western zone is moderately affected. Local names of *C. odorata* include Agatou (Quevre), Ketla, Hlayoma, Houefloussou, etc. (Atlantic & Zou), Jekan, and Gbalindo Houéflou (Mono). The weed is not considered a pest in southern Benin. Benefits of *C. odorata* include its dominance over *Imperata cylindrica* sp., soil fertilization, and reduction of the fallow period. It is used as an antibiotic and antimalarial drug, and for relieving rashes and treating wounds. Smoke from *C. odorata* repels mosquitoes. In large plantations, *C. odorata* is seen as a weed among older palm trees, a threat to grazing pastures, and it contributes to plant extinction by overshadowing certain species. It is also a natural habitat for the grasshopper *Zonocerus variegatus* (L.).

Résumé-*Chromolaena odorata* (L.) est perçue actuellement comme l'une des adventices les plus préoccupantes pour l'agriculture et l'élevage. En Afrique de l'Ouest, la partie méridionale du Bénin n'est pas épargnee. Le présent rapport est le résultat d'une enquête effectuée à la demande de la FAO sur la base d'un questionnaire. Dans les zones d'intérêt, des itinéraires précis ont été retenus, le long desquels l'équipe de prospection s'arrête tous les 5 km pour inspecter champs, friches et plantations. Il apparaît que l'adventice a fait son entrée au Bénin dès le début des années 70 à partir du Sud-Est, dans le département de l'Ouémé. Tout le bas Bénin est envahi par l'adventice jusqu'à la latitude de 8 degré N. La route Cotonou - Parakou divise le sud-Bénin en deux zones, l'Est fortement infesté et l'Ouest modérément infesté. Divers noms vernaculaires désignent l'adventice d'un département à l'autre: Agatou (Ouémé) Ketla, Hlayoma, Houeflousssou (Atlantique et Zou), Jekan et Gbalindo Houéflou (Mono). Les informations recueillies montrent

que dans le contexte actuel de l'agriculture au bas Bénin, *C. odorata* n'est pas une contrainte. Les paysans ont exprimé une réaction de satisfaction face aux bienfaits de la plante qui étouffe l'impérata, fertilize le sol et raccourcit la jachère. Elle possède de nombreuses vertus médicinales, combat l'abcès et le paludisme, cicatrise les blessures, guérit la gale et les boutons chez les enfants et sa fumée chasse les moustiques. On lui reproche toutefois d'être gênante en palmeraie industrielle sur palmiers d'âge avancé, de compromettre l'élevage villageois, de menacer certaines essences utiles qu'elle étouffe. Ses fourrés sont en outre le lieu de ponte du criquet puant, *Zonocerus variegatus* (L.).

Introduction

Le Bénin s'étend entre 0°45' et 3°50' longitude E et 6°15' et 12°30' latitude N. Il est limité au nord par le Burkina Faso et le Niger, au sud par l'Océan Atlantique, à l'est par le Nigéria et à l'ouest par le Togo. A son climat varié correspond une flore très diversifiée où foisonnent de nombreuses essences naturelles et qui représente une zone de transition entre les flores des zones d'endémisme guinéo-congolais et soudanais. Le Bénin est colonisé par des essences exceptionnellement dynamiques issues de ces zones d'endémisme comme *Chromolaena odorata* (L.), arbuste vivace, multicaule, très ramifié qui s'adapte à divers biotopes.

Originaire des Antilles et d'Amérique continentale, introduite comme plante de couverture en Asie et plus récemment en Afrique, l'herbe du Laos est devenue partout très vite envahissante (Audru *et al.* 1988). En Afrique de l'ouest, elle se rencontre, entre les régions côtières de la zone forestière et la limite méridionale de la savane guinéenne, dans toutes les formations naturelles perturbées qu'elle colonise rapidement en formant des buissons denses et enchevêtrés de 3 à 4 m de haut environ.

C. odorata est perçue actuellement comme l'une des adventices les plus préoccupantes pour l'agriculture et l'élevage du Bénin. Elle retient de plus en plus l'attention des agriculteurs, éleveurs et responsables du développement rural par sa vitesse d'extension.

Le présent rapport est le résultat d'une enquête effectuée à la demande de la FAO sur la base d'un questionnaire comprenant les points ci-après:

-histoire de l'introduction de l'adventice au Bénin
-distribution sur le territoire national
-élaboration d'une cartographie des zones infestées
-dommages de la plante
-politique nationale de recherche et de lutte coutre cette plante.

Méthodologie

Sur le terrain une enquête extensive à base de questionnaire et de discussions avec les paysans a été réalisée. Auparavant, des discussions ont eu lieu avec la Direction Générale des Centres d'Action Régionaux pour le Développement Rural (CARDER) de l'Atlantique, de l'Ouémé, du Mono et du Zou, (les quatre Départements colonisés par l'adventice). Ces séances ont permis d'identifier les zones d'intérêt et les itinéraires à suivre où l'équipe de protection s'arrête tous les 5 km et inspecte champs, friches et plantations. Selon l'importance de l'adventice dans la zone visitée l'équipe s'arrête au bord de la route, ou s'éloigne de 100-200 m, voire plus de la route en vue d'apprécier la densité de peuplement de la plante. Au total 1930 km ont été parcourus au bas-Bénin (Fig. 1). L'enquête réalisée en Mars-Avril 1992 n'a pu s'étendre au-delà de la latitude de Savé (8° N latitude) en saison du passage de feux de brousse.

Résultats et Discussion

La grande majorité des paysans interrogés au Benin situent l'introduction *C. odorata* vers 1976, suite au passage d'un avion qui a couvert l'atmosphère d'une traînée de poudre d'où son nom de agatou (fusil du haut). Pour certains, l'introduction de la plante coïncide avec la visite officielle de Sékou Touré de Guinée d'où son nom common de Sékou Touré ma (la feuille de Sékou Touré). Il semble que son apparition au Bénin ait eu lieu à partir du sud-est dans le département de l'Ouémé (Fig. 1).

Une multitude de noms out été donnés à cette adventice, suivant le département:

agatou ou agatouou, labte, hlayoma, alitchotama, agahounma, agahounkan (feuille d'avion), ahayo, akpalikpakan, antiota, houeflouassou, jekan, gbalindo, et houéflou.

La plante semble être apparue au Bénin à partir du Nigéria, ce qui explique que le département de l'Ouémé soit le plus envahi (Tab. 1). Les observations sur le terrain montrent que de l'est, la plante s'étend progressivement vers l'ouest et vers le nord. Elle a déjà couvert tout le bas-Bénin jusqu'à la latitude de Savé, l'axe routier Cotonou-Parakou divisant le bas-Bénin en une zone est fortement infestée et une zone ouest modérément infestée.

L'homme, (vêtements, chaussures, véhicules), les animaux en transhumance, les oiseaux, le vent jouent un rôle certain dans la propagation de *C. odorata*. Dans l'Ouémé, et le Mono, les cours d'eau ont joué un rôle appréciable dans l'introduction de cette plante.

Malgré l'abondance des populations de criquet puant *Z. variegatus* , les dégâts dûs à cet insecte restent négligeables.

L'adventice est un problème sérieux pour la palmeraie industrielle dans le Département de l'Ouémé. Après avoir colonisé les abord de certaines routes principales, la plante exerce sa pression sur les sentiers qui ne restent praticables que grâce à des coupes régulières. L'élevage villageois est compromis, tous les paysans interrogés s'accordent pour dire que *C. odorata* n'est pas consommée par les animaux, mais qu'elle exerce un effet favorable sur le rendement du maïs.

C. odorata est considérée comme utile contre *I. cylindrica* qu'elle étouffe facilement grâce à son étonnant pouvoir de multiplication. Elle produit une biomasse considérable qui se décompose facilement après une jachère que la plante raccourcit. Les vertus médicinales de la plante sont de:

combattre l'abcès, la gale et le bouton
de cicatriser,
de guérir le paludisme, et de détourner les moustiques.

En culture traditionnelle, l'essouchage permet de lutter facilement contre l'adventice dans la mesure où les racines sont superficielles. En revanche, les responsable du Développement Rural lui reprochent d'abriter le criquet puant, *Z. variegatus* et d'être

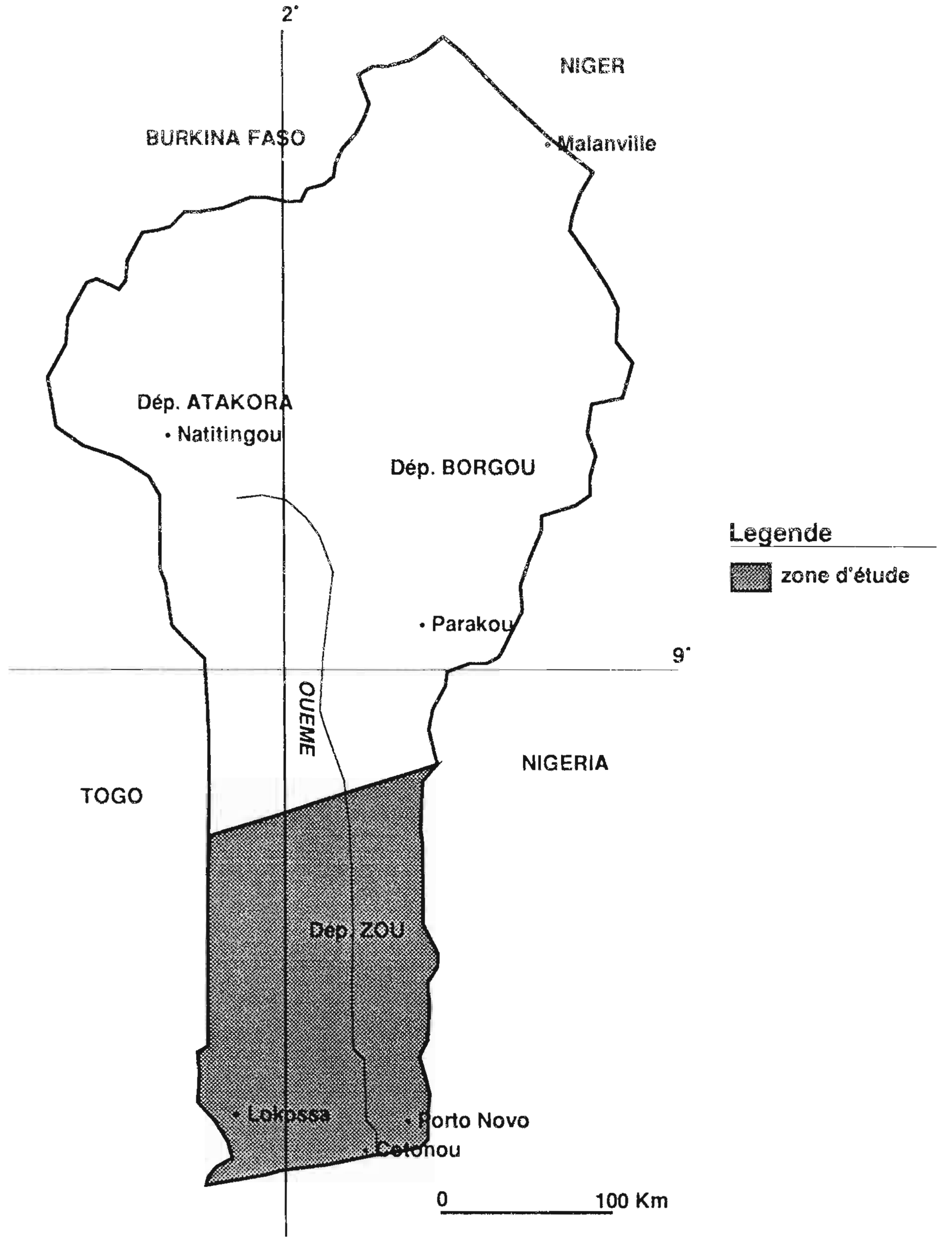

Figure 1. Republique du Benin.

Table 1. Présence, nature et type d'infestation par *C. odorata*.

Présence de *C. odorata*	Nature infestation	Type Infestation
2	1	1
3	4	5 teck palmier agrume 6 maïs palmier
2	2	1,3
3	4	5(palmier) teck
1	1	1
1	1	1

1.Présence de *C. odorata*
0=absent 1=rare 2=fréquent 3=très fréquent
2.Nature de l'infestation par *C. odorata*
1=pieds isolés 2=touffe 3=taches 4=peuplements denses
3.Type d'infestation
1=bord de route 2=village 3=zone non cultivée
4=friche récente 5=culture intensive 6=culture traditionnelle

gênante sous palmeraie industrielle en raison de compétition hydrique. *C. odorata* profite des poches de lumière laissées par les palmiers âgés pour croître rapidement, en sorte que 3-4 coupes annuelles sont nécessaires.

Conclusion

C. odorata passait inaperçue il y a quelques années encore. Elle semble largement acceptée par les paysans pour ses qualités améliorantes, racourcissant la jachère étouffant l'impérata et pour ses vertus médicinales. A la question de savoir s'il fallait éradiquer cette herbe, un groupe de paysans a ri avant de répondre ceci: "On ne détruit pas ce qui fait du bien". Cependant, certains paysans lui reprochent la menace qu'elle laisse planer sur l'élevage car elle n'est pas consommée par les animaux. Les spécialistes du Développement Rural lui reprochent en outre de constituer un réservoir de ponte pour le criquet puant, *Z. variegatus* et de menacer certaines essences utiles.

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***Chromolaena odorata* (L.) R.M. King and H. Robinson in the Congo.**

(*Chromolaena odorata* (L.) R.M. King et H. Robinson au Congo)

G. BANI and P. LE GALL
Laboratoire d'Entomologie agricole, Centre DGRST-ORSTOM
Brazzaville, Congo.

Introduction

C. odorata was introduced to Congo more than 3 decades ago. Its rapid growth makes it the most dominant weed in idle lands. Even though the majority of the population consider *C. odorata* as a noxious weed, some people find the plant beneficial. Based on personal observations and investigations conducted in Congo, this paper describes the present status of the plant in Congo.

Origin

Originating in Central and South America and the Caribbean, *C. odorata* was introduced to Asia in the 1840's. It came to Africa from Asia in 1937. *C. odorata* was first collected in 1965 (Gautier 1992), however, farmers began to notice the weed in the early sixties during the presidency of Marien N'gouabi, for whom the plant was named.

Habitat

C. odorata is found throughout Congo with the southern and southwestern regions being most affected (Fig. 1). The central region is currently being colonized. In the northern part of the country, *C. odorata* is less frequent. *C. odorata* is found in a variety of landscapes. Its spread is facilitated by land cultivation, road construction, and electrical lines. In cities, *C. odorata* even occurs in vacant lots and along sewer lines that are not being maintained.

Local names

The most popular names of *C. odorata* in the south and southwest are: lantana of N'gouabi, Mataya onbala (the invader); Comilog (a railroad company); Kalamilebe; Kalamana; and Diabantou (toxic).

Noxious effects

Due to its rapid growth rate, *C. odorata* displaces other spontaneous plant species from the forest and savanna. *C. odorata* also contributes to forest degeneration (de Foresta 1991). In addition, *C. odorata* reduces diversity of the vegetation and decreases the quality of pasture. Another ecological impact derives from its representing an optimum breeding habitat for *Zonocerus variegatus* (Bani 1990).

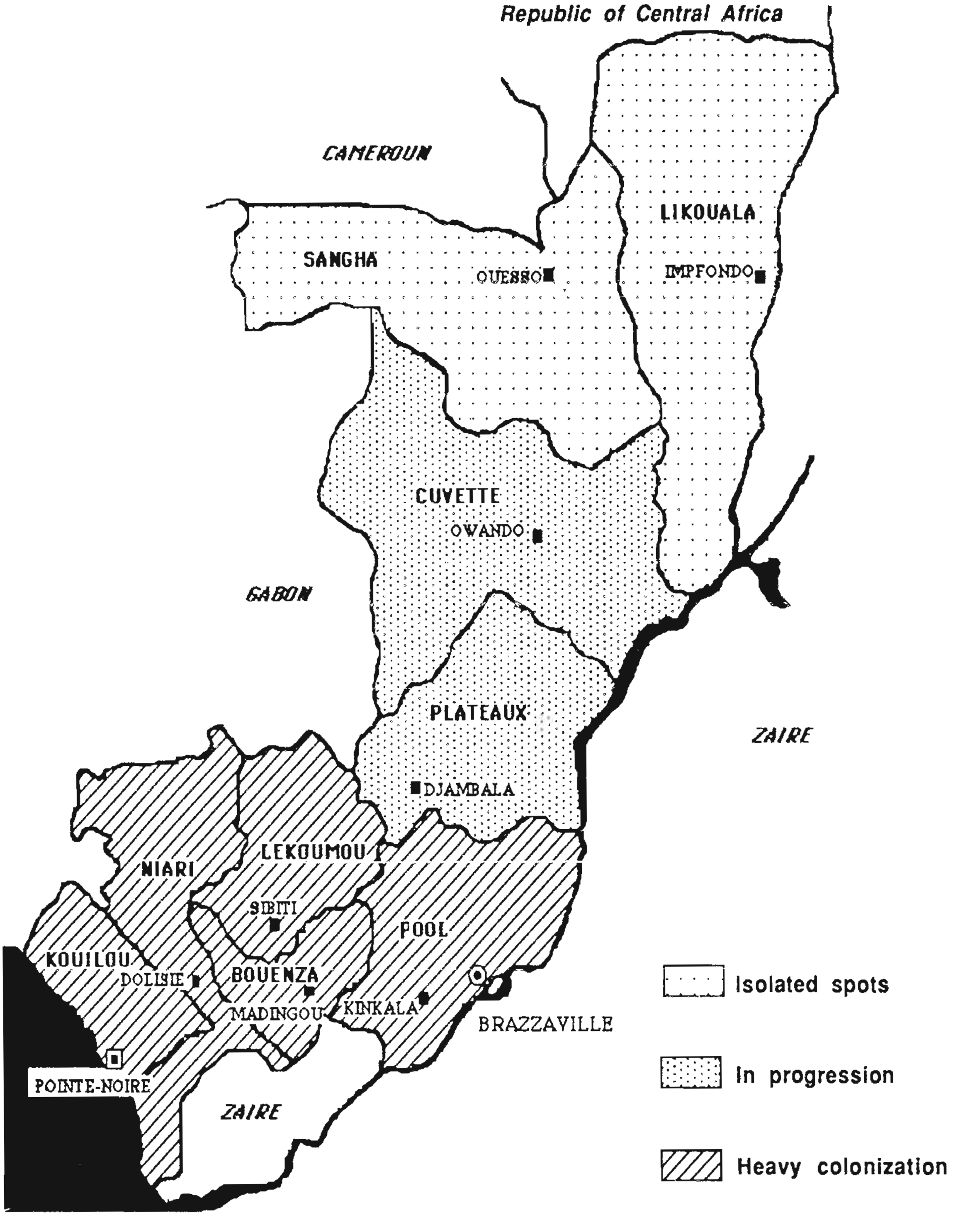

Figure 1. Status of *C. odorata* in Congo.

Farmers from the forest region of Chailla avoided growing cassava in areas where *C. odorata* is present because cassava roots are made more susceptible to rotting. In the area of Sibiti, an entire family is reported to have died during the 1980's after eating leaves of *Solanum aethiopicum* contaminated with leaves of *C. odorata*.

Benefits of *C. odorata*

Farmers in the Niari valley claim that C. *odorata* improves soil fertility, as seen in increased peanut productivity. This observation was confirmed by Madembo and Ekonamine (1993). *C. odorata* also inhibits the development of *Imperata cylindrica* and shortens periods of fallow land in Kombe and Niori valley from 6-7 to 3-4 years. Nematicidal effects of C. *odorata* were reported by Matondo *et al.* (1993). Oil extracted from leaves of *C. odorata* are reported to have potential insecticidal properties. Some medicinal properties are also attributed to *C. odorata*.

Actual status of *C. odorata*

The average Congolese farmer is concerned about the presence of *C. odorata*, and there is a tendency to request its removal. *C. odorata* is listed as a pest in the country and a national control committee has been established.

Control

Biological control of *C. odorata* seems to be generally accepted in the scientific community. Because a survey of the natural enemies of *C. odorata* did not show any host specificIty, it will be necessary to introduce an exotic biological control agent. Table 1 lists the phytophagous insects found on *C. odorata*.

Table 1. Phytophagous insects found on *C. odorata* in Congo.

Zonocerus variegatus L., (Orthoptera: Pyrgomorphidae)
Anoplocnemis curvipes (Heteroptera: Coreidae)
Phenacoccus madeirensis (Homoptera: Pseudococcidae)
Ferrisia virgata (Homoptera: Pseudococcidae)
Orthezia sp. (Homoptera: Ortheziidae)
Aphis citricola Van der Goot (Homoptera: Aphididae)
Urleucome composidae (Homoptera: Aphididae)

Conclusion

The desire to control *C. odorata* was clearly expressed by farmers. The weed's potential increase of soil fertility does not justify its presence. However, more research is needed on the advantages and disadvantages of *C. odorata*.

Ecological studies need to be conducted in areas where *C. odorata* does not frequently occur. The National Committee for the control of *C. odorata* welcomes any initiatives and collaborations with other institutions aiming at the same goals.

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Distribution and Significance of *Chromolaena odorata* (L.) R. M. King and H. Robinson Across Ecological Zones in Cameroon.

(Distribution et Signification de *Chromoleana odorata* (L.) R. M. King et H. Robinson dans les Différentes Zones Ecologiques du Cameroun)

S.F. Weise
Humid Forest Station, IITA (International Institute of Tropical Agriculture)
Yaoundé, Cameroon

Résumé- *Chromolaena odorata* (L.) R. M. King et H. Robinson, originaire des Néotropiques, s'est rapidement diffusée dans de vastes zones de l'Afrique Centrale et Occidentale. Cet article traite de la distribution de l'espèce et de sa signification pour les paysans dans les différentes zones écologiques du Cameroun. Un inventaire au niveau des villages a montré que *C. odorata* est devenue une espèce dominante des jachères dans la zone forestière ainsi que dans la zone de transition forêt-savane, et que les paysans la perçoivent comme un problème majeur. La recherche doit donc développer des stratégies de gestion integrée afin d'abord de réduire l'adventice pendant les cycles de cultures, ensuite d'évaluer en détails l'utilité de la plante en tant qu'espèce de jachère dans les systemes culturaux à jachère courte.

Abstract-*Chromolaena odorata* (L.) R. King and H. Robinson, originally from the neotropics, has rapidly spread to large parts of West and Central Africa. This paper reports on the distribution of the species and its significance to farmers in the different ecological zones of Cameroon. A village survey revealed that *C. odorata* has become a major fallow species in the forest and forest-savanna transition zones, and that farmers perceive it to be a major weed problem. Research must, therefore, develop integrated management strategies to reduce the weed during cropping cycles, as well as further assess the plant's usefulness as a fallow species in short-term bush fallow cropping systems.

Introduction

Chromolaena odorata (L.) R. King and H. Robinson (*Eupatorium odoratum* L.) was introduced to western Africa in the first half of this century (Gautier 1992a). Its rapid vegetative development and massive production of air-borne seeds have allowed it to spread to large parts of the region. Once established, it develops into a dense thicket in almost pure stands. The plant has become an important component of the natural succession in traditional slash and burn bush fallow cropping systems of the humid forest and moist savanna zones of West and Central Africa. Some reports indicate that as a fallow species *C. odorata* can return a substantial amount of nutrient-rich litter to the soil, improving its chemical and physical properties (Lucas 1989). *C. odorata* is perceived as a major weed problem in the establishment phase of plantation crops and in arable cropping stems (Lucas 1989). It is also able to suppress growth of the noxious grass, *Imperata cylindrica.*

This paper summarizes information from a village level survey on the distribution and significance of *C. odorata* in Cameroon. *C. odorata* constituted only a minor part of a comprehensive Resource Management Survey (RMS) in Cameroon. Unpublished RMS data on *C. odorata* provides a unique opportunity to assess the extent of its presence in different ecological zones, and its significance as perceived by local farmers.

Materials and Methods

In 1992, an RMS was carried out in Cameroon to ascertain the resource base of current farming practices, and identify development patterns related to agricultural intensification (Baker & Dvorak 1993). The RMS was implemented through village meetings in 85 randomly selected villages, chosen from a stratified, nationwide sample. The primary ecological zones of Cameroon and its provinces are depicted in Figure 1. The survey excluded the mid-altitude savanna zone of the Adamawa province. The northern part of the moist savanna zone and semi-arid savanna zone are grouped into the "northern savanna" zone in this paper. The RMS collected data on biophysical and socioeconomic characteristics of farming systems, i.e. field types, crop management, fallow lengths, important tree and fallow species, severity of pest problems, labor availability and distribution, and access to and dependence on markets.

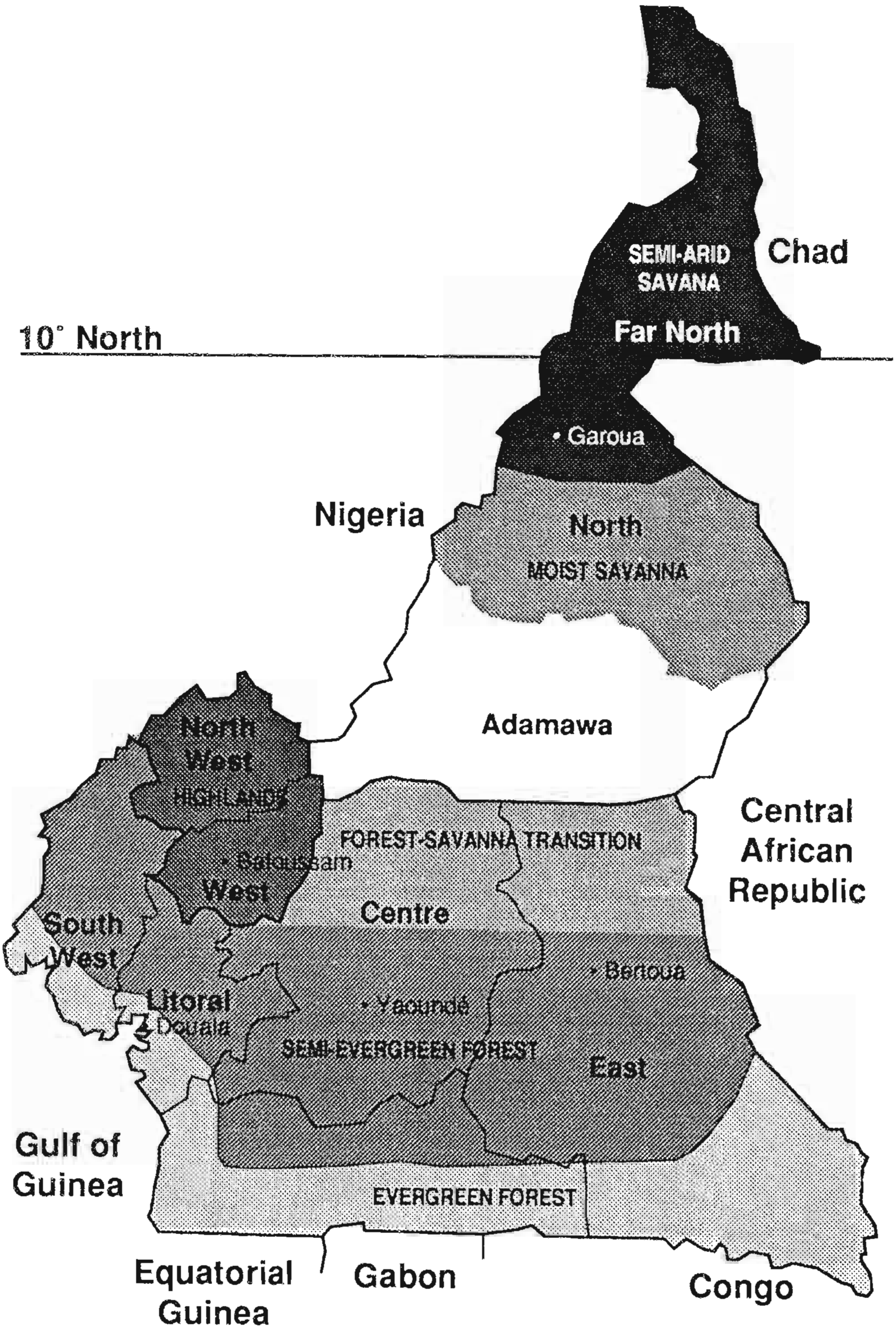


Figure 1. Ecological Zones and Provinces of Cameroon.

Results and Discussion

Presence and problem severity

Villagers ranked weeds as the most severe agronomic problem in the semi-evergreen forest, highlands, and the northern savanna. In the evergreen forest and tne forest-savanna transition zones where invertebrate and vertebrate pests posed greater problems, weeds ranked third. All villages from the forest and transition zones reported *C. odorata* as their primary weed problem (Tab. 1). A major concern of farmers in the forest zone is that clearing *C. odorata* thickets has doubled the time required for preparing a field. After slashing and burning thickets, the rootstocks need to be removed manually. The crop also requires one to two additional weedings if productivity is to be maintained. *C. odorata* is a lesser problem in the highlands, and was not present in the northern savanna. Although the RMS did not collect information on its distribution on Adamawa plateau, Douffissa (1993) and Essomba Bengono *et al.* (1992) have observed a gradual encroachment of *C. odorata* tufts into this area from the transition zone.

Savanna zones, and in all of the highland villages (Tab. 1). Over half of these villages consider *C. odorata* to be a moderate to severe problem. The incidence of *I. cylindrica* was limited in the forest zone where it is present in about a third of the villages, and only 11 percent consider it a problem. Although the presence of *Pennisetum purpureum* was similar to *I. cylindrica*, the former was considered less problematic. *Striga* spp. on the other hand, were the main weed problem in the northern savanna with some significance in the transition zone.

Time of invasion

C. odorata has been present at least since the 1970's along the coastal region. This area includes the southern part of the highlands (Bafoussam) to a broad band from Douala eastwards through Yaounde and Bertoua, bordering the Central African Republic (Fig. 2). Villagers north and south of this east-west band have observed the weed only since the 1980's. This distribution supports the hypothesis that *C. odorata* invaded Cameroon from Nigeria in the early 1960's (Gautier 1992a). It then probably spread eastwards along the Douala-Yaounde-Bertoua axis, facilitated by the presence of major roads connecting the towns and villages in the area. As noted by Gautier (1993), *C. odorata* reaches a new region by long-distance dispersal through exozoochory or anthropochory, and then it rapidly invades the area through a massive production of seeds dispersed through anemochory. However, our data does not necessarily discount the possibility of the weed spreading into eastern Cameroon from the Central African Republic in the early 1970's (Essomba Bengono *et al.* 1992). Invasion into the southern forest zone was probably slowed by reduced forest clearing, longer fallow periods associated with lower human population densities, and accessibility to markets. The overall pattern of invasion presented here tends to corroborate the findings of Essomba Bengono *et al.* (1992).

Table 1. Severity of selected weed species in the ecological zones of Cameroon (percent of villages).

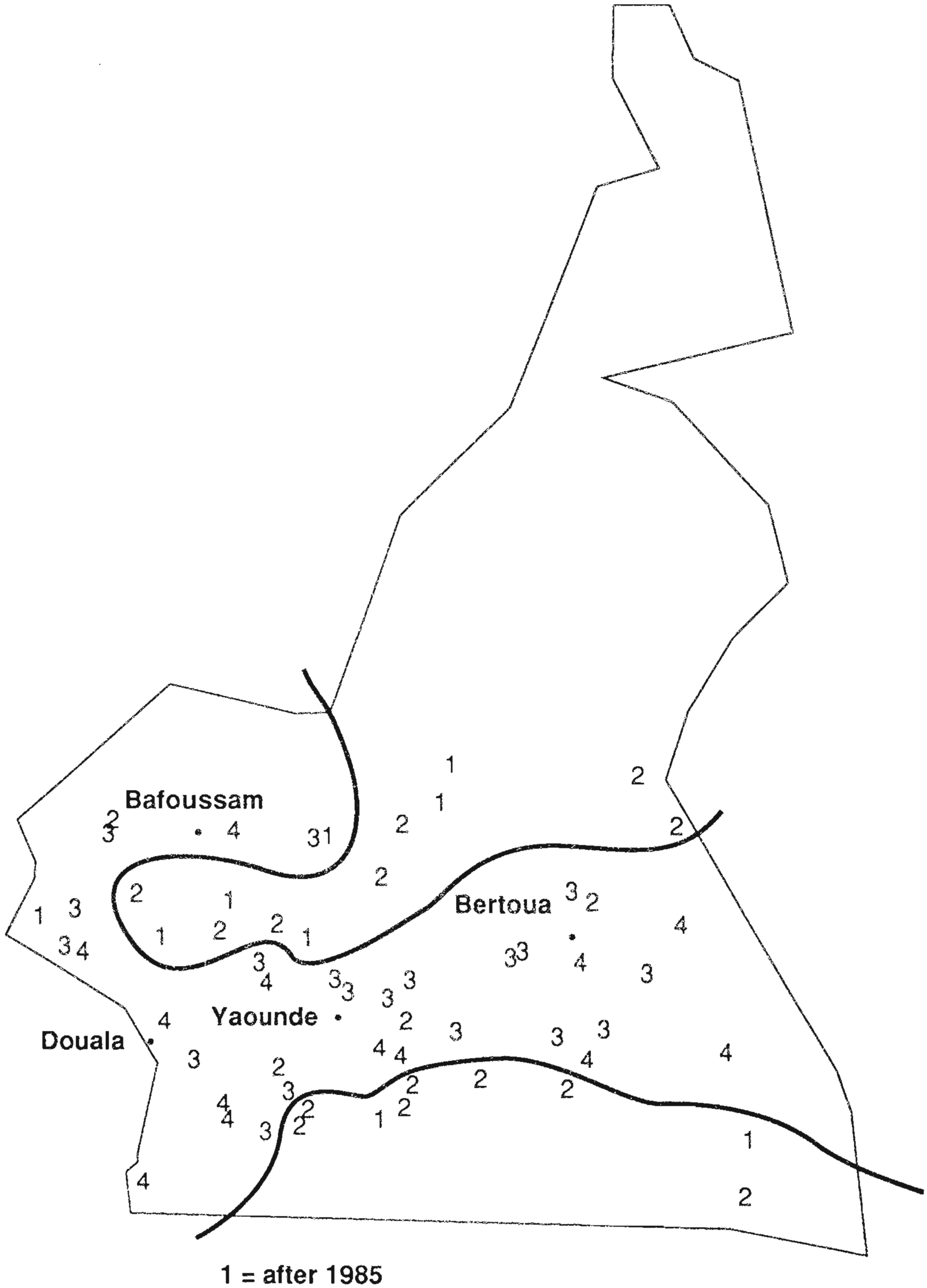
	Evergreen Forest	Semi-Evergreen Forest	Forest Savanna Transition	Northern Savanna*	Highlands
Chromolaena odorata					
Present	100	100	100	0	25
Moderate-severe problem	95	100	88	0	13
Imperata cylindrica					
Present	30	41	82	67	100
Moderate-severe problem	5	18	47	56	75
Pennisetum purpureum					
Present	55	67	71	65	100
Moderate-severe problem	5	11	18	41	38
Striga spp. (on cereal)					
Present	0	6	53	81	0
Moderate-severe problem	0	0	29	81	0
Number of villages	20	21	18	18	8

* Includes the northern half of the moist savanna zone and the semi-arid savanna zone.

Importance in fallows

In the forest and transition zones, food crops such as groundnut, maize, cassava, cocoyam and plantain are primarily grown on upland fields (mixed food crop fields) which have adequate drainage during the rainy season. Soil of the low lying areas often have hydromorphic properties and are used for off-season production of short-duration crops such as maize (wetland fields). *C. odorata* was one of the three most dominant fallow species in upland fields in over 85% of the villages in the forest and transition zones (Tab. 2). Field observations in Mbalmayo, an area 60 km south of Yaounde showed that *C. odorata* was present in 47 of 54 mixed food crop fields. In the Republic of Congo, de Foresta & Schwartz (1991) observed that shortening fallows from 15 to 5 years interrupts the succession to a mature rain forest, and development of a pioneer forest has largely been replaced by a *C. odorata* thicket.

The percentage of villages reporting *C. odorata* as an important fallow species in the wetland fields dropped to about 60% in the forest zone, and 28% in the transition zone



1 = after 1985
2 = 1980-1984
3 = 1975-1979
4 = before 1975

Figure 2. Period *Chromolaena odorata* was first observed.

Table 2. Presence of *C. odorata* as one of the three major fallow species in the ecological zones of Cameroon (percent of villages).

	Evergreen Forest	Semi-Evergreen Forest	Forest Savanna Transition	Northern Savanna*	Highlands
Mixed food crop fields					
Present (%)	85	95	88	0	25
Total No. of villages	20	21	17	18	8
Wetland fields					
Present (%)	63	59	28	0	13
Total No. of villages	16	17	14	10	8

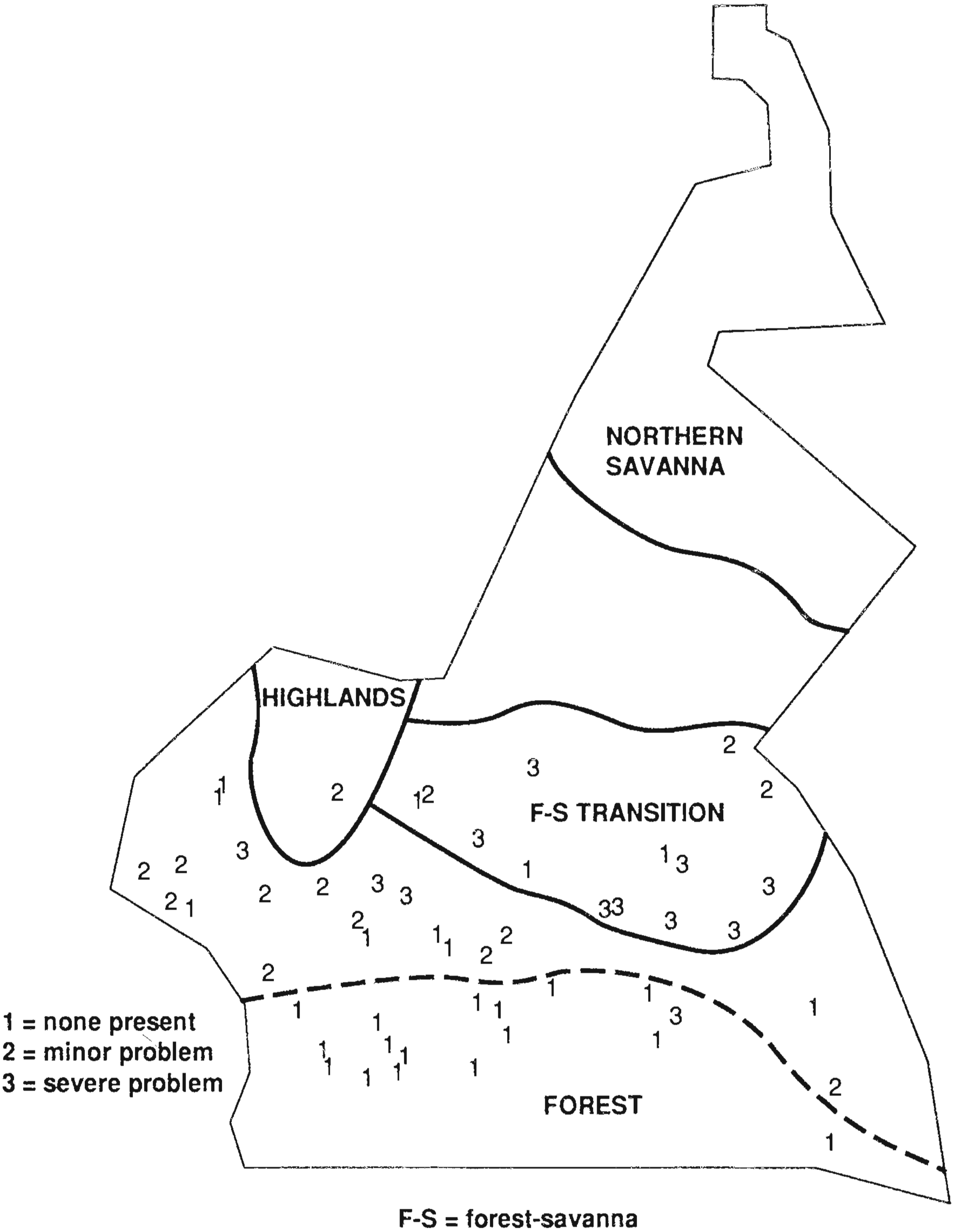
* Includes the northern half of the moist savanna zone and the semi-arid savanna zone.

(Tab. 2). It is not clear whether this reduced occurrence in the wetlands is associated with shorter cropping periods, or longer fallow periods leading to a type of successional development not conducive to establishment of a *C. odorata* thickets. De Rouw (1991) found if cultivation ceased after 1 year, pioneer forest species developed rapidly and shaded out *C. odorata* in the humid forest zone of Southwest Côte d'Ivoire. She also observed that fields prepared by clearing a secondary forest tended to enhance establishment of a thicket, as opposed to those cleared from a primary forest. Additionally, depending on the type of wetland, extended periods of waterlogging may not be conducive to growth of the plant. It is also important to note that 3 villages from the southwest Cameroon reported, *C. odorata* as a major fallow species in wetland fields but not in the uplands.

C. odorata appears to be able to suppress the invasion of *I. cylindrica* (Lucas 1989, de Rouw 1991, Gautier 1992b). The RMS shows that severe *I. cylindrica* and *C. odorata* problems primarily occur in the forest-savanna transition zone (Fig. 3). A detailed study of the role of *C. odorata* in the vegetation dynamics of a forest-savanna transition zone in Côte d'Ivoire, indicates that depending on the location in the toposequence and the frequency of burning, fallows dominated by either species can be found in close proximity of each other (Gautier 1992b). In the forest zone, dual appearance of *C. odorata* and *I. cylindrica* seems to be linked with land use intensity (Fig. 4). With intensive land use as in the Southwest province and major centers such as Douala and Yaounde, both species tend to become an agronomic problem. On the other hand, intensive land use in the southern forest zone shows that only *C. odorata* is a problem.

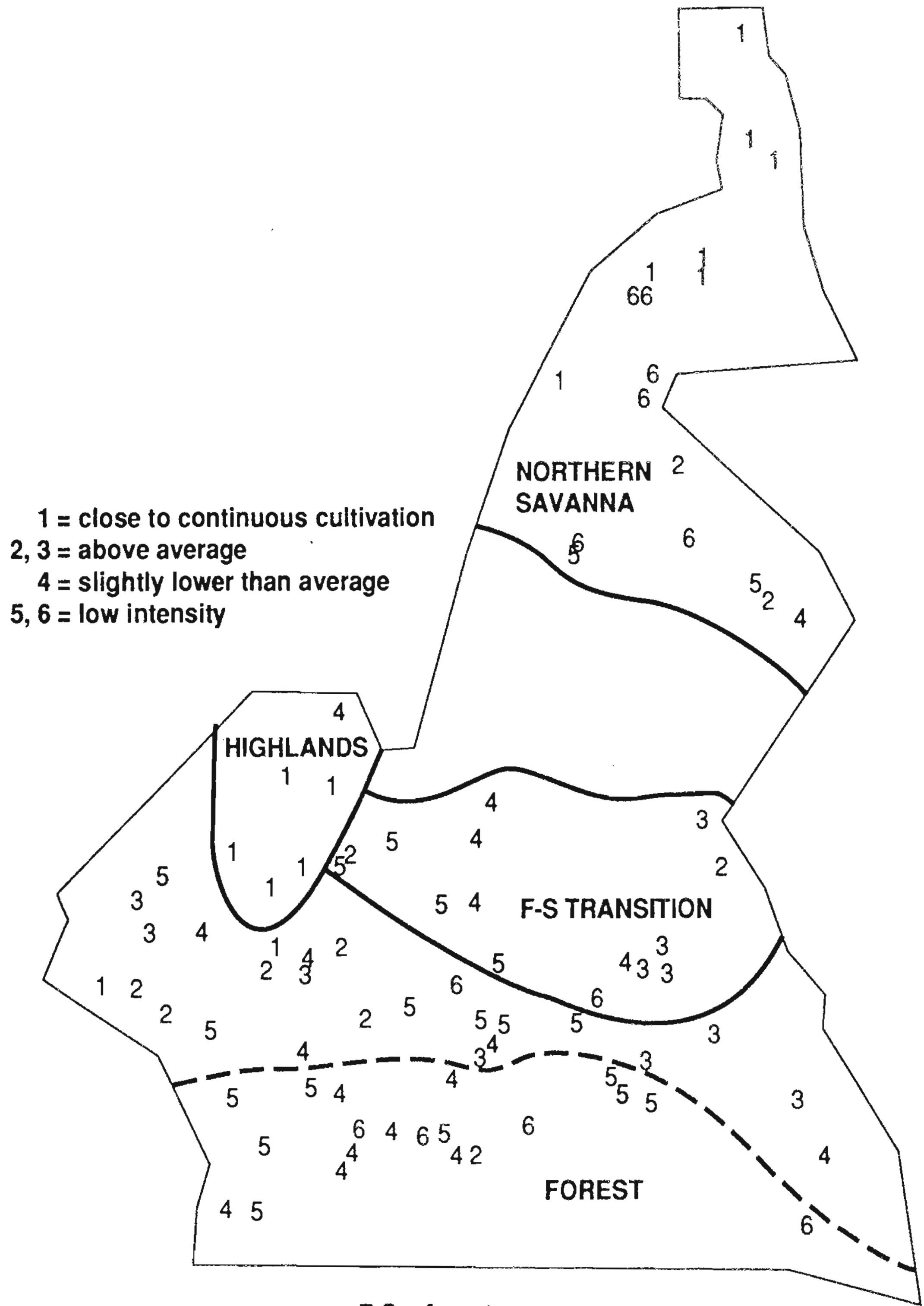
Conclusion

C. odorata is perceived as an important weed problem in the forest and transition zones of Cameroon. However, as de Foresta & Schwartz (1991) note, the species could actually play an important role in the fertility management of short-term fallows. The task is, therefore, two-fold: integrated management strategies need to be devised to reduce the negative effects of the species during cropping cycles, while at the same time soil rejuvenating properties of the plant need to be better understood and utilized.



F-S = forest-savanna
Northern Savana = Northern half of the moist savanna zone and the semi-arid savanna zone

Figure 3. Severity of *Imperata cylindrica* infestation in areas with major *Chromolaena odorata* problems.



F-S = forest-savanna

Northern Savanna = northern half of the moist savanna zone and the semi-arid savanna zone

Figure 4. Standardized classes of Land Use Intensity.

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National Report from Australia and the Pacific.

(Rapport National de l'Australie et du Pacifique)

R. Cruttwell McFadyen
Alan Fletcher Research Station
Australia

Résumé - *Chromolaena odorata* continue à se propager de l'Asie du Sud-Est vers le Pacifique Sud, où elle a d'abord été répertoriée dans les îles orientales Indonésiennes de Timor, Sulawesi et Irian Jaya. On l'a relevée ensuite en Nouvelle-Bretagne, dans les années 1980. Depuis, on l'a retrouvée en plusieurs endroits à l'intérieur des terres de la Papouasie Nouvelle-Guinée et d'Irian Jaya, mais elle n'a pas encore atteint les îles Salomon et l'Australie. Face à la menace sérieuse que représente *C. odorata* pour l'agriculture et l'environnement de ces pays, une campagne de prévention a été mise en place afin de détecter rapidement la présence de l'adventice pour la détruire avant qu'elle ne puisse durablement s'implanter.

Abstract-*Chromolaena odorata* continues to spread from Southeast Asia into the South Pacific, where it was first recorded from the eastern Indonesian islands of Timor, Sulawesi and Irian Jaya. It was recorded in east New Britain in the 1980's. *C. odorata* has since been recorded from several places in mainland Papua New Guinea and Irian Jaya, but is not yet present in the Solomon Islands or Australia. Since *C. odorata* poses a very serious threat to the agriculture and environment of these countries, a prevention campaign has been developed for early detection of the weed so it can be destroyed before becoming widely established.

History

Chromolaena odorata was introduced to Asia prior to 1870, probably through the Serampore Botanical Gardens in Calcutta (McFadyen 1989, Gautier 1993). Voigt (1845), in charge of the Serampore Gardens from 1834 to 1843, suggested that *C. odorata* was a suitable garden plant for the area. By the 1870's, the plant was wild in Dacca and the Ganges flood plain (Clarke 1876). The origin of the first introduction of *C. odorata* is not known but is likely to have been Jamaica in the West Indies, since at that time Calcutta was the capital of British India, and Kingston, Jamaica was the administrative center for the British West Indies. Officials within the

British Colonial Service, such as the government botanist or government medical officer (often the same person), were regularly transferred between Fiji, India and the West Indies. If Voigt or his successor in Calcutta introduced the plant, it is most likely that the seeds or specimens were obtained from their colleagues in Kingston.

From Calcutta, the plant spread east into Assam and Burma, and then progressively east and southeast to Indonesia and Indochina (McFadyen 1989). It was first recorded in the Philippines in the late 1960s (Pancho & Plucknett 1971), in Guam by 1963 (Marutani & Muniappan 1991), in the Marianas by 1973 (Fosberg & Falanruw 1973), in East New Britain by 1982 (Henty & Pritchard 1982), and in Timor by 1988 (S. Field pers. comm. 1988). In all countries affected it was rapidly recognized as a serious weed of plantation agriculture, and of pastures in drier areas (Ambika & Jayachandra 1980, Ivens 1974, Leggitt 1983, Olaoye 1986, Soerjani *et al.* 1975, Wu *et al.* 1984).

Australia started an awareness campaign in 1985, after it became concerned about the rapid southeast spread of this weed towards Australia and the Pacific. In a report to the Australian Quarantine Service, Michael (1989) of Sydney University stated that *C. odorata* was the greatest weed threat to northern Australia, both because of increasing certainty that it would reach Australia, and because of the potential damage to agriculture and the environment. Climate studies, using the computer program Climex and data on distribution of the weed in Asia, indicated that all wet coastal lands from the Kimberleys in West Australia to Brisbane on the Queensland-New South Wales border, were potentially suitable for invasion by this weed. Experience in Southeast Asia indicates that the weed is particularly invasive in areas with a pronounced dry season, as is typical of northern Australia. Also much of the wet/dry savannas of Arnhem Land and Cape York could be taken over by the weed, with disastrous results for the natural ecosystems and wildlife of this World Heritage area.

As a result of these reports, the awareness campaign was increased; leaflets illustrating the weed were sent to all quarantine and weed inspection officers in northern Australia, and talks were given to weed societies and quarantine officers (McFadyen 1989; 1990, Commonwealth of Australia 1988). The Northern Australia Quarantine Survey (NAQS) was established in 1988 to monitor the presence of potential insect and weed pests of Australian agriculture in the north, and in 1990 a NAQS botanist was based at Mareeba in northern Queensland to monitor potential weed problems in the area.

Australian Centre for International Agricultural Research (ACIAR) also became interested in the possibility of funding a biocontrol program in Southeast Asia, aiming to assist these countries in weed biocontrol, an area in which Australia has considerable expertise. Control of the weed in Southeast Asia would also reduce its threat to northern Australia. ACIAR funded this researcher's attendance to all three International Workshops on biological control of *C. odorata.* In January 1993, ACIAR began funding a biocontrol program in Indonesia and the Philippines (McFadyen 1993).

Recent Spread

As part of the NAQS effort, the spread of *C. odorata* in Irian Jaya and Papua New Guinea is being monitored, recording all new infestations. The South Pacific Commission (Fiji) which has responsibility for all of South Pacific Islands, is also actively surveying any occurrences of the weed. Since the 2nd Workshop in Bogor in 1991, a large area of *C.*

odorata has been found stretching at least 100 km from Jayapura in northern Irian Jaya, to Vanimo in Papua New Guinea (PNG) (Sipayung *et al.* 1991, B. Waterhouse pers comm. 1992). This is shown in Figure 1. The infestation at Rabaul in New Britain affects at least 50 km, and a small infestation has been found near Lae on the adjacent mainland. There is also an unconfirmed report of the plant from Goroka in the Highlands of PNG. Early in 1993, a small infestation was found near Merauke in southern Irian Jaya (Turner pers. comm., 1993). No infestations have yet been found in the South Pacific. Since infestation at nearby Rabaul has been reported for at least 15 years, it is likely that the weed does occur on Bougainville. However, due to the fighting in Bougainville, inspections of the area have been impossible for the past several years.

Prevention Program

The aim of the awareness campaign in Australia and the South Pacific is to use chemical herbicides to completely eradicate small infestations of the weed as soon as they are discovered to prevent further spreading. The success of this campaign depends on finding infestations within a few years of the first plant becoming established, and before the seeds spread into the countryside. This weed is likely to spread to Australia and the South Pacific in the following ways:

1) through seeds from Timor and the southern Philippines which get caught in the winds associated with cyclones in the wet season;
2) through seeds in machinery and imported products brought in from ports in Indonesia and the Philippines;
3) through seeds in the belongings or trade goods of native people using traditional sailing vessels and yachts to travel between the islands.

The first method of spread is impossible to prevent and could result in initial infestations anywhere in northern Australia. Arnhem Land and Cape York are very sparsely populated and the chances of finding infestations before there has been significant spread, are very slim. The only way of reducing risk is to reduce the amount of seeds being produced in Timor and the southern Philippines through the ACIAR biocontrol program in these countries (McFadyen 1993).

The second method of spread is perhaps more likely, but is also easier to monitor. There are extensive trading links between Irian Jaya, the Philippines and northern Australia, with regular movement of ships and machinery by mining, surveying, and timber companies, live cattle exporters, etc. Landing facilities used by these companies are now being inspected regularly and company personnel have been informed about the problem. It is hoped that any introduction of the weed through these channels will be found before there has been significant seeding and spread.

Spread through the third method is also likely and is more difficult to monitor. So long as *C. odorata* is not present in southern Irian Jaya and southern Papua New Guinea, the danger to Australia is not great. Increased spread of the weed into these areas, however is a major concern. There is a continuous chain of islands between Papua New Guinea and Cape York (Fig. 1), and the islanders traditionally trade and visit freely between the two countries. Northern Australia is a traditional fishing grounds for Indonesian fishing

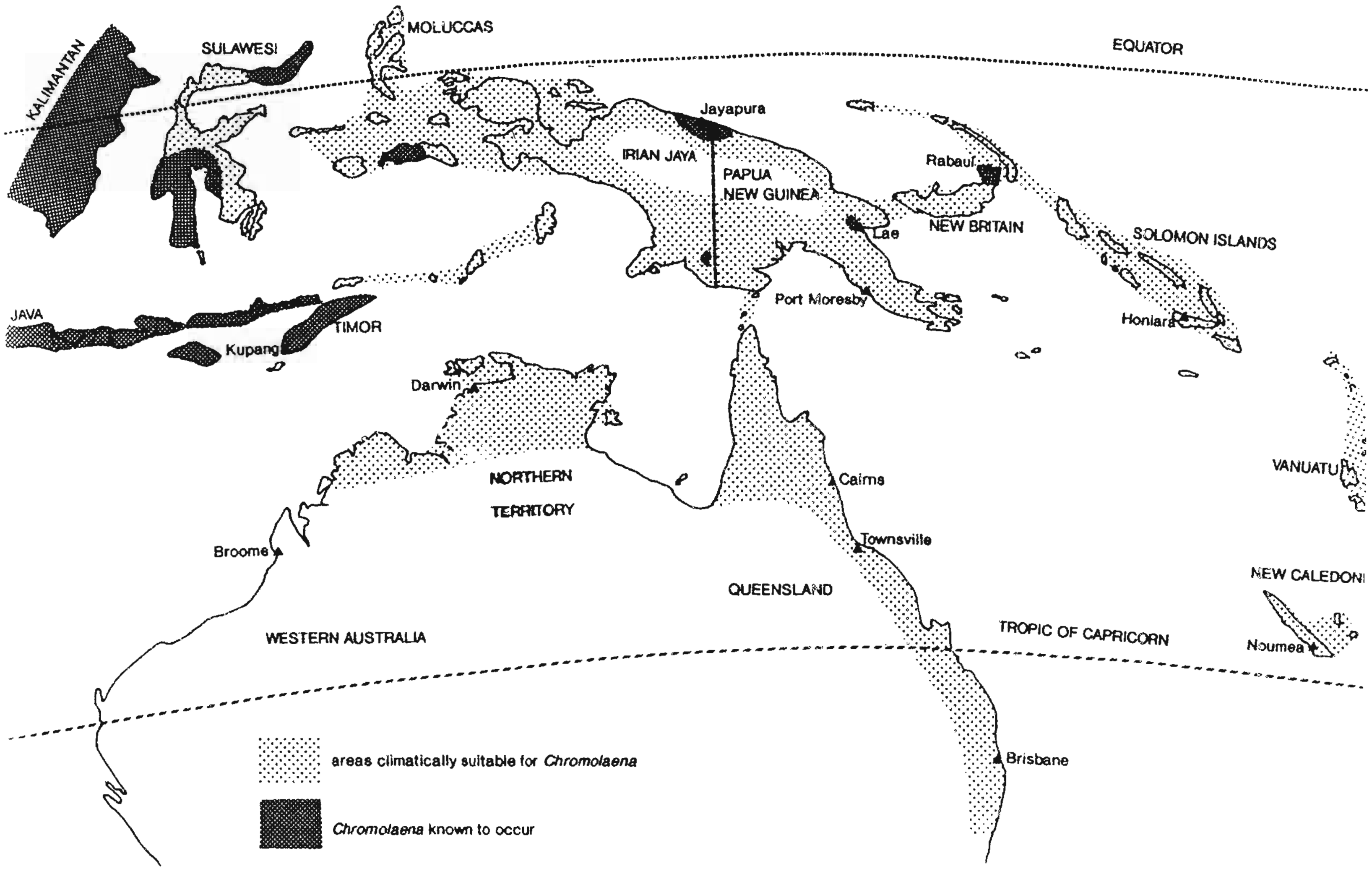

Figure 1. Distribution of *Chromolaena odorata* in Australia and the Pacific.

vessels from Timor and the Moluccas, who come on shore for fresh water or meat. There is also a problem with ocean-going yachts; these often spend months sailing from island to island, and may come ashore at remote Australian beaches to spend a few weeks resting and living off the country. If their last port was in the Philippines or Indonesia, these vessels may carry C. odorata seeds in their belongings. Once again, because of the long coastline and low population density, there is little chance of detecting any infestation within a few years of the first plant fully established.

Future concerns

Unfortunately, it seems inevitable that *C. odorata* will reach Australia and the South Pacific, spreading throughout the regions below 1500 m altitude and with at least 800 mm annual rainfall, and become an environmental disaster, at least for Australia. In the savannas of Arnhem Land and Cape York, replacement of native vegetation by *C. odorata* will destroy the habitat and food supply of native wildlife, including marsupials and invertebrates. These savannas burn frequently, but the grass fires are not very hot and do not affect the trees. If *C. odorata* forms dense stands along gallery and riverine vine forests and these stands dry off and burn in the dry season, the vine forests will be destroyed. These vine forests support a unique and scarcely known fauna that is already threatened by land-use changes, and will not survive further threats (Humphries *et al.* 1991). Wildlife tourism is a major source of income for northern Australia, and the government is responsible for preservation of World Heritage areas in the north. Chemical control is not economically feasible over these vast areas, and long-term, widespread use of chemicals is unacceptable for environmental and human health reasons. For these reasons, the existing biocontrol program is likely to be greatly increased if the weed becomes established in Australia.

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Chromolaena odorata: Calamité ou Chance pour l'Afrique Tropicale.

(*Chromolaena odorata:* Disaster or Hope for Tropical Africa)

H. de Foresta
Antenne ORSTOM in ICRAF
Bogor, Indonesia

Abstract-Most researchers and agronomists now consider *Chromolaena odorata* as a pest plant that should be fought by any means. A review of existing publications indicates that this reaction is based more on a fear of the invasion capabilities of *C. odorata* than an objective assessment of its impact. Along with studies in agronomy and indigenous knowledge from the humid tropics, recent findings indicate that *C. odorata* can improve soil fertility in surface layers of tropical acid soils. If such results are accurate and methods for controlled use of *C. odorata* in agriculture can be developed. then a solution for problems linked to acid soils and sustainable agriculture in tropical Africa may have been found. In conclusion, there is an urgent need for an objective assessment of problems linked to *C. odorata* as well as an assessment of its potential agricultural uses. These two new research directions are essential prerequisites before launching vast and costly global control programs.

Résumé-La grande majorité des chercheurs et agronomes considèrent actuellement *Chromolaena odorata* comme une "peste" végétale qu'il faut éliminer par tous les moyens. Après examen des publications existantes, l'auteur montre que ce "paradigme" ne repose pas sur une appréciation objective des qualités et défauts de cette plante, mais bien plutôt sur un réflexe de peur devant les capacités d'invasion très impressionnantes de *C. odorata.* S'appuyant tant sur d'anciennes études agronomiques tombées dans l'oubli que sur des enquêtes en milieu paysan, l'auteur expose certaines recherches récentes qui tendent à montrer que *C. odorata* pourrait augmenter notablement la fertilité chimique de l'horizon supérieur des sols acides tropicaux. Si ces résultats étaient confirmés, l'utilisation contrôlée de *C. odorata* en agriculture, selon des modalités qui restent à mettre au point, pourrait contribuer à résoudre les problèmes soulevés par l'extension des sols acides et leur culture durable en Afrique Tropicale. L'auteur conclut en soulignant l'urgence d'un rééquilibrage des recherches au profit d'une évaluation objective des problèmes dans les différents systèmes de culture d'une part, d'une évaluation des potentialités de *C. odorata* en agriculture d'autre part. Ces deux nouvelles orientations de recherches apparaissent comme des préalables indispensables au lancement de vastes et coûteux programmes de lutte.

Chromolaena: la Conquête d'un Continent

Originaire d'Amérique centrale, *Chromolaena odorata* aurait été introduite dans les années 1920 comme plante de couverture dans le Sud-Est Asiatique, d'où l'un de ses noms communs d' "herbe du Laos". Elle s'est rapidement répandue et y est devenue une composante à part entière des végétations anthropisées.

Il semble qu'elle ait été introduite en Afrique tropicale, et plus précisément au Nigéria, dans les années 1940. Après une phase d'extension lente jusque vers les années 1970, elle s'est répandue depuis comme un feu de brousse dans toute l'Afrique occidentale et centrale. "Sekou Touré "en Côte d'Ivoire, "Acheampong" au Ghana, "Bokassa", mais aussi "JaBinDe" (l'envahissante) en Centrafrique, "Lantana N'Gouabi", mais aussi "Matapa M'Bala" (l'envahisseur) au Congo, "Mighbe" (celle qui écrase tout) au Cameroun: ce sont là quelques-uns des noms locaux donnés à *C. odorata* en Afrique, noms qui traduisent à la fois l'époque de l'invasion de cette plante et le caractère massif et inexorable de cette invasion.

C. odorata, connue maintenant de tous les paysans en Afrique centrale et occidentale, pose à tous, paysans, chercheurs, agronomes, décideurs, un défi entièrement nouveau et d'une importance cruciale pour le développement des zones rurales: apprendre à gérer cette plante de façon à en maximiser les effets bénéfiques et à en minimiser les effets néfastes.

Chromolaena: le Paradigme

Plusieurs centaines d'articles concernant *C. odorata* ont déjà été publiés (cf. par exemple *Chromolaena* Newsletter No.1, ainsi que les Actes des deux précédents Ateliers). Il n'est pas question ici d'en faire une analyse détaillée, mais simplement d'en tirer quelques enseignements quant aux principales orientations de recherche passées et à leur évolution au fil des ans.

Il est possible de regrouper les publications existantes, de façon très schématique, en cinq groupes principaux:

a) Evaluation des aspects positifs de *C. odorata*. On trouve dans ce groupe extrêmement réduit (une quinzaine de publications, dont trois seulement concernant des expériences agronomiques!!!) les premiers articles autres que purement botaniques sur *C. odorata*, directement issus de son utilisation dans les plantations asiatiques comme plante de couverture (Poilane 1952). Notons au passage que Chevalier (1952), agronome tropicaliste éminent, recommande alors l'introduction de *C. odorata* en Afrique pour lutter contre *Imperata cylindrica* et empêcher la dégradation des sols.

En relation avec l'importance croissante de *C. odorata* dans les paysages anthropisés, diverses utilisations possibles de la plante ont été explorées par la suite, telles que la production de biogaz ou la production de fibres (Gautier 1992).

b) Evaluation de l'impact négatif de *C. odorata*. Les études bien documentées sur le sujet sont peu nombreuses et ne concernent en fait que les grandes cultures de plantation, cocotier, café, coton, palmier à huile, hévéa, ou les essais de reforestation, ou encore les pâturages extensifs (Audru *et al.* 1988, Gautier 1992). Les premières de ces études précèdent de peu celles sur la lutte contre *C. odorata* (Moni & George 1959).

c) Lutte contre *C. odorata*. Bien qu'il soit parfois fait référence à certains de ses aspects positif, la plante est toujours considérée ici comme une "peste majeure" qu'il faut impérativement combattre.

C'est là indiscutablement le sujet principal si l'on en juge par le nombre de publications: 146 articles consacrés uniquement à la lutte chimique ont ainsi été dénombrés entre 1972 et 1990 (Cruttwell-Mc Fadyen 1991). Les premières de ces études ont été publiées vers 1960 (Mohan Lal 1960) et elles dominent massivement la production scientifique depuis le début des années 1970.

Ces études ne concernent en général pas les systèmes de culture en vigueur chez les paysans, mais essentiellement les grandes cultures de plantation ou les pâturages. Notons également qu'alors que l'impact de la lutte chimique et mécanique est restreint en première approximation aux surfaces traitées, une lutte biologique basée sur l'utilisation de prédateurs affecterait tous les systèmes de culture sans distinction. Dans ce cas, *C. odorata* n'est pas considérée comme une peste relativement à telle ou telle culture, mais bien comme une peste absolue.

d) Biologie et autoécologie de *C. odorata*. Bien qu'il soit parfois fait état d'aspects positifs de la plante, la grande majorité de ces travaux considère *C. odorata* comme une peste, qu'il s'agit de bien connaître pour pouvoir la combattre efficacement. Les premiers de ces travaux ont été publiés vers le milieu des années 1970 (Edwards & Stephenson 1974), et les nombreux aspects abordés depuis permettent à la communauté scientifique de disposer d'une bonne connaissance de la biologie de *C. odorata*.

e) Synécologie de *C. odorata*. Ces recherches, encore très peu nombreuses (une dizaine de publications) sont apparues les dernières. Les publications les plus récentes, qui concernent le Congo et la Côte d'Ivoire, montrent clairement les relations entre la progression de *C. odorata* en Afrique tropicale et le système d'agriculture itinérante (de Foresta et Schwartz 1991, de Rouw 1991, Gautier 1992). Ils montrent également qu'en zone forestière les fourrés à *C. odorata* retardent les processus "normaux" de succession mais ne les empêchent pas, et qu'en zone de savane, l'implantation de *C. odorata* favorise la reforestation, confirmant ainsi les études menées en Asie (Eussen & Wirjahardja 1973).

Bien que la littérature scientifique concernant *C. odorata* soit très abondante, il apparaît donc que l'essentiel des publications traite de la lutte contre *C. odorata* en tant que "peste".

Il apparaît également que les chercheurs, dans leur immense majorité, considèrent *C. odorata* comme une peste absolue qu'il faut éradiquer, ou à tout le moins dont il faut réduire drastiquement le pouvoir compétitif.

Tel est le paradigme actuel, dont il faut souligner la force: il est très difficile aux chercheurs commençant des études sur *C. odorata*, ou aux décideurs, d'échapper à son emprise; au Congo, ce n'est qu'après avoir observé que certains paysans avaient développé des méthodes permettant de mettre en culture avec de bons résultats les terrains envahis par *C. odorata* et après avoir disposé des analyses de sol sous friche à *C. odorata* que j'ai pu adopter une vue plus équilibrée des problèmes posés par cette plante. De même, la répartition des fonds et des ressources humaines affectés à la recherche sur *C. odorata* est profondément influencée par ce paradigme, ce qui bien évidemment ne contribue pas à sa remise en question.

Or, pour que ce paradigme reflète une réalité objective, il nous faudrait une documentation substantielle concernant les aspects positifs et négatifs de *C. odorata*, ce dont nous ne disposons pas: bien qu'elle ait été introduite volontairement comme plante de couverture, donc à des fins d'amélioration agricole, l'évaluation des potentialités agronomiques de *C. odorata* brille par son absence; de même, l'évaluation de son impact sur les différents systèmes de culture existants, et notamment sur l'agriculture itinérante, qui constitue encore aujourd'hui le système dominant dans la zone tropicale humide, n'a été qu'ébauchée.

Il semble donc bien que le paradigme actuel ne soit pas le résultat d'une appréciation objective.

Je suggère ici que la formation de ce paradigme résulte d'abord du caractère extrêmement impressionnant de l'expansion de *C. odorata*; devant l'importance de l'invasion, les études se sont orientées, "tout naturellement", vers la recherche de moyens de lutte... Ce paradigme me paraît également résulter d'une approche par trop sectorielle, dominée directement et indirectement par l'agronomie de plantation. Or une telle approche, qui empêche de replacer les problèmes posés par *C. odorata* dans leur contexte global, est manifestement inadaptée à l'ampleur continentale de l'invasion.

Chromolaena en Afrique: Quelles Voies de Recherche?

L'invasion de *C. odorata* en Afrique est sans conteste un bouleversement écologique majeur (Ruf 1992). Ce bouleversement rend obsolètes nombre d'études antérieures, par exemple toutes les synthèses sur l'écologie de la régénération forestière après agriculture itinérante ou celles sur le futur des plantations paysannes (Ruf 1992).

L'invasion de *C. odorata* appelle donc, pour l'ensemble de la zone touchée par l'invasion, une mise à jour des études tant en écologie qu'en économie rurale; d'autre part, la faiblesse de nos connaissances dans ce domaine souligne la nécessité d'une évaluation objective des qualités et défauts de *C. odorata* dans divers types de situation.

Combler les vides majeurs de la littérature scientifique, à travers l'obtention de réponses claires aux grandes questions posées par l'invasion de *C. odorata*, constitue un préalable indispensable à toute prise de décision cohérente concernant sa gestion.

<u>Examinons maintenant quelques-unes de ces questions</u>:

Quel est l'impact social et économique de *C. odorata* en fonction des différents systèmes de culture? Quel serait, globalement et selon les systèmes de culture, l'impact écologique, social et économique des différents types de lutte?

Ces deux grandes questions, qui sont pourtant fondamentales pour l'avenir du monde rural en Afrique tropicale et qui demandent des réponses claires, n'ont à notre connaissance pas encore été abordées. Elles montrent à l'évidence l'importance d'une nouvelle approche des problèmes liés à *C. odorata*, approche globale et par conséquent multidisciplinaire.

Quel est l'impact de *C. odorata* sur le rythme de déforestation? et sur la préservation de la biodiversité forestière?

Malgré l'importance de cette question, nous ne disposons ici que de quelques éléments de réponse. Pour les "petits paysans" des zones forestières, l'envahissement des jachères par *C. odorata* est encore souvent un phénomène neuf; la puissance de la plante est telle que, dans un premier temps, la plupart sont découragés et abandonnent les terrains envahis comme s'ils étaient impropres à la culture. Bien que les paysans adoptent par la suite une perception nettement plus positive des jachères à *C. odorata*, cet abandon initial des terrains envahis constitue l'amorce d'un cercle vicieux qui a pour effet d'augmenter le rythme des défrichements en forêt secondaire ancienne ou en forêt primaire, ce qui à son tour entraîne l'augmentation des surfaces envahies par *C. odorata*, et ainsi de suite.

D'autre part, dans les systèmes d'agriculture itinérante, les jachères à *C. odorata*, très pauvres en espèces, ont remplacé ou sont en train de remplacer très rapidement les jachères arborées classiques dominées par les parasoliers et autres espèces pionnières arborées (de Foresta et Schwartz 1991, de Rouw 1991, Gautier 1992). Ce remplacement entraîne sans nul doute une perte de biodiversité, qu'il faut maintenant apprécier à diverses échelles d'espace et de temps, en la comparant à l'enrichissement dû à la reforestation des savanes qui serait, sous certaines conditions, favorisée par *C. odorata*.

Celà dit, avec le raccourcissement des temps de jachère et avec la remise en culture de toutes les terres forestières précédemment ouvertes par l'agriculture, deux tendances très générales dans la zone intertropicale, la perte en espèces occasionnée par l'envahissement de *C. odorata* ne constitue-t-elle pas en réalité une "simple" accélération d'un processus très général de réduction de la biodiversité forestière sous la pression croissante des activités agricoles, elle-même liée à l'intensification de la pression démographique?

Quelles sont les potentialités agronomiques de *C. odorata* en fonction des différents systèmes de culture? Existe-t-il des pratiques agricoles permettant de bénéficier de ses qualités tout en limitant ses effets négatifs?

Nous l'avons vu, peu d'études ont été menées sur ce thème, pourtant d'une importance cruciale pour l'établissement du statut de *C. odorata* - peste ou plante utile; néanmoins certains aspects positifs de la plante ont pu être mis en évidence:

-*C. odorata* est une excellente plante de couverture, qui assure une protection efficace des sols contre l'érosion, qui restitue au sol une énorme quantité de matière organique, qui améliore la structure du sol, qui sous climat humide, reste verte et ininflammable et garde le sol humide et frais pendant la saison sèche, qui bloque le lessivage des éléments minéraux en limitant les mouvements descendants de l'eau dans le sol (Chevalier 1952, van der Meulen 1977, Audru *et al.* 1988).

-*C. odorata* améliore de manière notable la fertilité minérale et organique des sols peu fertiles (Agbim 1987, Assa 1987, Ivens 1974, Mohan Lal 1960, de Foresta et Schwartz 1991, Herren-Gemmill 1991). Sur sols ferrallitiques désaturés, fortement acides, au Congo, les sols sous jachère à *C. odorata* montrent, par rapport aux sols sous forêt primaire ou secondaire, une augmentation du pH de 1, 5 à 2 points, liée essentiellement à un enrichissement en calcium (de Foresta et Schwartz 1991).

-l'utilisation de *C. odorata* comme engrais vert sur des sols peu fertiles a montré un accroissement substantiel du rendement des cultures, notamment pour le riz irrigué et le manioc (Mohan Lal 1960, Litzenberger & Lip 1961).

C. odorata a montré d'importantes propriétés nématicides, notamment dans les cultures de poivre et de tomate (Litzenberger & Lip 1961).

-enfin, *C. odorata* a montré, tant en Afrique qu'en Asie, ses capacités à contrôler et à finalement supplanter une Graminée envahissante qui pose d'énormes problèmes pour l'agriculture, *Imperata cylindrica*.

Que peuvent apporter les connaissances pratiques développées par les paysans au contact de *C. odorata*?

Les résultats positifs des études agronomiques et des relations entre la fertilité des sols et *C. odorata* se voient confirmés par l'observation paysanne, lorsqu'elle a eu le temps matériel de se développer: en Indonésie occidentale par exemple, où l'invasion de *C. odorata* est déjà ancienne, les paysans apprécient hautement la plante pour ses capacités à lutter contre *I. cylindrica*, et la considèrent comme un signe de fertilité du sol (Dove 1986, de Foresta obs. pers.). Il en est de même dans certaines régions de l'Inde (Mohan Lal 1960), ainsi qu'au Vietnam, au Laos et au Cambodge (G. Michon comm. pers.). En Indonésie orientale, les jachères à *C. odorata* sont également appréciées et ont été intégrées avec profit au système de culture (Field 1991). Au Congo (de Foresta et Schwartz 1991) comme en Côte d'Ivoire (N'guessan et Tié 1986, Gautier 1992, Ruf 1992), et en Centrafrique (Audru *et al.* 1988), certains paysans se trouvant dans l'obligation de mettre en valeur ces formations commencent également à en apprécier l'activité fertilisante.

L'analyse des enquêtes FAO sur *C. odorata* (Huguenin 1993) montre que dans tous les pays africains étudiés (Cameroun, Centrafrique, Côte d'Ivoire, Ghana, Guinée équatoriale, Togo, Bénin, Zaire), la plante est reconnue par les paysans comme permettant le raccourcissement des temps de jachère et la restauration de la fertilité du sol. Il est à noter que l'expérience paysanne vient ici confirmer l'hypothèse théorique d'une utilisation de *C. odorata* en jachère courte dans le cadre d'une agriculture semi-permanente (de Foresta et Schwartz 1991).

Dans tous ces cas, les paysans ont développé, au contact de *C. odorata*, d'importantes pratiques de gestion, pratiques dont le recensement et l'analyse enrichiraient notablement nos connaissances agronomiques et permettraient sans nul doute une meilleure appréciation des potentialités de la plante en fonction des systèmes de culture.

Calamite ou Chance pour l'Afrique

Le titre de cet article, qui a pu choquer certains, est volontairement provocateur. Il est destiné d'abord à amener le lecteur à douter du caractère de "calamité" de *C. odorata*; il est destiné ensuite à favoriser une remise en perspective du statut de la plante, un rééquilibrage dont l'urgence est amplement soulignée par l'ampleur des enjeux tant pour l'environnement que pour les sociétés rurales de la zone intertropicale africaine.

Car il faut bien comprendre que le paradigme actuel (*C. odorata* égale "peste" absolue), associé à l'ampleur géographique de la zone envahie par *C. odorata*, ont pour conséquence directe l'attribution de facto d'un caractère de "calamité" ou de "fléau" -terme employé par le représentant du Ministère Ivoirien de la Recherche- pour désigner l'invasion de *C. odorata* en Afrique.

Or ce paradigme, non seulement ne repose pas sur des bases scientifiques objectives, mais encore se trouve contredit avec force par l'examen des aspects positifs de *C. odorata*.

Permettre la réduction des temps de jachère sans diminution des rendements et sans devoir faire appel à des intrants coûteux, c'est là beaucoup plus qu'une anecdote: c'est une véritable révolution agricole!

Il apparaît donc que *C. odorata* n'est pas une peste absolue. Il s'agit d'une peste dans certaines conditions seulement, dans certains systèmes de culture, dans certaines conditions climatiques... Mais dans d'autres conditions, il s'avère que *C. odorata* peut au contraire être considérée comme une plante utile, et même parfois comme une plante-miracle!

Ce nouveau statut multiple de *C. odorata*, s'il était effectivement reconnu par la communauté scientifique, présente d'importantes implications en ce qui concerne le bien fondé du recours à la lutte biologique: en effet, tant que *C. odorata* est perçue comme une "peste" absolue, cette méthode de lutte est sans nul doute la mieux adaptée, en raison notamment de ses résultats durables et de la suppression de la plante dans toutes les situations. Mais les caractéristiques mêmes qui justifient le recours à cette méthode deviennent inacceptables dès lors que l'on reconnaît le statut multiple de *C. odorata* et donc l'existence de situations variées demandant soit une suppression de la plante en raison de ses aspects négatifs soit au contraire son maintien en raison de ses aspects positifs!

En effet, les agents de lutte biologique ne peuvent pas distinguer les jachères à *C. odorata*, utilisées avec profit par une agriculture semi-permanente, des plantations pérennes où la suppression de la plante serait nécessaire.

Ces mêmes agents biologiques ne peuvent également pas distinguer les pays qui auraient adopté une politique de maintien de *C. odorata* des pays qui auraient au contraire adopté une politique de suppression de la plante.

Enfin, une question fondamentale reste en suspens: quelles sont les végétations qui viendraient remplacer les friches à *C. odorata* si ces dernières venaient à être éliminées? Sur la base d'exemples antérieurs à l'invasion de *C. odorata*, on a de bonnes raisons de penser que l'on assisterait à l'implantation dans les friches d'autres espèces envahissantes telles que les fougères *Pteridium* et *Dicranopteris*, ou encore *Imperata*, toutes espèces provoquant le blocage des successions et dont les effets sur les sols et sur la remise en culture peuvent être qualifiés de désastreux.

En raison des problèmes éthiques et politiques liés aux conséquences d'une suppression de *C. odorata* sans distinction de situations agro-écologiques ni de frontières, le recours à la lutte biologique contre *C. odorata* en Afrique ne devrait donc pas pouvoir être adopté par un pays ou une institution avant qu'un consensus international à l'échelle de la zone intertropicale africaine ait émergé.

Ce consensus doit reposer sur des bases scientifiques solides et ne peut donc à l'heure actuelle être atteint valablement en raison de nos connaissances encore très limitées dans des domaines essentiels tels que l'impact de *C. odorata* sur les rendements agronomiques et économiques des différents systèmes de culture, ou l'impact écologique, social et économique de la plante à l'échelle des communautés, des pays et de la région.

Dans ces différents domaines, il est clair que des recherches doivent être entreprises d'urgence et il faut qu'elles bénéficieht d'un soutien important en termes de finances comme de ressources humaines.

C. odorata, nous l'avons vu, n'est certainement pas une calamité pour l'Afrique Tropicale. Il n'est pas question de sous-estimer les problèmes que pose son invasion, mais, grâce à la transition vers une agriculture semi-permanente qu'elle permettrait, il se pourrait bien que *C. odorata* soit par contre perçue comme une chance par les millions de paysans qui vivent aujourd'hui des produits d'une agriculture itinérante de plus en plus inadaptée.

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Establishment of *Chromolaena odorata* in a Savanna Protected from Fire: an Example from Lamto, Central Côte d'Ivoire.

(Etablissement de *Chromolaena odorata* dans une Savane Protégée du Feu: l'Exemple de Lamto, Côte d'Ivoire Centrale)

L. Gautier
Conservatoire et Jardin Botanique de la Ville de Genève
Chambésy/GE, Switzerland

Résumé- *C. odorata* a un impact significatif sur la mosaïque forêt-savane du centre de la Côte d'Ivoire. Cet impact n'est pas restreint aux forêts degradées. Cet article traite de la transformation de la végétation dans trois parcelles de savanes: une parcelle témoin brûlée, une parcelle non brûlée et une parcelle labourée. Apres trois années d'expérimentation, *C. odorata* s'est établie principalement dans les zones ombragées des parcelles non brûlées et labourées. Ces résultats sont ensuite comparés à une parcelle non brûlée depuis 25 ans afin d'interpréter les processus impliqués dans la colonisation par *C. odorata* des savanes protégées du feu.

Abstract- *Chromolaena odorata* has significant impact on the forest-savanna mosaic of the central Ivory Coast. Its impact is not restricted to depleted forests. This paper addresses the transformation of vegetation in three savanna plots. These include a burned control plot, an unburned plot, and a ploughed plot. After a 3 year experiment, *C. odorata* established mainly in the shaded parts of the unburned and ploughed plots. The results were then compared with a 25 year old unburned savanna to interpret the processes involved in the colonization of savannas protected from fire by *C. odorata*.

Introduction

Chromolaena odorata (L.) R.M. King and H. Robinson (*Eupatorium odoratum* L.), is an important tropical weed which has spread widely in the last 150 years (Gautier 1992a). The species probably arrived in Cote d'Ivoire around 1950. It was first seen in Eloka, in the southeastern part of the country, by Professor Miege in 1952 (Delabarre 1977).

The species is known to invade clearings in forests as well as perennial plantations. However, it is not restricted to the rainforest zone. So far, *C. odorata* has also been recorded from the northeastern part of the country in the southern Sudan savannas, near the border of Burkina-Faso (Zebeyou pers. comm.)

In the forest-savanna mosaic in central Côte d'Ivoire, *C. odorata* was first recorded at Lamto in 1971, in a savanna that had been protected from fire since 1962 (Vuattoux 1976). The plant has since completely invaded the protected savanna, forming a dense thicket up to 2 m high in places not shaded by trees. It is also frequently found in the forest margins facing yearly burned savannas and in the fallows of traditional shifting cultivation of neighboring villages.

This paper, partly extracted from a doctoral thesis on the ecology of the species in central Côte d'Ivoire (Gautier 1992b) addresses the establishment of *C. odorata* in savannas protected from fire.

The Study area

This study was carried out in the Lamto reserve, 6°13'N, 5°02'W, south of V-baoulé in central Côte d'Ivoire (Fig. 1). The climate in this area is transitional equatorial, with a mean yearly temperature of 27°.6C, and a mean annual rainfall of ca. 1200 mm. The main dry season extends from mid-November to mid-February; a second dry season occurs around August. The basal rock is mainly made of Precambrian granites. According to Perraud (1971), soils in the area are mainly young ferruginous soils with little leaching or reshaped modal to improved ferralitic types.

Vegetation of the Lamto reserve is a forest-savanna mosaic. According to Swaine *et al.* (1976), the mosaic is of the "savanna interfluve type", with gallery forests fringing the streams. In the northern part of the reserve, an interfluve has been colonized by a dense semi-deciduous forest.

The savannas are physiognomically characterized by the palm tree, *Borassus aethiopum*. At the bottom of slopes and in places with shallow soils, these savannas have a very low woody cover. These areas are dominated by *Loudetia simplex*. On well-drained sites, the savanna is dominated by various species of Andropogoneae (*Hyparrhenia* spp. and *Andropogon* spp.) (Roland & Heydacker 1963). The woody cover of these drained savannas increases upslope, from shrub to wooded savanna (Bonvallot *et al.* 1970).

Afforestation nuclei consisting of fire-sensitive species appear at the top of slopes where savanna tree cover is maximum (Devineau 1984, Gautier 1989). In general, despite annual fires, the equilibrium between forest and savanna is shifting towards forest in the V-baoulé (Spichiger 1975, Spichiger & Pamard 1973, Gautier 1990).

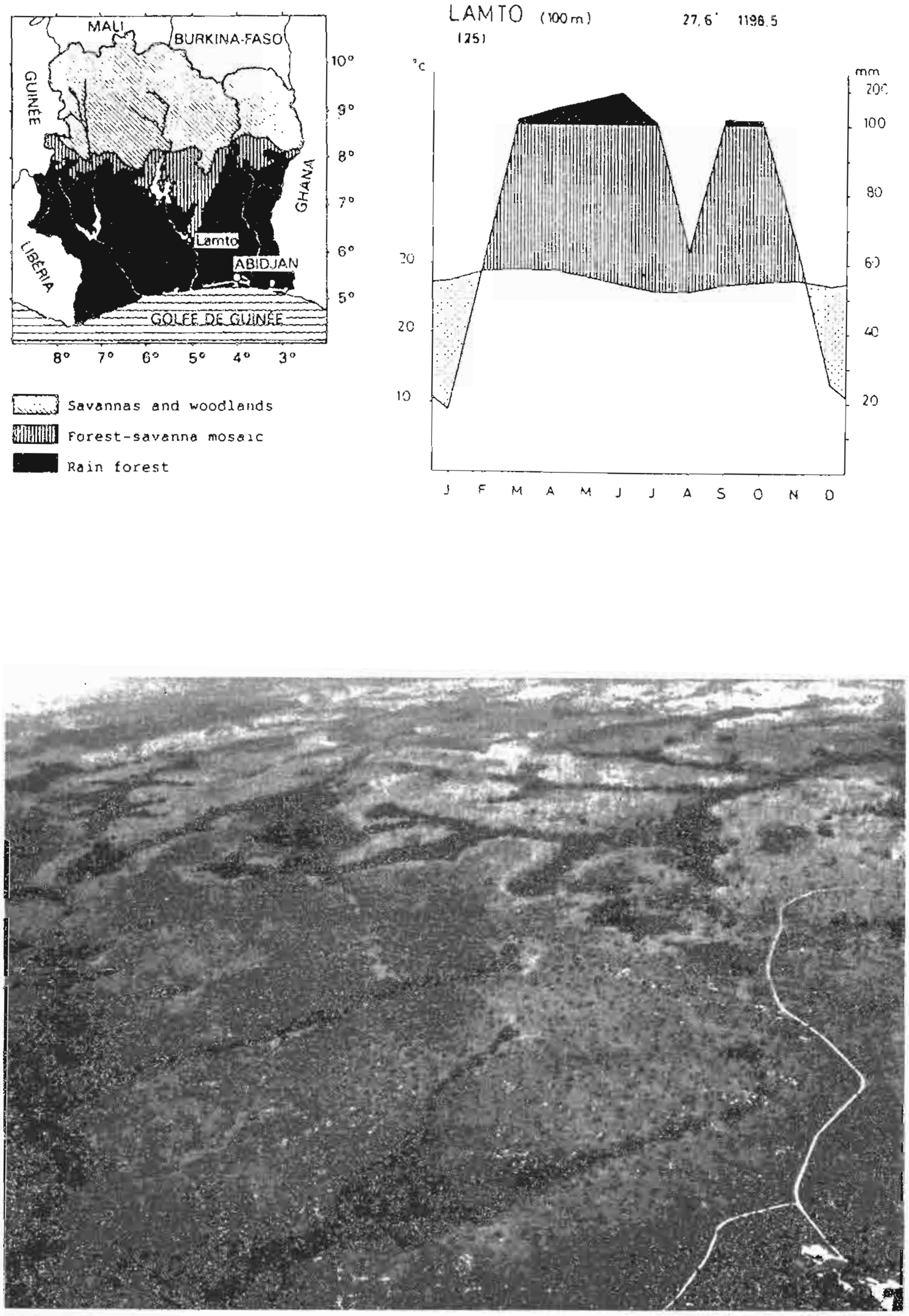

Figure 1. The Lamto Reserve: location, climatic diagram and aerial view of the vegetation.

Experimental Design

In December 1985, one hectare of savanna was protected from annual fires near the gallery forest of "Marigot Salé" in Lamto. A strip on the northern side of the protected plot was hand ploughed in April 1986. After ploughing, this plot was also protected from fire. Thus the three treatments were:

1) Savanna burned annually (outside the protected plot);
2) Savanna protected from fires since the end of 1985;
3) Savanna ploughed in April 1986, and protected from fires.

Within each treatment, ten 20 m^2 permanent circular samples were randomly chosen and marked. Five of these samples were selected from an open facies with almost no savanna shrub shading, and another five samples were selected from areas with a considerable shrub cover.

To assess vegetation changes, floristic relevés were made in November of each year, for 3 years. The volume sampled was separated vertically into 4 strata: 0-2 m; 2-5 m; 5-10 m; and >10 m. The cover of each species was estimated in each stratum using the Braun-Blanquet (1967) cover scale.

The establishment of *C. odorata* was monitored once every 2 months during the first year and half, and then 3 more times during the next year and half. Since the cover scale was not fine enough to assess the evolution of *C. odorata*, its above ground biomass was looked at using a non-destructive method. Each plant was registered and categorized according to the number of its leaves (for plants <20 cm) and its height (for plants >20 cm). For plants which had rooted outside the sample, only the length of the twig occurring inside the sample was estimated. In dense thickets, the volume was estimated. Using standard values for each class, length and volume totals were then converted to above ground biomass. These values were obtained from harvests made outside the plots and weighed 24 hours after drying at 95°C. The results are presented in Figures 2, 3 and 5.

The lines on Figures 2, 3 and 5 represent the aboveground biomass of *C. odorata,* and the group of three bars represents covers of other species. The hollow part of the bars corresponds to the total cover of savanna species, and the hatched part corresponds to the total cover of forest species. To compare the biomass of *C. odorata* with cover values of other species, the scale of biomass was based on a square root value of 1600 g/m^2 corresponding to 150% of cover.

Results

Savanna burned annually (Fig. 2).

By May 1989 when the experiment ended, only a few seedlings of *C. odorata* were recorded in the open facies. This biomass was negligible with the total equaling just over a hundred or ca.1 per square meter. These seedlings were destroyed during a fire early in the following year. All others recorded are savanna species which have a steady high cover in the lower stratum and low cover in the higher stratum.

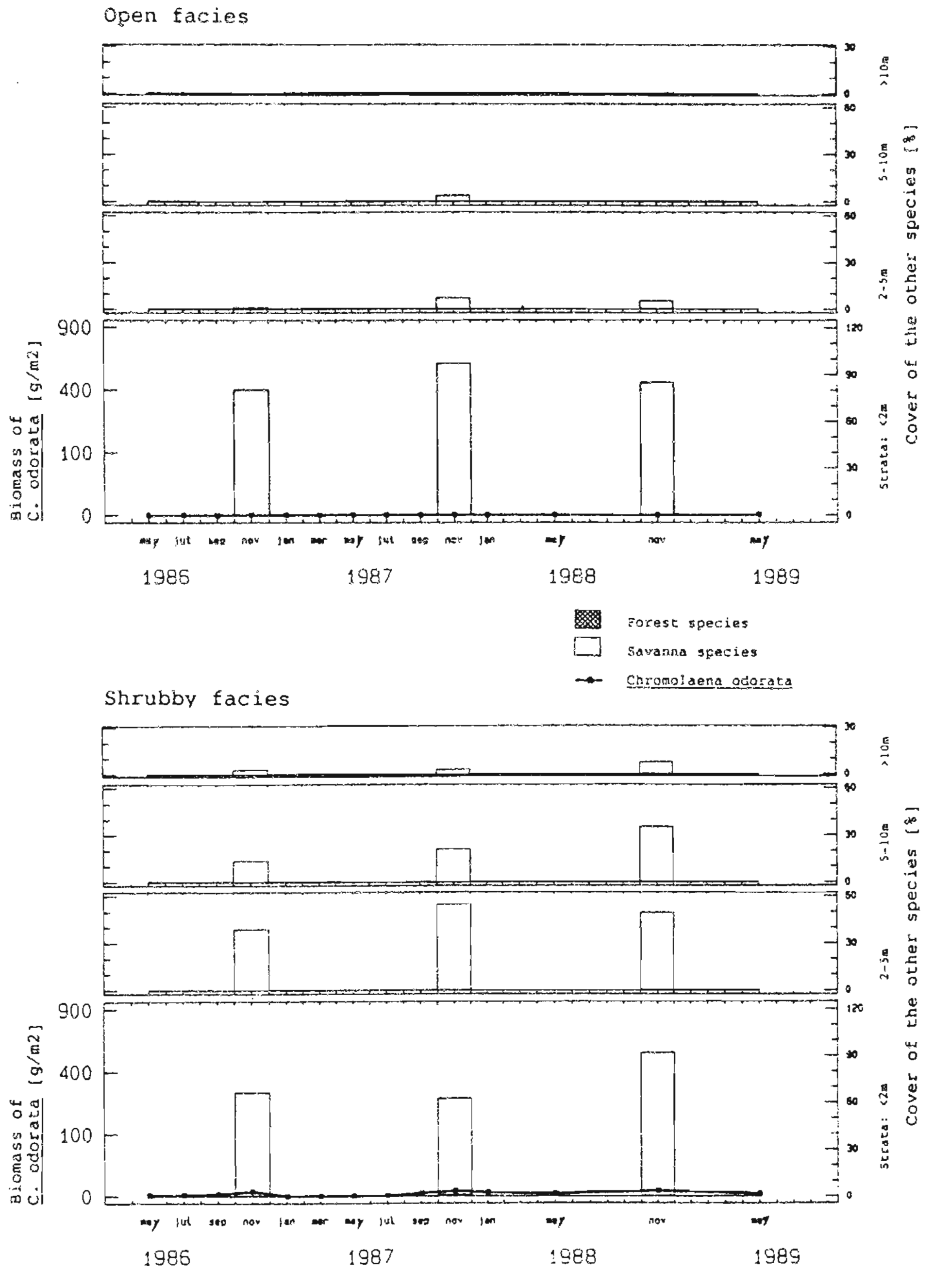

Figure 2. Establishment of *Chromolaena odorata* in the annually burned plot.

In shrubby facies, the above ground biomass of *C. odorata* at the end of each year is systematically higher. Nevertheless, these plants are destroyed by next year's fire. Only one plant survived the fire of January 1988, but was destroyed a year later. The others are almost exclusively savanna species, except for a seedling of forest liana noted in 1988, which was later destroyed by fire. As a consequence of higher values in the higher strata, the overall cover of the lower stratum is lower than in the open facies.

Savanna protected from fire (Fig. 3)

Results in the open facies are similar to the preceding treatment. Fig. 3 graphs the time period 17 months after the last occurrence of fire. The establishment of *C. odorata* during the first half of the experiment was very low. Up until the end of 1987, there was a slight increase in biomass; this dropped by May 1989. This increase was the result of twigs from an individual plant established outside one of the plots. In general, however, *C. odorata* does not establish in open savannas during the first year of protection. The cover of other plants is due exclusively to savanna species. The 2-5 m stratum continuously increased its cover.

Results of the shrubby facies differ markedly from all others. Establishment of *C. odorata* is very clear in this facies (Fig. 4). The biomass increased regularly, reaching the highest values of the entire experiment by May 1989. Also, at the end of the experiment there was a noticeable establishment of forest species which reach the 2-5 m stratum. The species are listed in Table 1, in chronological order of appearance (unless author names are given, nomenclature follows Hutchinson & Dalziel 1954-1972):

The cover of savanna species in the lower stratum was steady for the first two years, dropping markedly afterwards.

Savanna Ploughed and Protected from Fire (Fig. 5)

Figure 5 charts the time period 5 months after the last occurrence of fire, i.e. 2 months after the ploughing. In the open facies, above ground biomass of *C. odorata* follows a regular increase. There are fewer plants involved, but these reach a considerable size by the end of the experiment.

With reference to other plants, most savanna species at the first relevé (8 months after the ploughing) had reestablished, but had much lower values than in the burned plot. High values in the lower strata can be attributed to *Imperata cylindrica*, a savanna species whose secondary behavior is well known. The deep rhizome of *I. cylindrica* allows its survival under the superficial ploughing used in this region. *I. cylindrica* is highly competitive and quickly establishes wherever space is not a limiting factor. Following ploughing, establishment of *C. odorata* during the first year was difficult under these conditions but a few remaining seedlings established rapidly growing above *I. cylindrica* (Fig. 6). If fires can be controlled, *C. odorata* will out-compete *I. cylindrica* even if its cover does not reduce in the first 3 years. If on the other hand, fires are allowed in the plot, *I. cylindrica* will be favored. It is interesting to note that forest species are negligible in the beginning probably because of the bare soil conditions. Later, the establishment of forest species is probably further hampered by the fierce competition between the two weeds.

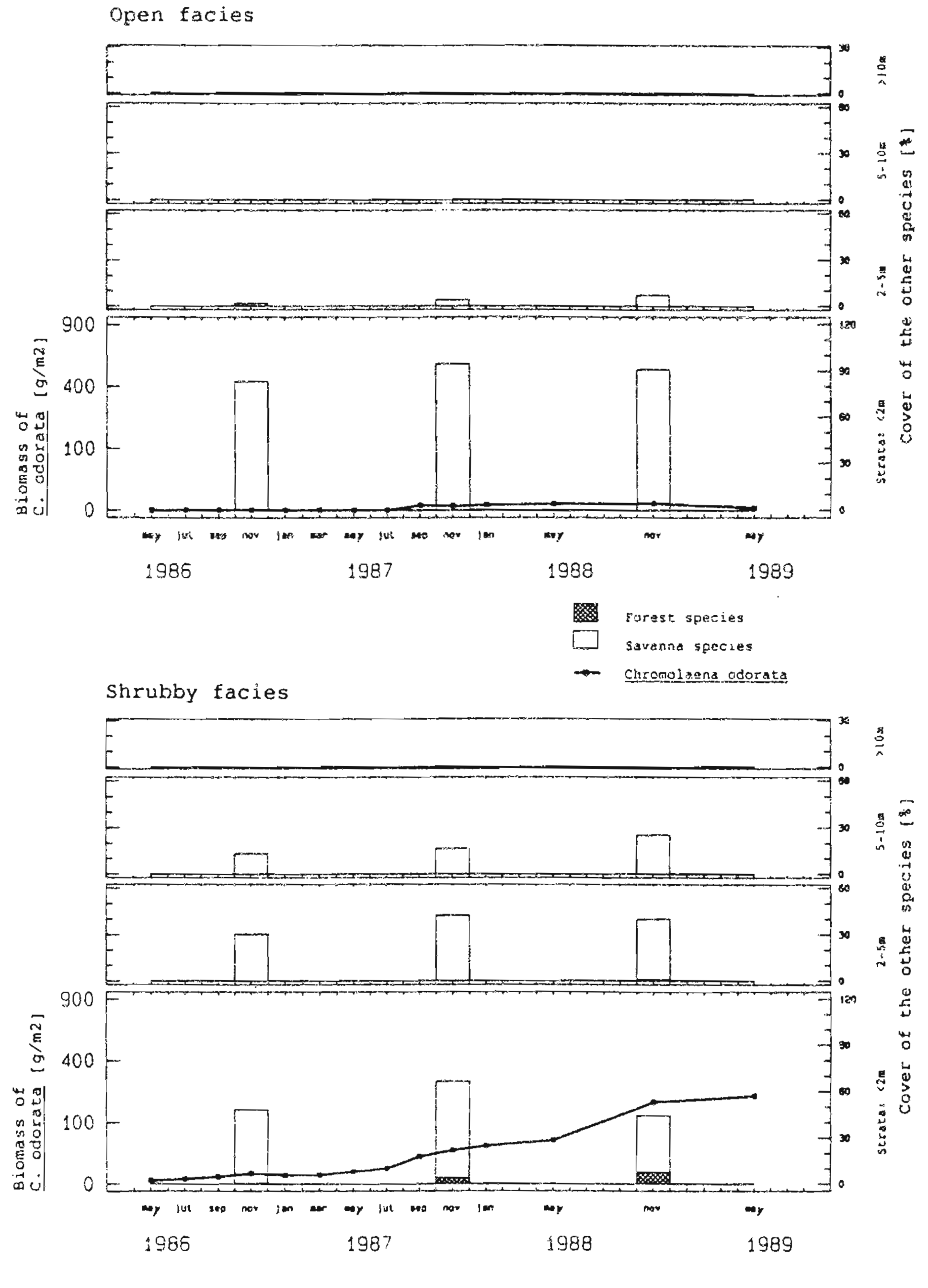

Figure 3. Establishment of *Chromolaena odorata* in the plot protected from fire.

Figure 4. Invasion of *Chromolaena odorata* in the shrubby facies of the protected plot. The photo was taken in December 1988, after 3 years of protection.

Table 1. List of Forest species established in the shrubby facies in the Savanna protected from fire.

Paullinia pinnata
Lonchocarpus sericeus
Holarrhena floribunda
Adenia cissampeloides
Uvaria ovata
Afzelia africana
Cynometra megallophylla
Chionanthus sp. (=*Linociera* sp.)
Erythroxylum emarginatum
Canthium hispidum
Ceiba pentandra
Milicia excelsa (Welw.) C. C. Berg (=*Chlorophora excelsa*)
Pouteria altissima (A. Chev.) Baehni (=*Aningeria altissima*)
Antiaris toxicaria Leschen. (=*Antiaris africana*)
Ficus natalensis Hochst.(=*F. leprieuri*)

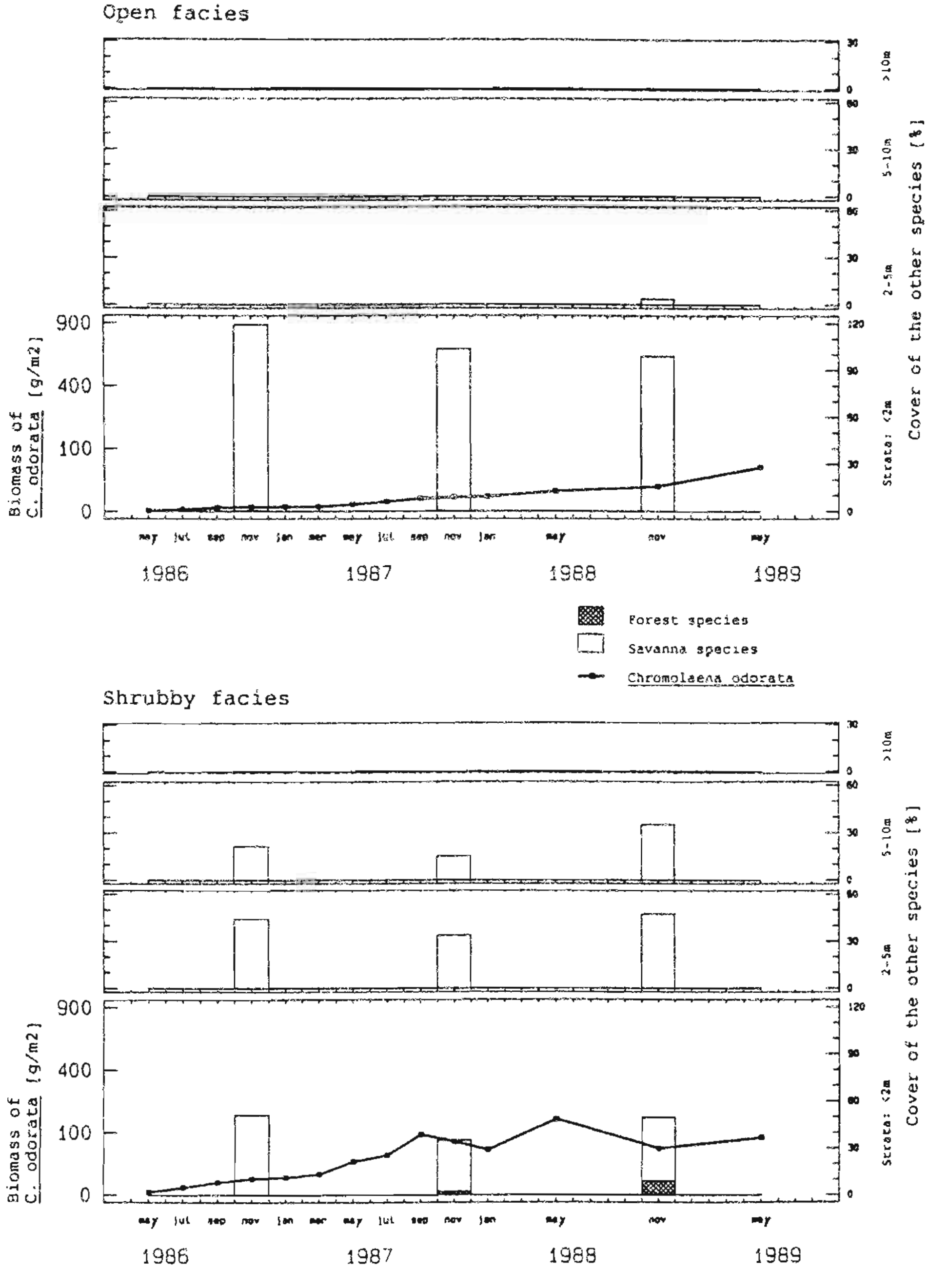

Figure 5. Establishment of *Chromolaena odorata* in the ploughed plot.

Figure 6. Open facies of the ploughed plot. A few individuals of *Chromolaena odorata* already overtop *Imperata cylindrica*. The photo was taken in October 1987, 18 months after the ploughing.

In the shrubby facies, *C. odorata* is well established. Its biomass increases similar to comparable slopes of the shrubby facies in the protected plot. Figure 5 shows earlier establishment of *C. odorata* since it begins 5 months after the last fire, instead of 17 months as in the non-ploughed protected plot. The aboveground biomass seems to stabilize at a lower value by the end of the experiment. As in the non-ploughed protected plot, forest species settle under savanna shrubs. The forest species include those previously identified along with *Margaritaria discoidea* (Baillon) Webster (*Phyllanthus discoideus*), *Millettia zechiana*, and *Allophylus africanus*.

Additional observations

After the last relevés in May 1989, the plots were abandoned and firebreaks were not made at the end of that year. In January 1990, five years after the last occurrence of fire, over two-thirds of the protected plot was invaded by a thicket of *C. odorata*.

In January 1990, a fire from the north impacted the ploughed plot first. The open facies burned because there was enough dry necromass of *I. cylindrica* to set *C. odorata* on fire. In the previously protected plot, the fire burned the open facies not invaded by the weed.

In the shrubby facies of both treatments a dense *C. odorata* thicket was established. Because the thicket was still green when the fire occurred, it prevented the facies from being burned. These parts of the plots have not burned in the following three annual fires.

Discussion

In annually burned savanna, seedlings of *C. odorata* often try to establish during the growing season, especially under the shrub cover. These attempts however, often fail due to fires in the following dry season. This confirms the observation made in Natal by Macdonald & Frame (1988) that savannas burned regularly are less likely to be invaded by alien species, including *C. odorata*.

Nevertheless, individual plants can survive the fire, especially where grass biomass is low or if the fire is weakened by climatic conditions. If so, the plant builds an underground storage organ sufficient to ensure its resprouting after the next fires. This explains establishment of *C. odorata* thickets elsewhere in the unprotected parts of Lamto reserve, where savanna tree cover is very high.

Fire protection favors the establishment of *C. odorata* in savanna. In this experiment, *C. odorata* established mainly in the shrubby facies. As with annually burned savanna, it seems that a less dense lower stratum favors settlement of the light anemochorous cypsella of the species, as well as growth of its seedlings. In protected savanna, presence of the previous year's necromass might also delay establishment of seedlings in the open facies.

The appearance of forest species in the protected plot is an important phenomenon. Based on this experiment, it is difficult to determine if this appearance parallels the establishment of *C. odorata* in an independent manner, or if seedlings of forest species find a more suitable micro-environment under *C. odorata* as opposed to a herbaceous lower stratum.

In the third treatment, ploughing reduced the dominant tussock savanna Poaceae which seems to facilitate establishment of *C. odorata* in open facies. Even with a heavy increase of *I. cylindrica* cover, there is sufficient space between the culms to allow *C. odorata* to settle. In shrubby facies, establishment of *C. odorata* is accelerated, but its growth is reduced after two years.

Observations made in the protected plot during the three years following the last relevé indicate shrubby facies are sheltered from fire by the *C. odorata* thicket. However, after an especially dry year (4 years rainfall totaling less than 1000 mm in the 28 years recorded at the station), established thickets of *C. odorata* may still burn, destroying the established forest species.

The evolution of savannas protected from fire in this region can be deduced from observations made in a neighboring 60 ha savanna, protected from fire since the Lamto Reserve was established in 1962. Several papers describe this evolution (Vuattoux 1970;1976, Devineau *et al.* 1984) focusing on woody vegetation by relying on observations made partly before *C. odorata* became so important. In summary, there is an increase in size and frequency of savanna shrubs and trees in the first phase. In the second phase, there is establishment of pioneer forest species. The third phase is a decline of savanna species as a result of increased size of forest species, and subsequent transformations of micro-climatic conditions.

Succession initiated by protection against the savanna fires is an example of the "Facilitation Model" (Connell & Slatyer 1977), with each step favoring establishment of the next phase. An increase in savanna shrub cover facilitates establishment of forest species. Under their cover, forest seedlings find a suitable environment for establishment

The protected savanna of Lamto was a mosaic of these various phases when *C. odorata* began to settle. The area surrounded by gallery forests, south of the protected savanna, was ahead in succession with physiognomy of a young secondary forest. Elsewhere, the woody cover was still low. A few scattered spots of vegetation still looked like a savanna, especially in water-logged and alkaline "black" soils.

A recent study on the protected savanna of Lamto by Valkeman (1985), takes into account the importance of *C. odorata* in succession. According to Valkeman, *C. odorata* does not establish firmly in closed canopies and young developed forests due to lack of light. Only a few weak individuals develop. These will not have any influence on succession and will soon be out-competed. In places with open or no canopy, the weed invades massively except for a few spots on water-logged soils. Valkeman (1985) infers growth of *C. odorata* alters the succession scheme by causing a blockage. This blockage can intervene at an early stage when only savanna species occupy the upper strata, not obscuring the lower strata. Blockage can also intervene at a later stage when forest trees establish and start to eliminate savanna trees and shrubs. The open space and light available when a savanna tree dies can be colonized by *C. odorata*. The present study also found succession is slowed and young forest trees have difficulty reaching light through the dense canopy. Lower levels of forest species were measured regenerating under *C. odorata* thickets, than in established groves where the weed is absent. The observations validate Valkeman's findings in the parts of protected savanna not yet colonized by forest species.

Valkeman (1985) questions of the future of areas infested with *C. odorata*. In his view, reducing light is essential for weakening the weed to allow for succession. It is possible that light reduction can result from a forest tree that grows through the thicket; however, light reduction is more likely to occur gradually from the borders of neighboring forests or groves. The "Inhibition Model" (Connell & Slatyer 1977) should be considered if *C. odorata* is present in the succession because this stage hampers the development of the next one.

Conclusions

Savannas protected from fire are first colonized by *C. odorata*. The higher the woody cover of savannas, the quicker colonization occurs. The lower the woody cover, the denser *C. odorata* thickets will be.

In shrubby savannas, forest seedlings appear after rapid invasion by a relatively sparse thicket of *C. odorata*. These slowly form a grove, extending and further shading the neighboring thicket, making it more vulnerable the growth of young forest trees.

In open savannas, the density of herbaceous species slows the establishment of *C.odorata* and forest species. Following this slow period, the weed establishes forming a very dense thicket. The establishment of forest species is severely hampered. Further evolution of the vegetation will take a long time if it only occurs inside the system. Evolution is more likely to occur through a riverine progression from neighboring forests or groves. The mechanisms of such a spatial evolution will be discussed in a future paper on the role of *C. odorata* in the dynamics of forest edges.

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The Use of *Chromolaena odorata* as Fallow in a Semi-Permanent Cropping System in South-West Côte d'Ivoire.

(L'Utilisation de *Chromolaena odorata* comme Jachère dans un Système Cultural Semi-Permanent du Sud-Ouest de la Côte d'Ivoire)

J.J. P. Slaats
Department of Agronomy, Wageningen Agricultural University
Wageningen, The Netherlands

Résumé- Après avoir été ouverte à l'exploitation forestière, la région de Taï dans le Sud-Ouest de la Côte d'Ivoire a été envahie par *Chromolaena odorata*, ce qui a entrainé une perturbation majeure du système traditionnel d'agriculture itinérante. Cette espèce domine actuellement la végétation pendant les premières années des jachères. Les paysans de la région de Taï ont commencé à utiliser les jachères à *C. odorata* pour cultiver du mais. L'Université d'Agriculture de Wageningen est en train d'évaluer le potentiel des peuplements naturels de *C. odorata* comme jachère dans les systèmes de culture semi-permanents. Cette étude traite de la croissance et du développement des jachères à *C. odorata*, de leur gestion en vue de cultures ultérieures, et de leur développement pendant et après la période de culture. *C. odorata* paraît dominer la végétation des jachères pendant les cinq premières années. A partir de la deuxième année, les graminées et les herbacées surcimées disparaissent. Les rendements agricoles augmentent et la concurrence des plantes non-cultivées se réduit après une période de jachère de trois ans. Le feu et le sarclage ralentissent le développement de *C. odorata* pendant la culture, tandis que sa régénération pendant la période de jachère suivante est réduite par un sarclage fréquent et par de longues périodes de culture. L'utilisation de *C. odorata* comme jachère dans un système de culture semi-permanent, permettant une intensification de l'agriculture itinérante, offre d'intéressantes perspectives. De plus un tel système ne nécessite que de faibles niveaux d'intrants. Celà dit, des périodes de culture prolongées et un sarclage intensif constitueraient une menace pour la pérennité de ce systeme.

Abstract-*Chromolaena odorata* invaded the Taï region in Southwest Côte d'Ivoire after the area opened up for timber production, leading to a subsequent breakdown of the traditional shifting cultivation system. This species presently dominates vegetation during early stages of the fallow period. Farmers in the Taï area have started to use *C. odorata* fallow land for maize cropping. Wageningen Agricultural University is doing a comprehensive evaluation on using natural stands of *C. odorata* as fallow in a semi-permanent cropping system. This study comprises the growth and development of *C. odorata* fallow vegetation, its management for subsequent crop production, and its development during and after the cropping period. *C. odorata* appeared to dominate fallow vegetation during the first five years. Grasses and herbs in the understory disappeared from the second year onwards. Consequently, crop yields were higher and competition of non-crop plants was reduced after a three year fallow period. Burning and weeding slowed the development of *C.odorata* during cropping, while regeneration in the subsequent fallow period was mainly reduced by frequent weeding and long cropping periods. The use of *C. odorata* as fallow in a semi-permanent cropping system has good prospects since it is more intensive use of land than shifting cultivation. It also requires low external input to agriculture. Prolonged cropping and intensive weeding, however, threaten the continuity of this system.

Introduction

The use of *Chromolaena odorata* as fallow in a semi-permanent cropping system was studied in the Taï region, Southwest Côte d'Ivoire. This region of the lowlands is located at 5°N, and has a humid tropical climate of the Köppen Aw-type. Rainfall is distributed bimodally with an annual mean of 1800 mm; mean temperature is around 26°C with very little diurnal and yearly variation. Cropping seasons run from April to June, and from July to November. In the past, this region was covered by evergreen rain forests and was sparsely populated. The inhabitants practiced a shifting cultivation system for food crop production. About 30 years ago the region was opened for timber extraction. This was followed by forest clearing for perennial cash crops. After a massive influx of immigrants, large parts of the forest were transformed into tree crop plantations. The remaining areas of forested land diminished rapidly. Consequently, fallow periods on these lands were shortened and cropping periods were prolonged.

Since its introduction to the eastern part of Côte d'Ivoire in the early fifties, *C. odorata* has spread in northern and western directions (Delabarre 1977, Gautier 1992). Due to geographical isolation and high forest cover, this species was not seen in the Taï region until the early eighties. Its invasion has been successful due to disturbance of the natural vegetation as a result of the timber industry and breakdown of the shifting cultivation system (de Rouw 1991). At present, *C. odorata* is found in areas where forests have been cleared, particularly in frequently cropped fields around the villages. In these areas, *C. odorata* dominates the early stages of succession.

Original inhabitants of the Taï region who still own forested land consider *C. odorata* a nuisance because it delays regeneration of the forest. On the other hand, immigrants who possess little forest land have started to use *C. odorata* fallow land for maize cropping. A system is now developing where a two-four year fallow is alternated with one year of maize growing (Slaats 1992).

As part of the research program "Analysis and Design of Land-use systems in Taï, Southwest Côte d'Ivoire", Wageningen Agricultural University is doing a comprehensive evaluation using natural stands of *C. odorata* as fallow in a semi-permanent cropping system. This study comprises the growth and development of *C. odorata* fallow vegetation, its management for subsequent crop production, methods to improve crop yields, and its development during and after cropping periods. Arguments in favor of using *C. odorata* as fallow include its wide distribution and adaptation to ecological conditions of the humid tropics, as well as its role in the successional process of forest regrowth. Eradication of *C. odorata*, an alternative management option, is not economically feasible. If *C.odorata* is eradicated, grasses are likely to dominate early vegetation stages of the fallow period. Generally, grasses are considered an unfavorable fallow crop. Moreover, *C. odorata* is able to suppress undergrowth of herbs and grasses within a short time, and has a rather high biomass production which can store large amounts of nutrients. This paper presents the major findings of research on management aspects of *C. odorata* use as fallow in semi-permanent food production.

Growth and development of *C. odorata* fallow

Growth and development of *C. odorata* fallow was studied on farmers' fields that had zero to five year old fallow vegetation. Observations were made on biomass, plant density and composition of fallow vegetation during the growing period.

Results show that *C. odorata* is the major weed species during the cropping season. It establishes from both stump sprouts and seedlings. Four months after harvesting, fallow vegetation covered 90% of the soil, with a biomass of 4.3 tons/ha, of which 70% was *C. odorata*. In subsequent years, the fallow vegetation developed into a 3 meter high thicket, made up of a dense mass of tangled, half-woody *C. odorata* branches. Beginning the second fallow year, the undergrowth of grasses and herbs had already disappeared. During development of the fallow vegetation, density of *C. odorata* plants fell from about 150 at 4 months after crop harvest, to 1 plant/m^2 in the 5 year old fallow vegetation.

The dominant position of *C. odorata* in development of fallow vegetation is reflected in biomass changes over time (Fig. 1). From the beginning to the fifth year of fallow, *C.*

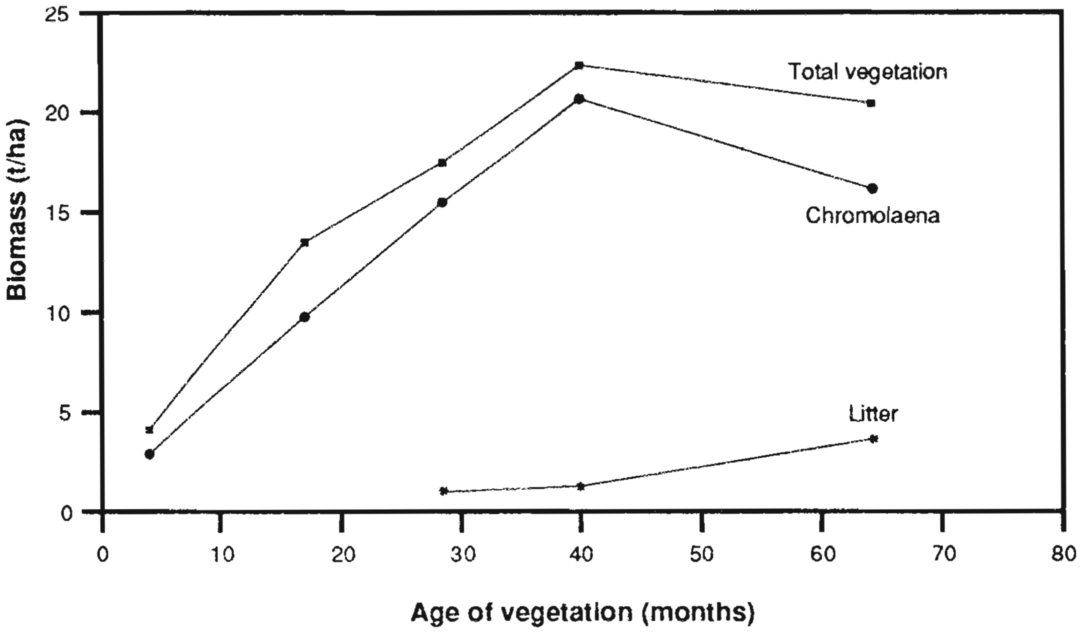

Figure 1. Development of *Chromolaena odorata* fallow over a 80 month period.

odorata was the main component of vegetation biomass. By the third year of fallow, total vegetation reached a maximum biomass production of 22.3 t/ha, and *C. odorata* reached a maximum of 20.8 t/ha. In older vegetation, biomass production decreased as did the proportion of *C. odorata* in the total biomass. However, the amount of litter increased rapidly. These changes indicate the vegetation is dying back. On 5 year old fallow fields, *C. odorata* canopies started to disintegrate, allowing shoots of tree stumps to pierce through. It is assumed *C. odorata* will gradually disappear in subsequent years as a result of this tree shading.

Crop production subsequent to a *C. odorata* fallow

Crop production on *C. odorata* fallows was studied in several field experiments. This paper highlights effects of the length of fallow on subsequent crop production. For the first three seasons, this effect was studied in three cleared fields, differing in ages of fallow vegetation from 2 to 4 years. The experimental design combined two frequencies of weeding (one versus two weedings per cropping season), and three levels of fertilizer application (no fertilizer, P, P and N) in each field. The test crop was a hybrid maize. Effects of the length of fallow and weeding frequency on crop yields during the first and third season are presented in Figure 2. Yield figures are averaged for all fertilizer treatments. Results of the

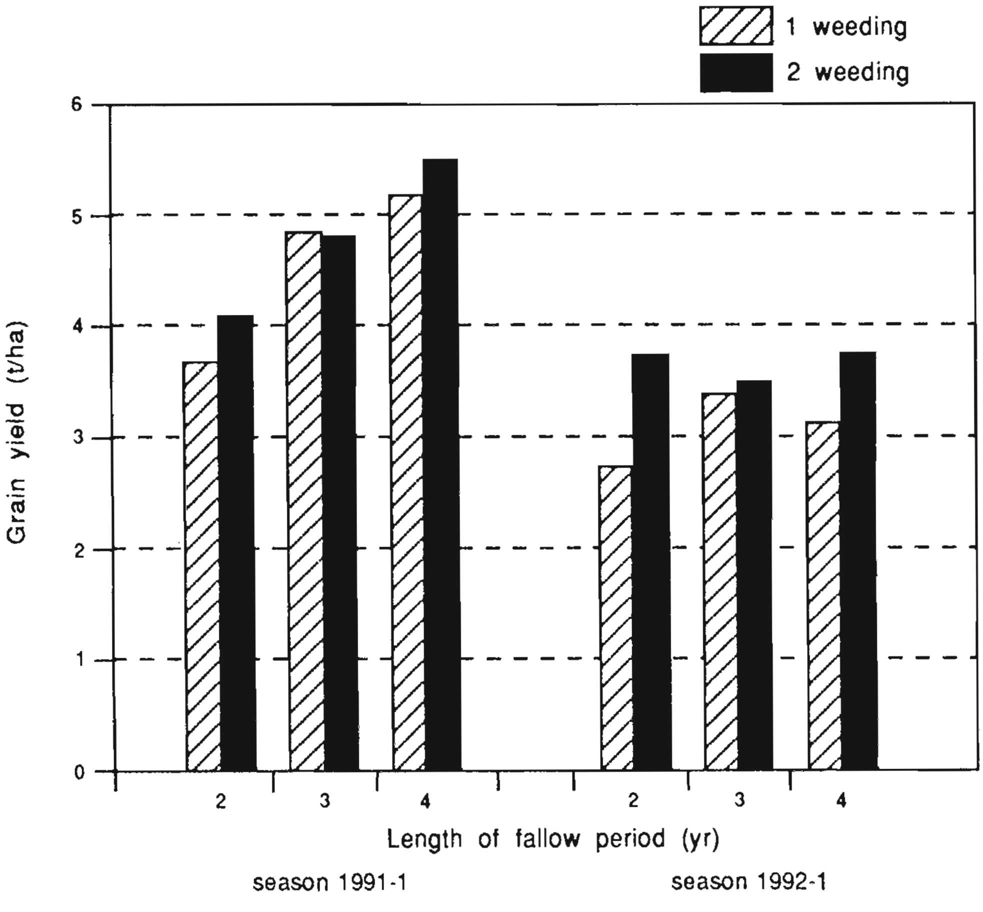

Figure 2. Effects of length of fallow and weeding frequency on crop yield during two seasons.

second season are not given since they are very similar to the third season. In the first season, crop yields were higher when the preceding fallow period was longer. In the third season, yield levels were almost the same in all three fields, having fallen to lower levels than the first season's yield levels. On the 2 year old field, a second weeding resulted in significantly higher yields during both seasons. On the 3 and 4 year old fields, weeding twice did not significantly raise crop yield. Responses to fertilizer application were highly significant on all fields during the three seasons.

The research findings indicate that a longer fallow period results in long term reduction of weed competition and short term yield increase. The benefits were highest when the fallow period was prolonged from 2 to 3 years. By giving N and P fertilizers at a rate of 100 kg N/ha and 25 kg P/ha, the yield level was almost doubled.

Development of *C. odorata* during cropping

After the C. *odorata* fallow vegetation has been cleared, the plant re-establishes rapidly by sprouting stumps and emerging seedlings. Hence, it may become a weed during cropping. This dual role of *C. odorata*, the main component of the fallow vegetation and weed, was the reason for studying the effects of clearing methods and weeding on the re-establishment of the plant during cropping. Clearing methods used were removing of slashed fallow vegetation or burning at two intensities. For low burning intensity the standing vegetation was burnt in situ after slashing. At the high burning intensity, the amount of slashed vegetation was doubled by adding vegetation from the outside and then burning. Weeding was done by scraping the top soil and clipping sprouts of stumps with a short hoe at 4 weeks after clearing. Observations were made on the number, spread and soil cover of *C. odorata* sprouts and seedlings.

Sprout development was reduced more when slashed vegetation was burnt as opposed to when it was removed. By burning, parts of the stumps were killed while sprouting was delayed on living stumps; this resulted in a lower number of sprouts per surface unit and in poor soil covers. After weeding, sprout development was no longer affected by the method of clearing. Soil cover and sprout numbers were similar using either clearing method, primarily because weeding resulted in fewer stumps due to unintentional uprooting. Seedling development was rather slow at the start of the cropping season for all clearing methods. Burning had reduced the number and cover of seedlings, before as well as after weeding.

Both clearing methods led to a slow seedling development at the start of the cropping season. These results indicate that *C. odorata* sprouts have a higher potential than seedlings to compete with crop plants, and that sprout development was restricted by burning and hoe weeding.

Re-establishment of *C. odorata* after cropping

Research on the re-establishment of *C. odorata* after cropping has focused on the effects of management practices. These effects were studied by following the regrowth of fallow vegetation subsequent to cropping on former experimental fields. The fields differed in length of cropping and fallow periods, and in clearing methods used prior to cropping.

Within each field, there were two levels of weeding frequency: 1 or 2 weedings per season, and 3 levels of fertilizer application (no fertilizer, P, P and N). One to two months after harvest, the cover of several components of the soil cover of fallow vegetation were recorded. After four months, their biomass was quantified.

The re-establishment of *C. odorata* is reduced by frequent weeding during cropping, and by a prolonged cropping period. In Figure 3, the biomass of both sprouts and seedlings for two weeding frequencies is given. The data were gathered from a field with a 2 year old fallow, where three maize crops had been grown prior to these observations. Figure 3 indicates that weeding twice reduced the biomass of sprouts, but hardly affected seedlings. In Figure 4, the biomass of both sprouts and seedlings from 3 different fields is presented. The data refer to plots which have been weeded once per season during the cropping period. The figure shows that both sprout and seedling biomass were reduced by prolonged cropping. Both figures clearly illustrate that intensive management of cropping systems on *C. odorata* fallows slow down the re-establishment of this fallow type.

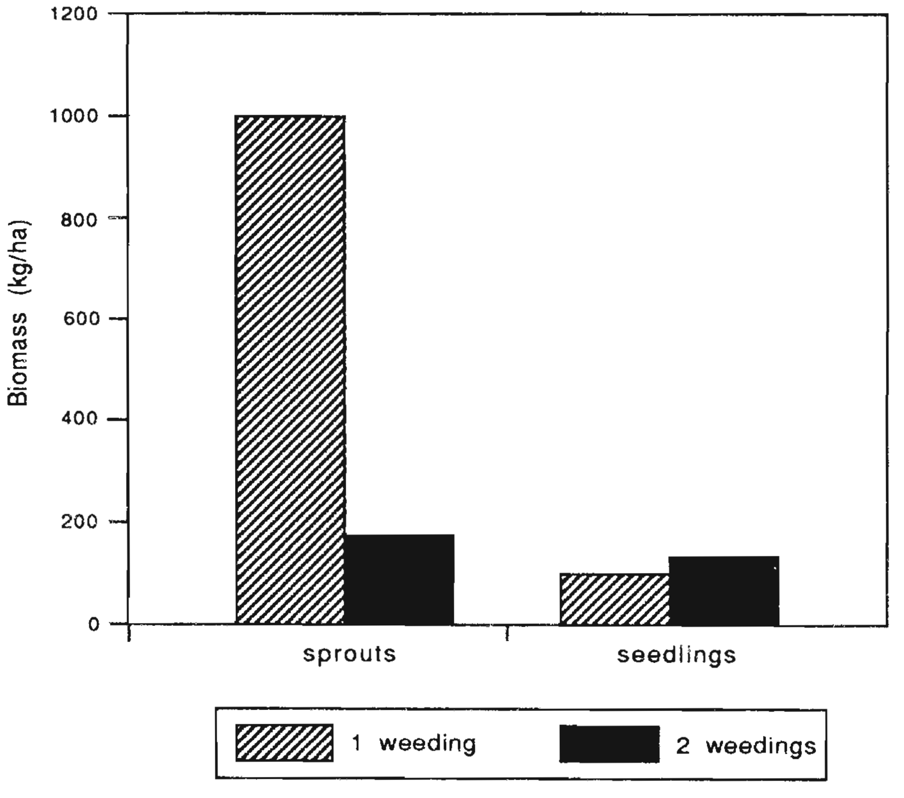

Figure3. Effects of weeding frequency during cropping on regrowth of *Chromolaena odorata* in the subsequent fallow period.

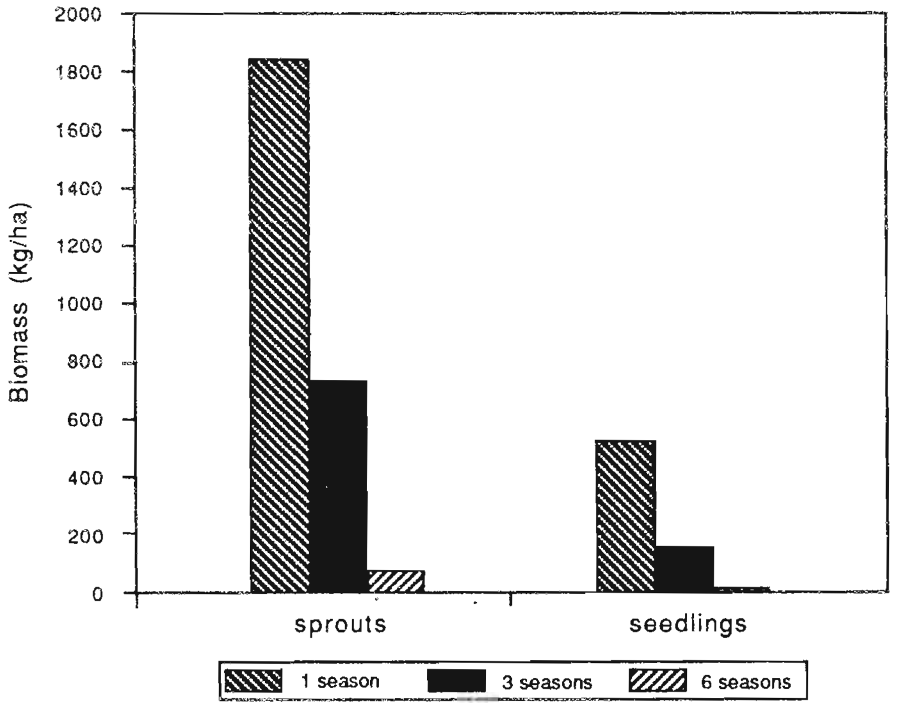

Figure 4. Effects of the length of cropping on regrowth of *Chromolaena odorata* in the subsequent fallow period.

Conclusions

Results showed that *C. odorata* fallow vegetation reached a rather high biomass production within a short period, while the undergrowth of grasses and herbs had disappeared. The number of *C. odorata* plants also had been reduced. These characteristics contribute to relatively high yields and a limited weed problem during cropping. The development of *C. odorata* as a weed during cropping can be effectively reduced by burning and weeding. Its re-establishment after the cropping period, however, is hampered by intensive management practices. A fallow period of 3 years, alternated with one season of cropping under an extensive management regime, is considered to be the optimal use of *C. odorata* as fallow in terms of crop growth conditions.

Due to its abundant presence and specific properties, use of *C. odorata* enables more intensive land-use to be achieved without forcing farmers to greatly intensify production methods. Hence, the use of *C. odorata* as fallow in a semi-permanent food cropping system may form an attractive alternative for longer bush fallows, thus contributing to conserving the last remnants of tropical rainforest.

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Chromolaena odorata in the Farming Systems of South-West Côte d'Ivoire.

(*Chromolaena odorata* dans les Systèmes de Production du Sud-Ouest de la Côte d'Ivoire)

A. de Rouw
ORSTOM
Niamey, Niger

Résumé- Pendant une période d'étude s'étalant de 1979 à 1989, des observations ont été faites sur l'introduction et la diffusion de *Chromolaena odorata* dans le sud-ouest de la Côte d'Ivoire. Dans le système d'agriculture sur brûlis avec une saison de riz pluvial suivie par une jachère forestière de plus de 16 ans, *C. odorata* est supplantée par les arbres et lianes dont les graines étaient présentes dans le sol avant défrichement. Dans les régions où les périodes de jachères ont été réduites à moins de 6 ans, le nombre de graines d'arbres dans le sol diminue tandis que les graines d'herbacées s'accumulent. Dans ces régions, *C. odorata* devient une peste parce qu'elle remplace et domine la végétation naturelle des jachères. La culture du riz est alors remplacée par celle du mais et du manioc. La culture de riz pluvial, en alternance avec de courtes jachères se maintient uniquement dans les zones de sol mixte alluvial-marécageux où les rhizomes de *Marantaceae* restent dans le sol pendant la saison de culture. Les *Marantaceae* croîssent vigoureusement après la récolte du riz, empêchant le développement des adventices, y compris de *C. odorata.* D'autre part, les paysans plantent souvent des caféiers et des cacaoyers avec les cultures vivrières. Si la plantation est peu sarclée pendant les premières années, les adventices et *C. odorata* sont controlées par les composants arborés de la jachère. Par contre si les paysans sarclent leur plantation trop souvent, ils éliminent tous les plants d'arbres; ceux-ci sont alors remplacés par les adventices et par *C. odorata.* Les plantations où caféiers et cacaoyers sont morts évoluent en forêt secondaire dans le premier cas, et en fourré à *C. odorata* et graminées dans le second cas.

Abstract-During the study period of 1979 to 1989, observations were made on the introduction and spread of *Chromolaena odorata* through southwest Côte d'Ivoire. In the shifting cultivation system of one dry rice crop followed by more than 16 years of forest fallow, *C. odorata* is shaded out by trees and lianas whose seeds were present in the forest soil before clearing. In areas where the shifting cultivation system degenerates to short fallows under 6 years, the number of tree seeds in the soil diminishes while arable weed seeds accumulate in the soil. In these areas, *C. odorata* becomes a pest because it dominates and replaces the

natural fallow vegetation. Rice cultivation is substituted by maize and cassava. Dry rice cultivation alternating with short fallows continues only in areas with mixed alluvial-swampy soil where tubers of *Marantaceae* remain in the soil during the cropping period. These grow vigorously after the rice harvest, shading out arable weeds, leaving the fallow trees, but checking the installation of *C. odorata*. Farmers often plant cocoa or coffee along with foodcrops. If the plantation receives little weeding during the first years, arable weeds and *C. odorata* are controlled by the woody fallow vegetation. If farmers keep their plantations weeded, they eliminate all woody seedlings; these are replaced by arable weeds and *C. odorata*. Planted areas where cacao and coffee have died revert to secondary forest in the first situation, and to *C. odorata* thicket and grasses in the second.

Introduction

The last region to be invaded in Côte d'Ivoire by *Chromolaena odorata* was the thickly forested area in the southwest. The plant was introduced to this part of Côte d'Ivoire in 1980, by machines used for road improvement in the northern part. Areas further south where no roadwork has been done remained uninfested probably up to 1986 (Gautier 1992). However, *C. odorata* invaded soon after most of the forest had been cut. High levels of forest cover in the northern part delayed *C. odorata* infestation of fields. It first appeared in rice fields in 1984. The level of *C. odorata* infestation in fields and its dominance in fallow vegetation depends largely on the agricultural system practiced.

The Study Area

The study area, 5°57' - 5°20' N latitude and 7°30' - 7°14' W longitude, covers the agricultural zone between the Cavally River and the Taï National Park. It receives a mean annual rainfall of 1900 mm, falling primarily in two rainy seasons. Most food cultivation is performed in the heaviest rainy season from March through August. The land is undulating to sloping with severely leached, poor, acid, and often gravelly soils (Collinet *et al.* 1984, van Reuler & Janssen 1989).

The Taï National Park consists largely of undisturbed rain forest. Outside the Park, fields, patches of primary forest, secondary forest of different ages, and degraded vegetation form a mosaic. These primary and secondary forests have been studied by Alexandre *et al.* (1978), Guillaumet (1967) and Jaffré and de Namur (1983). Human-modified vegetation and land use have recently been described and mapped by de Rouw (1991).

The indigenous people of Oubi, Guéré and Krou slash and burn mature forest to crop it with rainfed rice for a season, then let it return to a forest fallow. Along with subsistence farming, cocoa and coffee are cultivated. Population pressure, widespread cocoa farming, and extension of the nearby National Park has resulted in reduction of fallow periods to about 6 years. This trend began in 1984 and has gained momentum since then.

The majority of the population consists of non-forest peoples, mainly Baoulé from central Côte d'Ivoire, and Mossi from Burkina Faso. They migrated to the region in the seventies and eighties to grow cocoa. They do not practice shifting cultivation with forest fallow. The main food crops of maize, yam and cassava are interplanted with cocoa. In some cases, maize is grown alternating with 2 to 4 years of fallow (Slaats 1992).

Methods

Between 1979 and 1989, a total of 308 surveys were conducted among fields and young fallow vegetation. Fields chosen were thought to be representative of the region: shifting cultivation fields with rainfed rice as the dominant crop and fields under cocoa and various other food crops. Fields differed in cutting period, soils and forest cover. Each survey consisted of identifying all plants growing in a plot and counting the number of individuals per species, and describing the vegetation structure (cover and height per stratum). Where *C. odorata* was present, a differentiation was made between plants regenerating from seed or resprouting stumps. Plots covered 9 m^2 in rice fields (3 replications/ field), 18 m^2 in cocoa plantations (1 replication/field), and 36 m^2 in secondary forest. Environmental measurements included slope position, drainage, and soil profile description from auger samples of 1-120 cm depth. Crop history of the field was recorded and its surroundings were checked for possible seed sources.

Results

Figure 1 schematically shows the estimated number of viable seeds buried in forest soil in relation to the number of years elapsed since the last clearing. The total number of seeds diminishes as the secondary forest gets older. The group of "arable weeds" are sub-woody, herbaceous, annual plants of open spaces, which deposit seeds during the last cropping period and have since perished into the forest regrowth. The group of "secondary forest plants" consists mainly of pioneer trees, lianas and some shade-tolerant herbs. Secondary forest trees start to produce seeds after a juvenile stage of 1 or more years, depending on the species. As a result, contributions made by woody species increase with age of the fallow, while arable weed seeds degrade in the soil. With time, pioneer trees are replaced by primary forest trees. Secondary forest trees produce continuously and copiously small, long-lived seeds, whereas primary forest species produce fewer seeds which are larger and generally short-lived (Swaine & Whitmore 1988). Thus the soil under primary forest contains few seeds

The lower portion of Figure 1 shows densities of plants appearing in fields at different ages, after fallow vegetation had been cleared. Seedlings were counted from non-weeded plots in the first six months after cutting. The relationship shown in Figure 1 corresponds with trends at other humid tropical sites (Garwood 1989).

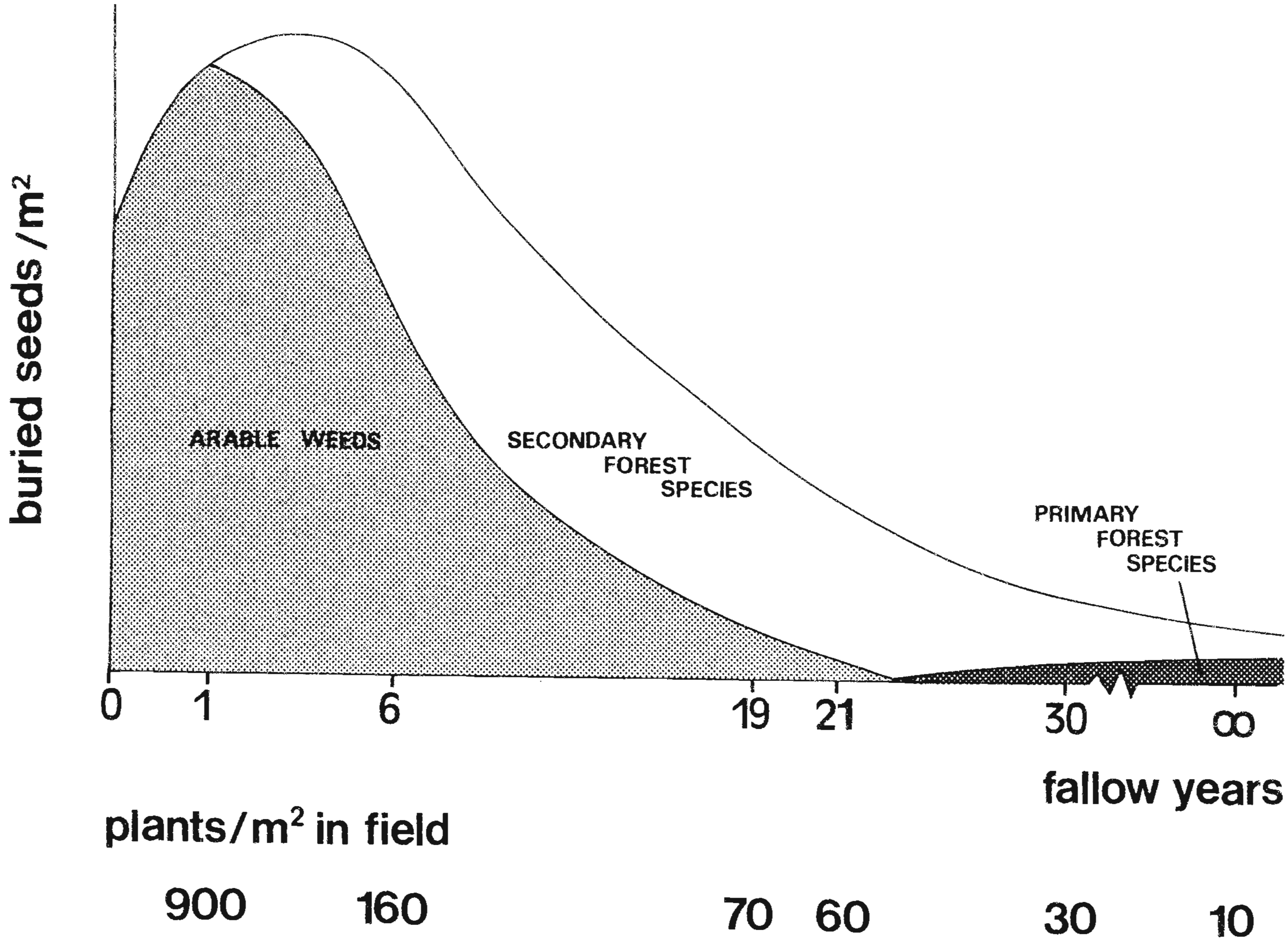

Figure 1. Density of arable weeds and secondary and primary forest species in relation to the length of fallow.

Rice - Long Fallow Periods

After felling and burning secondary forests ranging between 16 and 30 years old, about half of the viable weed stock in the soil is lost (de Rouw & van Oers 1988). Other cultural practices helping to reduce weed growth include minimal tillage by dibbling the rice seeds into the top soil, which reduces the number of dormant weed seeds near the surface. Burning leads to instant mineralization of organic matter while ashes reduce soil acidity. Local varieties of rice are tall and vigorous plants (up to 1.8 m) with broad and droopy leaves which reduce sunlight required for germination of some weed seeds. However, *C. odorata* germinates with crop plants, annual weeds, pioneer trees and coppice from resprouting forest trees (Fig. 2).

The brief cultivation period allows annual weeds to produce just one seed crop before being choked in the forest regrowth. *C. odorata* may reach the canopy (2 - 4 m high) but is only able to produce one or two seed crops as it degenerates with the forest fallow growing thicker and higher.

Rice - Short Fallow Periods

Many weed seeds remain viable during short fallow periods. During this time, less biomass is produced so less nutrients are liberated by burning. The fire is less intense and kills only a limited number of buried seeds. Rice plants are shorter, suffering from weed stress because arable weeds, more troublesome than tree seedlings, outnumber woody plants. *C. odorata* is able to occupy the general crown layer after the rice harvest. It gets firmly established and tends to form dense thickets suppressing other plants. Numerous seeds are produced annually resulting in a persistent seed bank.

Several cycles of rice cultivation and short fallow periods have considerably reduced tree seeds from the seed bank. Coppicing tree stumps have also become scarce under repeated cutting and burning. *C. odorata* dominates the natural fallow vegetation. After each clearing, vigorous sprouts are released from established plants and along with other arable weeds, seedlings are simultaneously recruited from the seed bank (Fig. 3). Rainfed rice cultivation becomes impossible so maize and cassava are planted instead. Because of its shorter cycle (3 instead of 5 months), maize escapes the heavy infestation by *C. odorata*. Cassava is preferred since it can be planted in smaller fields without reducing the caloric needs of the family.

In two small areas comprising 0.8% of the study area (640 ha), rainfed rice is grown for one season followed by a short fallow period not exceeding 6 years. Both areas are almost flat and the soil is a combination of valley bottoms and alluvial floodplains. Because of short fallow periods the seed bank consists mainly of arable weeds. Few seeds are destroyed by burning. Natural vegetation of these wet places include many Marantaceae and Zingiberaceae, which are stout, herbaceous climbing plants. Although these are cut back during the cropping period, they resprout from underground tubers at the end of the season. Their large leaves and vigorous growth assure a rapid ground cover, thus preventing the spread of heliophil weeds like grasses, sedges and annual dicots. However, neither

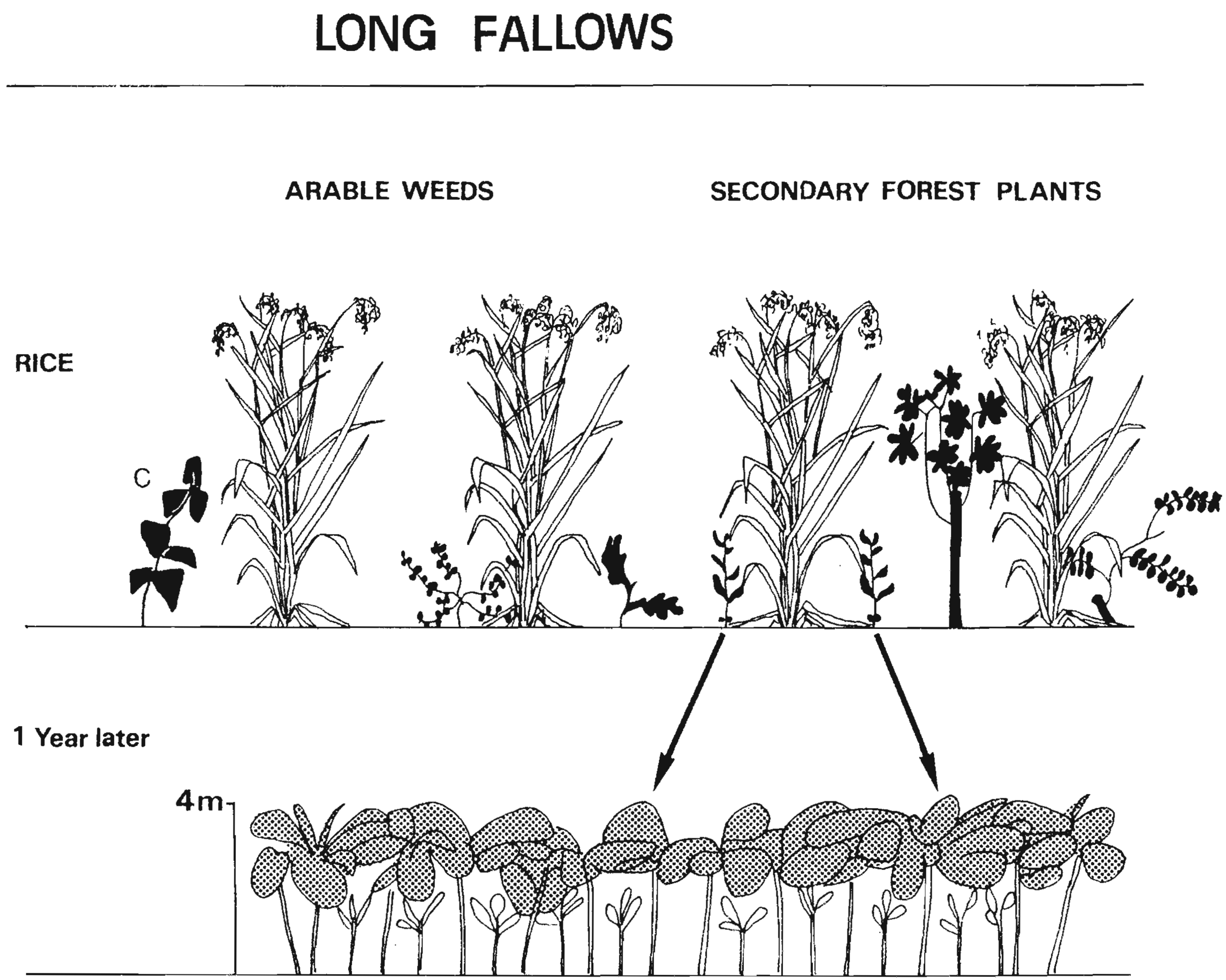

Figure 2. Spontaneous plant growth in Rice planted in a 16 year old fallow.

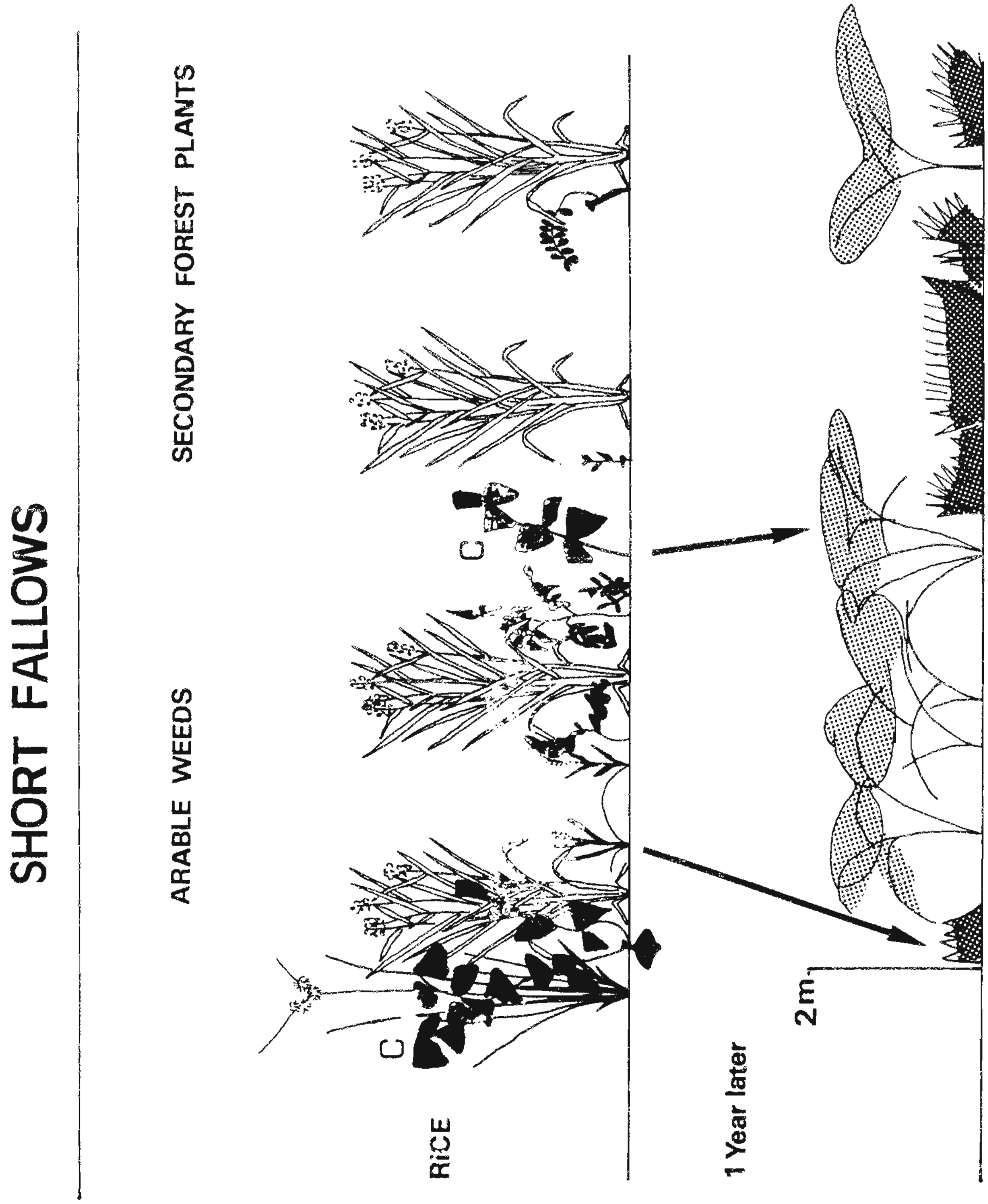

Figure 3. Spontaneous plant growth in Rice planted in a 6 year old fallow.

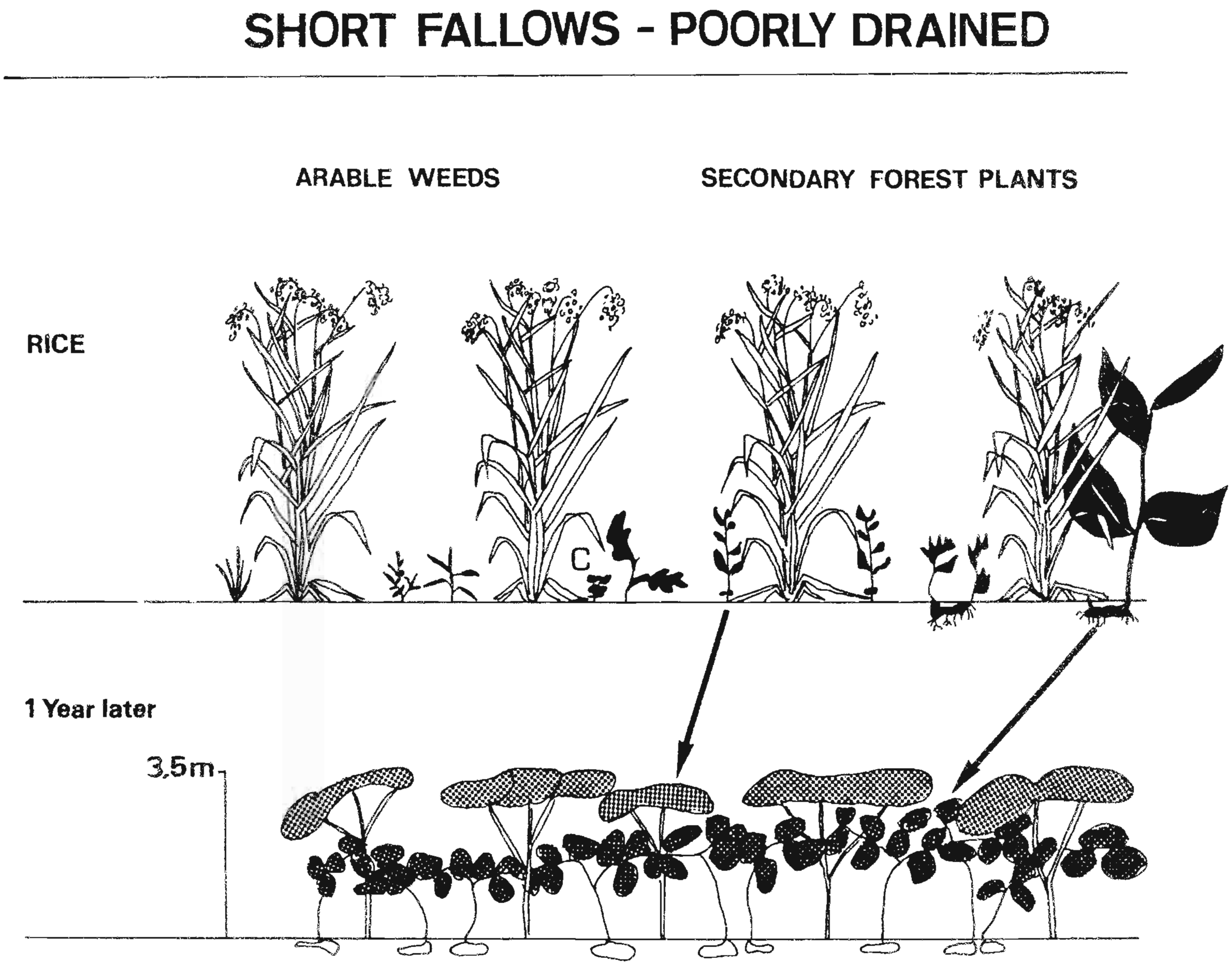

Figure 4. Spontaneous plants, including Marantaceae and *C. odorata* among Rice grown in a 6 year old fallow in porly drained soils.

growth of pioneer trees nor development of *C. odorata* is suppressed. One of the conditions for rice growing is the removal of *C. odorata* seedlings early in the season. It constitutes the only severe threat to starting a fallow vegetation consisting of both pioneer trees and Marantaceae climbers (Fig. 4). It is the resprouting ability of established *C. odorata* plants that would drive out the Marantaceae and make rice cropping impossible.

Rice - Cocoa

Cocoa and coffee cultivation is widespread although forest people and immigrants use different procedures. Instead of allowing rice fields to revert to forest, cocoa or coffee is planted. Often young trees are interplanted as the rice reaches maturity. Fields are weeded every one or two years. A result of the almost permanent shade is stunted growth of young cocoa. Another consequence is the disappearance of arable weeds and degeneration of *C. odorata.*

Unhealthy adult plantations revert naturally to secondary forest, whereas healthy plantations always have some tree cover since fields were never weeded. In both of these cases, shade is sufficiently dense to prevent colonization by C. *odorata.*

Cocoa and other Food Crops

Immigrants concurrently plant maize, cassava and yams with cocoa seedlings. By weeding fields several times a year, the seed stock of woody plants is destroyed and resprouting stumps are weakened. Open spaces are created and filled by species with very effective means of dispersal, such as annual weeds and *C. odorata.* These plants will re-seed the field continuously, being checked only by weeding or by canopy formation.

Only a healthy adult plantation provides sufficient shade to keep out *C. odorata.* In plantations where cocoa plants die out, weeding is not carried out. A solid thicket of *C. odorata* forms after a period during which it out-competes grasses and low weeds. In areas with acute land shortage, maize and cassava are cultivated in cocoa plantations that are already dying back.

Discussion and Conclusion

Small farmers are too poor to use herbicides and have a problem managing weeds in the humid environments where weeds grow and produce seeds continuously. They control weeds by pulling, cutting, and manipulating shade. Shading out weeds by cultivation is a defensive measure against the buildup of weeds. Canopy shade can be used only at the season's end because almost all food crops require open light.

Canopy shade is produced most rapidly where pre-existing tree seeds and stumps simply sprout. The rice shifting cultivation system in Taï is such an example. The same process has been reported from other rain forest areas where upland rice is grown in shifting cultivation (Kochummen & Ng1966, Kunkel 1966, Symington 1933). The success of rice cultivation and low levels of weed infestation including *C. odorata*, are both related to the maintenance of long fallow and short occupation periods. In all these cases, forested land is or was in good supply.

Canopy shade forms more slowly when the viable seeds in the soil are destroyed. Here, post-harvest forest cover is not able to develop from tree seeds since they have been weeded. Vacant spaces in the system are filled by *C. odorata*. In some cases where resprouting plants have been preserved, rapid overhead shade is produced by these forest plants. As shown by this and other studies (Delvaux 1985, Aweto 1981, Zinke *et al.* 1978, Vine 1954), the ability of resprouting plants to exclude and suppress weeds has been used in shifting cultivation systems suffering from land shortage. In Taï and Nigeria (Aweto 1981), *C. odorata* is controlled either by weeding or does not enter the system because it is shaded out rapidly.

Where repeated cutting and burning destroys both the seedbank of trees and the population of resprouting forest plants, canopy shade of forest fallow is replaced by a thicket. The thicket-forming *C. odorata* unbalances the system and whole areas may pass into other systems of land development. This too has been described for Taï (Slaats 1994) and elsewhere (Ahn 1958, Smitinand *et al.* 1978, Zwetsloot 1981).

Unlike shifting cultivators who grow cereals, farmers planting tubers are obliged to clean the forest soil more thoroughly by extra burning, tilling to bury the plant material, and extra weeding because of the longer growing season. Inevitably, they destroy much of the forest seed stock. Thus, farming systems with root or tuber crops are more prone to *C. odorata* infestation than cereal crop systems even when forested land is in good supply. Examples of this have been given by de Foresta & Schwartz (1991), and Uhl & Murphy (1981).

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Potentials for *Chromolaena odorata* (L.) R. M. King and H. Robinson in Fallow Management in West and Central Africa.

(Potentiels de *Chromolaena odorata* (L.) R. M. King et H. Robinson dans la Gestion des Jachères en Afrique Centrale et Occidentale)

I.O. Akobundu and F.E. Ekeleme
IITA (International Institute of Tropical Agriculture)
Ibadan, Nigeria

Résumé - *Chromolaena odorata* (L.) R. M. King et H. Robinson est une adventice introduite devenue bien établie dans les zones humides forestières et dans une partie des zones humides de savane du Centre et de l'Ouest de l'Afrique, là où la pluviométrie dépasse 1200 mm/an. L'espèce croît rapidement et vigoureusement, et chaque individu peut produire plus d'un million de graines dispersées par le vent. Elle peut devenir un sérieux problème dans les plantations non entretenues. *C. odorata* est une importante espèce des jachères partout en Afrique Occidentale et Centrale. Sa production de litière est plus élevée que celle des jachères naturelles de même âge, avec une moyenne de 3700 kg/ha en zone de savane et de 4000 kg/ha dans les zones de forêt humide du Nigeria. D'importantes quantités d'éléments minéraux sont retournés au sol lors de la décomposition de la litière. Une étude sur la gestion des jachères a montré que *C. odorata* provoquait une réduction de la densité d'*Imperata cylindrica* de 82% en 39 mois, comparée à une réduction de 60% avec *Stylosanthes guianensis*, 10% avec *Pueraria phaseoloides* et 0% avec les Légumineuses arborées telles que *Leucaena leucocephala* et *Gliricidia sepium.* Ces arbres ne suppriment complètement *I. cylindrica* que lorsque la période de jachère excède 52 mois. Bien que les paysans reconnaissent l'importance des problèmes posés par *C. odorata,* ils pensent que la fertilité des sols est meilleure dans les jachères à *C. odorata* que dans celles dominées par les graminées. Nos recherches confirment également que la pression en adventices dans les Tropiques Humides est généralement élevée lorsque graminées et autres adventices dominent la végétation des jachères.

Abstract-*Chromolaena odorata* (L.) R.M. King and H. Robinson is an introduced weed that has become well established in the humid forest zone and in parts of the moist savanna zone of West and Central Africa, where rainfall exceeds 1200 mm per annum. It grows rapidly and luxuriantly, and each plant produces over a million seeds that are wind-dispersed. It can become a serious weed problem in plantations that are not well managed. *C. odorata* is an important fallow species throughout West and Central Africa. Litterfall from this weed is higher than that

of a natural bush regrowth of the same age, with averages of 3700 kg ha^{-1} in the derived savanna, and 4000 kg ha^{-1} in humid forest zones of Nigeria. It is also reported to return high amounts of nutrients as the litter decomposes. In a study on fallow management, *C. odorata* caused 82% reduction in the density of *Imperata cylindrica* within a 39-month period compared to 60% reduction by *Stylosanthes guianensis*, 10% by *Pueraria phaseoloides*, and no reduction by tree legumes such as *Leucaena leucocephala* and *Gliricidia sepium*. These tree legumes suppressed *I. cylindrica* completely when the fallow period was up to 52 months. Although farmers recognize that *C. odorata* is a serious weed problem, they believe that fertility of arable fields is better improved when bush fallows are dominated by *C. odorata* than when such fields are taken over by grasses. Research also confirms that weed pressure in the humid tropics is generally high in arable fields where grasses and other weeds dominate the fallow vegetation.

Introduction

Chromolaena odorata (L.) R.M. King and H. Robinson (Siam weed) is a common weed of both plantation and arable crops in West and Central Africa. Its presence in tropical savanna and dry woodland ecologies has also been described (Macdonald & Frame 1988). Various workers have reported on its origin, taxonomy, morphology, distribution, ecology, reproduction, phenology and control (Audru *et al.* 1988, Lucas 1989, Olaoye & Egunjobi 1974).

Most of the studies on *C. odorata* have focused on how to control this weed with herbicides or biological control agents. Although herbicides such as 2, 4-D, fluroxypyr, glyphosate, imazapyr, paraquat, picloram and triclopyr have been screened over the years (Erasmus & Noel 1989, George 1968, Ivens 1973, Keli 1986, Porn chei-Lueag-a-Papong 1989), chemical control does not appear to be an attractive option for smallholder farmers of West and Central Africa. This is partially due to lack of knowledge on herbicide application techniques, cost, and availability of these products. Attempts have been made to use various biological agents to control the weed from spreading. *Aphis gossypii, A. citricola, Homona coffearia and Pareuchaetes pseudoinsulata* have been identified as potential biological control agents of Siam weed (Kluge 1989, Muniappan *et al.* 1988, Torres 1986). In Sri Lanka, *Tephrosia purpurea* was introduced to control *C. odorata* in coconut estates (Ooi *et al.* 1988).

While attempts at Siam weed control have received considerable attention, other studies have focused on the economic importance of this weed. Examples of these studies include reports on its bactericidal action on *Staphylococcus aureus* and *Escherichia coli* (Inya-Agha *et al.* 1987). Major essential oils have also been extracted from *C. odorata* (Inya-Agha *et al.* 1987, Shankaranarayana & Kamala 1989). The potential of *C. odorata* in producing biogas has also been reported (Akinluyi & Odeyemi 1989, Jagadeesh *et al.* 1990).

Although *C. odorata* is widespread throughout West and Central Africa, little is known about its role in the smallholder farming environment. This paper looks at the potentials of *C. odorata* for fallow management in West and Central Africa.

C. odorata in West and Central Africa

C. odorata is now widespread throughout the humid forest zone of West and Central Africa. It is also present in the derived savanna zone of this region and appears to grow luxuriantly in all parts of the subhumid tropics, where rainfall is up to 1200 mm per annum. It was first seen in *Gmelina arborea* (Roxb.) plantations in Southeastern Nigeria. It is reported to have been brought as a contaminant of *G. arborea* seeds, a fast-growing tree probably introduced to Enugu, Nigeria from Sri Lanka in 1936-37, for erosion control (Odukwe 1965). The weed soon established and spread along the West African coast, eastwards into Cameroon, and westwards to other countries in the region. Zebeyou (1991) and Tchoume (1980) have reviewed the origin of *C. odorata* in Francophone West African countries, suggesting that the weed may have been introduced either as a contaminant of rubber seeds or deliberately as a cover plant. It is reported to have been first observed in Cote d'Ivoire in 1952-53 (Miege 1955, Delabarre 1977).

There are indications that the presence and distribution of this weed in West and Central Africa is not from a single introduction point. For example, while it could have conceivably spread to the former British colonies from a single human act of importing a batch of contaminated *G. arborea* seeds, its presence in the Congo, Central Africa, in the early 1970's after the construction of Congo-Ocean railway line (de Foresta & Schwartz 1991), and in Côte d'Ivoire at an earlier date, suggest multiple and separate introductions from outside the continent. This is further supported by the fact that there was little or no trading activity between West African countries during the colonial period.

C. odorata as a weed problem

C. odorata is known by different names in different parts of West and Central Africa. Local community names suggest different perceptions of the weed. Farmers describe *C. odorata* as aggressive, ubiquitous, occurring in high density and having luxuriant growth, but it is not noxious. It is easily killed with herbicides and can easily be controlled by mechanical means. Therefore, it is similar to other common weeds in arable fields of West and Central Africa. Although seedlings appear in large populations on newly cleared land, a characteristic *C. odorata* shares with other members of the Asteraceae, they can be controlled in arable crops like other annuals. The seedlings have no regenerative ability once they have been pulled or destroyed by other cultural methods. Seedlings can be a problem in neglected plantations and could increase maintenance cost in other well-managed plantation crops, but *C. odorata* is an important component of traditional bush fallow systems in West and Central Africa. Results from farm research conducted in Côte d'Ivoire reveal that upland rice farmers have developed management practices which enable them to derive benefits such as soil fertility maintenance and reduced weeding frequency (Remington & Sahrawat 1992). In reviewing the ecology of *C. odorata,* McFadyen (1991) noted the weed's importance in Asia and Africa, but that it is seldom weedy in the New

World. She attributed this to Siam weed being less aggressive in the New World, due to pressure from pests, diseases and competition from other plants. McFadyen concluded that its aggressiveness in Africa and Asia is associated with the absence of these enemies in the Old World.

Role in weed suppression

A full canopy cover in natural bush fallow in some agroecological zones is often difficult because of perturbations resulting from fire or logging for fuel and other domestic uses. Such perturbations often result in low species diversity, and consequently, a reduction in total biomass yield of fallow vegetation. In such agroecological zones, particularly where fallow length has drastically dropped to below 4 years, *C. odorata* fallow appears to be a good alternative to natural bush regrowth. *C. odorata* has been cited as a prolific producer of biomass (Jagadeesh *et al.* 1990, Olaoye 1976). Litterfall monitored throughout the year under *C. odorata* has shown to be regular and follows the same pattern in both the humid and subhumid zones. Highest litterfall was noted in the dry season (Tab. 1). Good canopy cover is achieved within a very short time in well established fields. With full canopy cover, light transmittance to the herb layer underneath is reduced, smothering the undesired weeds in the fallow. Once established, *C. odorata* maintains its density naturally by continuous growth until tree shading severely limits its access to sunlight; this occurs within 3 to 5 years in the humid forest zone. Seed production ranges from 50,000 in the first year of growth to nearly 2,000,000 seeds per plant in fully established thickets (Olaoye & Egunjobi 1974). Basal stems of *C. odorata* will regrow when slashed and even after flash bushfire. The impression that this weed is difficult to control is associated with vigorous regrowth from these basal parts, and the fact that a contact herbicide or application of a preplant herbicide has no effect on such regrowth. Effective control of *C. odorata* at this stage requires good tillage to remove the rootstocks before planting food or plantation crops.

Results of current research in IITA show that *C. odorata* can control *Imperata cylindrica* within a 3 year fallow. Table 2 shows that there are very few *I. cylindrica* stands under *C. odorata* canopy after three years of fallow period. This could be attributed to the ability of *C. odorata* to establish easily and compete successfully against other plants. Shading by *Leucaena leucocephala* and *Gliricidia sepium* completely eliminated *I. cylindrica* within four years.

Role in bush fallow systems and soil fertility maintenance

Increasing human population pressure on a finite arable land mass in West Africa has led to a decline in the bush fallow period. The practice of long bush fallows, the major method of soil fertility maintenance decades ago, is no longer an option for smallholder farmers. Consequently, food production by these farmers in West Africa has drastically declined. To increase food production therefore, fallow management techniques need to incorporate species which use environmental resources efficiently, and can quickly produce biomass. Litterfall as well as mineralization of the litter of such species should be high. Ability to compete successfully with weeds and other species is desirable.

Table 1. Percent of nutrient content in a one year collection of oven dried litterfall under *C. odorata*.

	Humid forest (Ikenne)				Derived savanna (Fashola)			
Month	Litter (kg ha^{-1})	N <—	P (%)	K —>	Litter (kg ha^{-1})	N <—	P (%)	K —>
January	755	2.28	0.17	0.56	330	1.72	0.38	1.20
February	334	1.57	0.12	0.41	1080	1.40	0.24	0.45
March	184	1.30	0.10	0.35	1154	1.38	0.19	0.70
April	112	1.43	0.05	0.10	452	1.31	0.24	0.27
May	134	1.97	0.10	0.16	89	1.46	0.08	0.12
June	237	2.10	0.10	0.18	90	1.24	0.19	0.24
July	311	1.50	0.10	0.20	114	1.74	0.22	0.24
August	423	1.43	0.14	0.25	183	1.53	0.28	0.50
September	545	1.98	0.12	0.15	260	1.87	0.26	0.21
October	318	1.78	0.10	0.15	339	1.75	0.17	0.29
November	280	1.57	0.10	0.46	196	1.71	0.28	0.52
December	671	2.23	0.17	0.65	220	1.12	0.18	0.80

Source: Olaoye (1976).

In southeastern Nigeria, litterfall under a 4 month old *C. odorata* canopy was reported as 1970 kg ha^{-1} (Agbim 1987). This amount of dry matter was shown to be comparable to figures obtained by Nye (1961) and Swift *et al.* (1979), under moist tropical forest conditions when scaled down to 4 months. Rapid mineralization of litter as well as high pH values were also reported (Agbim 1987, Olaoye 1976).

Research carried out in Ultisols of southeastern Nigeria shows that mulching with dry *C. odorata* shoots decreased soil bulk density and increased soil moisture retention for soil moisture tension between 0.05 and 15 bars. Increased yield of yam was recorded in plots mulched with *C. odorata* (Opara-Nadi & Lal 1987). Eussen and Slamet (1973) have also

Table 2. Effects of fallow species on the stand density of *Imperata cylindrica*. (Ijaye, Nigeria 1993)[1].

Fallow Species	0	39	52
	Months after planting		
	<—— (no.m-2)		——>
Desmodium gyroides	48	69bc	36bc
Flemingia macrophylla	46	55c	48b
Tephrosia candida	36	68bc	36bc
Cajanus cajan	32	68bc	48b
Acacia auriculiformis	33	60bc	25bcd
Leucaena leucocephala	26	69bc	0d
Gliricidia sepium	27	60bc	0d
Desmodium ovalifolium	48	64bc	41d
Chromolaena odorata	50	9e	3cd
Tithonia diversifolia	33	65bc	32bcd
Centrosema pubescens	45	97a	52b
Mucuna puriens var. *utilis*	46	56c	55b
Stylosanthes guianensis	47	19de	28bcd
Pueraria phaseoloides	48	43dc	33bcd
Control	46	87ab	124a
S.E		±9.5	±11.7

[1]Akobundu, I. O. 1993, unpublished data.

shown that mulching with *C. odorata* shoots stimulated the growth and yield of cucumber plants. Chemical analysis of litter from a number of vegetation sources were compared with that of *C. odorata* by Olaoye (1976). Results show that *C. odorata* litter contains percentages of N, P and K that are comparable to either the natural bush fallow, forest regrowth or *Dactyladenia barteri*. A grass fallow litter had the lowest concentration of N, P and K (Tab. 3).

Table 3. Plant nutrient concentrations (% of oven-dry weight) in the litterfall under *C. odorata* and other fallows.

Fallow type	N	P	K
	<———	(%)	———>
5 year *C. odorata* fallow	2.23	0.17	0.65
5 year secondary forest	1.08	0.04	0.21
40 year secondary forest	1.54	0.06	0.45
6 year *Dactyladenia barteri* fallow	1.08	0.07	0.28
Stargrass fallow	0.85	0.05	0.40
Pueraria phaseoloides	2.00	0.11	0.80
Natural bush fallow	1.80	0.08	0.60

Adapted from Olaoye (1976).

Consequences of unrestricted biological control of *C. odorata* in West and Central Africa

Herren-Gemmill (1991) described the potential role of *C. odorata* in fallow management in West Africa, noting that it was the most frequently occurring species in the study site. Some of the data from our study on improved fallow management in the derived savanna zone, show that *C. odorata* accounted for over 42% of the biomass in continuously cropped arable plots during bush clearing before the onset of rains. It also constituted up to 71% of the biomass in arable plots fallowed for 2 years (Tab. 4). This high production of biomass contributes to its role in soil fertility maintenance. The decline in *C. odorata* biomass after 3 years of fallow may be the result of intraspecific competition. Others who have studied this plant have noted its contribution to soil fertility maintenance through return of nutrients in the soil, biomass production and litterfall, as well as by providing favorable conditions for earthworm activity (Olaoye 1976). When we used a mixture of picloram and 2, 4-D to eliminate *C. odorata* that dominated a natural bush fallow, Guineagrass (*Panicum maximum*) took over when the field was returned to cultivation after a short fallow period, becoming more difficult to control than *C. odorata*. This also occurs when grasses such as *Pennisetum purpureum* or *Andropogon tectorum* occupy arable land after removal of *C. odorata*. Ivens (1973) reported that a dense cover of grass weeds took over *C. odorata* infested sites where a mixture of picloram and 2, 4-D was used to eliminate Siam weed.

Table 4. *C. odorata* and legume biomass in selected fallow systems.

Crop/Fallow ratio	% of Biomass					
	Bush		*Pueraria*		*Leucaena*	
	C	L	C	L	C	L
1:0	42.2	7.2	25.7	3.6	6.2	1.3
1:1	55.9	1.0	24.8	19.0	38.8	4.3
1:2	70.7	0.1	16.2	18.3	51.4	12.8
1:3	44.4	4.7	16.4	8.8	51.4	10.2

C= *C. odorata*
L = includes all legumes except for the species used in the main plot treatment; mean of four replications.

A well established stand of *C. odorata* can be difficult to control if the crop is planted without first uprooting the stumps or spraying the regrowth from the basal stumps. This problem is most pronounced among plantation crops where *C. odorata* can regrow from the stumps after flash bush burning. Proper control has been achieved by spraying the regrowth with hormone-type herbicides such as picloram and 2, 4-D and glyphosate, or by uprooting the basal stumps. Proper burning of residue has been reported to minimize coppicing from basal stumps. This practice is widely used by upland rice farmers in Côte d'Ivoire (Remington & Sahrawat 1992).

Several studies have been reported on potential biocontrol agents for *C. odorata*, and an international workshop was held on biological control of this plant (Muniappan 1988). While biological control of this weed may be justified in Southeast Asia, there appear to be no compelling arguments supporting such measures for West and Central Africa. Since biological control will not eradicate this weed, the potential ecological hazard of such control methods will reduce the plant's vigor, lessening its role in soil fertility maintenance. Furthermore, there is no guarantee that the biological control agents introduced into one country in the region will not spread to other countries, where the role of *C. odorata* in bush fallow management outweighs its nuisance as a weed. It has been documented that soils in the humid forest and the derived savanna of West and Central Africa, where this plant dominates the early years of bush regrowth, are very fragile and need to be protected from erosion. Soil fertility maintenance calls for the protection and maintenance of the green mantle of vegetation that covers arable lands. *C. odorata* is one of the few bush fallow species that can quickly re-establish after any form of perturbation, in both humid and subhumid agroecological zones in West and Central Africa. This plant can contribute to soil fertility maintenance without additional input from farmers. In addition, a cross section of smallholder farmers appreciate the fact that land under *C. odorata* bush fallow is generally more productive than land that has been under grass fallow. The need to protect the bush fallow lands of West and Central Africa in the maintenance of the natural vegetation resource is, therefore, an important component of sustainable agriculture in the region.

Conclusion

It is well known that *C. odorata* occurs throughout the tropics. Its importance as a weed is, however, mainly limited to Asia and Africa, where pressure from its natural enemies is minimal. In places where the level of its weediness is seen as requiring control interventions, measured response in line with agricultural sustainability concepts should be identified and implemented. In West and Central Africa, where traditional food production practices are carried out on soils with low exchange capacities, and where some level of bush fallow management is an acceptable method of soil conservation and rejuvenation, advocates of widespread management initiatives for *C. odorata* must consider its role in preventing soil degradation. This should be done before drastic measures such as biological control of this plant are embarked on. *C. odorata* also responds to routine control and cannot therefore be termed noxious. It can, however, become a serious weed problem in poorly managed plantations. It is an important component of natural bush fallow systems in West and Central Africa. In these systems, its attributes include contribution to maintenance of soil organic matter, weed suppression, soil fertility maintenance and erosion control.

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Le Contact Forêt-Savane dans l'Est du Cameroun et *Chromolaena odorata:* Considérations Préliminaires.

(Contact between Forest and Savanna in Eastern Cameroon: Preliminary Studies of *Chromolaena odorata*)

G. Achoundong
Herbier National du Cameroun

J. Bonvallot
ORSTOM, Yaoundé, Cameroun

and

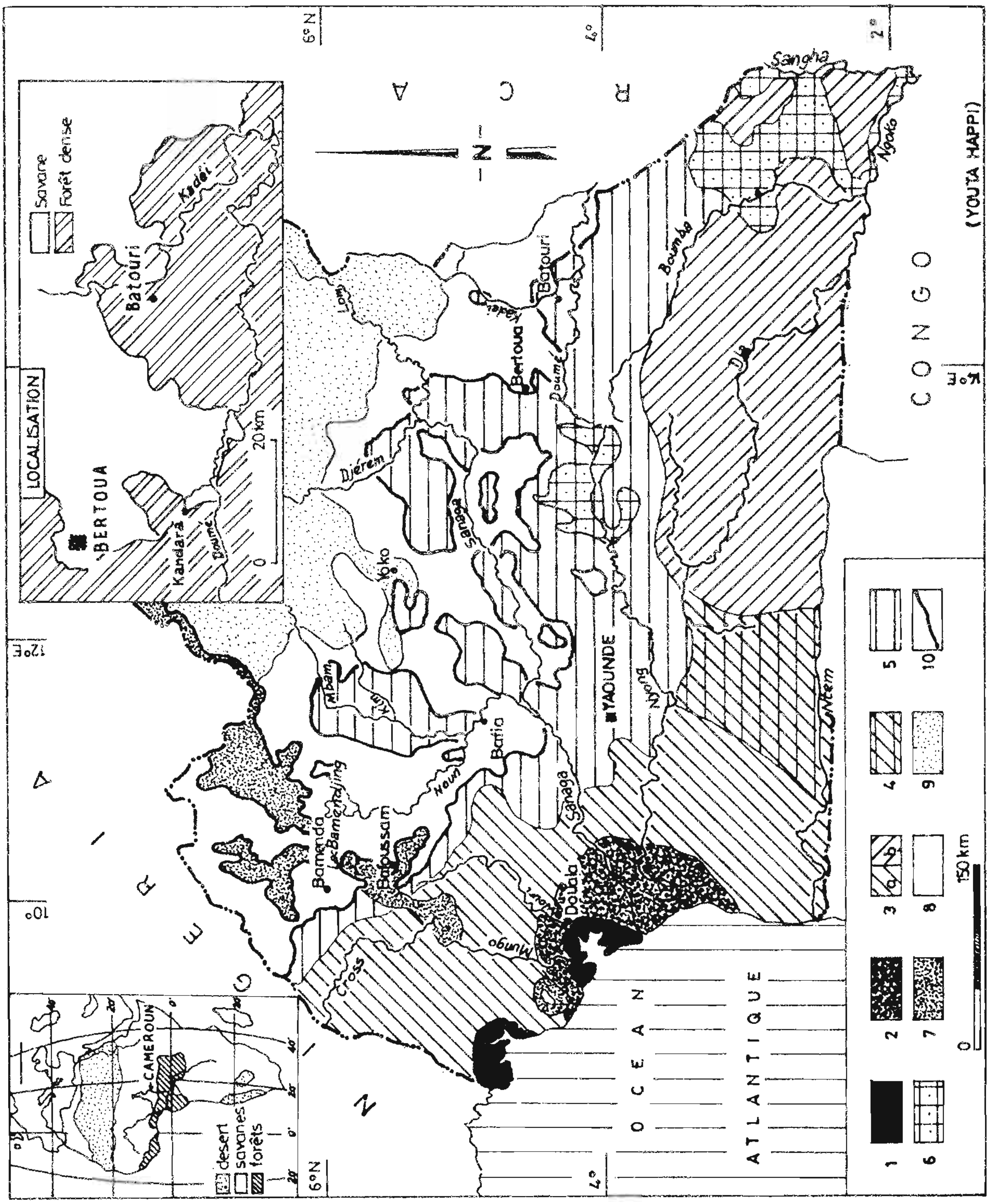
Y. Happi
Département de Géographie de l'Université de Yaoundé I, Cameroun

Abstract-This is a preliminary study of the role of *Chromolaena odorata* in a forest - savanna transition zone, south of Bertoua in Eastern Cameroon. With a transitional equatorial climate, the Kandara Savanna is characterized by a rapid progression of forest over grasslands despite late bush fire. This paper discusses the passive and active roles of *C. odorata* in the forest - savanna transition zone. In general, the weed tends to enhance the progression of forest into savanna.

Résumé-Cette étude préliminaire des contacts forêt-savane porte sur une zone de l'est du Cameroun, au sud de la ville de Bertoua. Sous climat équatorial de transition, la savane de Kandara est caractérisée par une avancée rapide de la forêt sur les formations graminéennes malgré les feux de brousse - souvent tardifs - annuels. Le rôle passif et actif de *Chromolaena odorata* est analysé. Dans le contexte général de conquête forestière, cette plante semble accélérer le phénomène.

Au Cameroun, la configuration géographique de la limite entre les forêts denses semi-décidues et les savanes guinéennes périforestières, présente un tracé irrégulier caractérisé par de grands saillants des formations forestières sur les savanes, séparés les uns des autres par de profonds golfes occupés par les formations graminéennes (Fig. 1). C'est le cas, au nord de Yaoundé du "golfe" de Bafia et, à l'est, non loin de la frontière de la République Centrafricaine, de celui de Bertoua-Batouri.

Dans le cadre du grand programme ECOFIT (Ecosystèmes des forêts de la zone intertropicale), l'ORSTOM a entrepris depuis quelques mois l'étude de ces contacts. Ce programme a reçu le label du Programme International Géosphère-Biosphère (P.I.G.B.), et s'attache, entre autres, à retracer l'histoire des formations forestières tropicales au cours



Legende: 1. Mangrove; 2. Forêt sempervirente atlantique à *Lophira alata* et *Saccoglotis gabonense*; 3. Forêt sempervirente congo-quinéenne, type: (a) biafréen, (b) congolais; 4. Forêt mixte sempervirente et semi-décidue; 5. Forêt semi décidue à Ulmaceae et Sterculiaceae; 6. Forêt marécageuse; 7. Forêt montagnarde indifférenciée; 8. Savane périforestières; 9. Savane arborée; 10. Contact forét-savane.

Figure 1. La végétation du Sud du Cameroun (d'après Letouzey, 1975, 1979, White 1986).

des dix derniers millénaires, au Brésil, au Congo et au Cameroun. Les efforts d'une équipe de recherche multidisciplinaire se sont concentrés, au Cameroun, sur les savanes et les forêts de Kandara (4°20'N et 13°45'E) situées au sud de Bertoua, sur la piste reliant Dimako à Batouri.

Savane de Kandara

Climat

La région de Kandara est caractérisée par un climat équatorial de transition à deux saisons des pluies et deux saisons sèches. La pluviosité moyenne est de l'ordre de 1 500 mm, les mois les plus humides étant ceux de juin et septembre-octobre. La petite saison sèche est cependant peu marquée puisque des pluies notables peuvent être enregistrées au mois de juillet.

Relief

Le substratum géologique est formé par la "série des gneiss et des granites indifférenciés" (Gazel 1954) et l'on a pu mettre en évidence que le nord de la savane était occupé par les granites alors que le sud était sur gneiss. Au total, le modelé de la zone de Kandara est caractérisé par un plateau à une altitude moyenne de 650 m, entaillé sur ses bordures par des vallées peu encaissées à fond plat et marécageux, qui isolent entre elles des lignes de collines surbaissées. Notons cependant que certaines têtes de vallées présentent des entailles vigoureuses (10 m et plus) bien qu'elles soient actuellement occupées par la forêt dense, indice d'un changement récent des conditions morphoclimatiques.

Sols

Les sols développés sur les interfluves et les versants sont de type ferrallitique de couleur rouge, à texture limono-sableuse ou argilo-sableuse. Ils sont généralement cuirassés en profondeur, bien que des études complémentaires soient encore nécessaires pour préciser l'extension réelle des formations indurées. Sur les versants en pente douce qui bordent le plateau, la cuirasse affleure à une altitude remarquablement constante (635 m) sous forme de blocs dispersés à la surface du sol. Il n'y a donc pas, à proprement parler, de corniche constituée par la cuirasse et les affleurements se rencontrent indifféremment en savane et en forêt. Les sols sableux des talwegs ont un horizon hydromorphe en profondeur. Ils sont recouverts par une couche de tourbe mal décomposée qui peut avoir jusqu'à 2 m d'épaisseur. Ils portent des prairies marécageuses à *Cyclosorus striatus* ou des forêts monospécifiques à *Raphia monbuttorum*.

Savane

La savane de Kandara est une savane maigrement arbustive à *Imperata cylindrica* et *Aframomum latifolium.* (Letouzey 1968). Les principales espèces d'arbres y sont: *Albizia zygia, A.. adianthifolia, Bridelia ferruginea, Ficus sp., Annona senegalensis. A. zygia* et *A. adianthifolia* se rencontrent également sous forme de grands individus dans la forêt dense à Sterculiacées et Ulmacées voisine où ils constituent parfois des peuplements presque purs (Fig. 2).

La savane est parcourue annuellement par les feux courants sans que l'on puisse établir une règle générale quant à leur date. En 1993, tendance a plutôt été aux feux tardifs du début du mois de mars, bien que des feux précoces en janvier aient été constatés çà et là.

Forêt

La forêt dense semi-décidue est composée, au contact avec la savane, des espèces principales suivantes:

Albizia zygia
Albizia ferruginea
Albizia adianthifolia
Tabernaemontana
Funtumia elastica
Myrianthus arboreus
Sterculia rhinopetala
Markhamia lutea
Voacanga africana
Celtis zenkeri
Albizia glaberrima

Cette bande de végétation dont la largeur varie de 90 à 500 m est caractérisée par la présence en sous-bois de nombreuses Marantacées.

Lorsqu'on s'enfonce dans le massif forestier , elle fait place à une forêt dont la richesse spécifique augmente et qui est dominée par les espèces suivantes:

Erythrophleum sp.
Triplochiton scleroxylon
Terminalia superba
Pycnanthus angolensis
Alsthonea boowei
Chlorophora excelsa
Petersianthus macrocarpus
Piptadenistrum africanum
Albizia zygia

En sous-bois, l'apparition de plusieurs espèces de *Rinorea* (Violacées) semble indiquer l'ancienneté de cette forêt.

Occupation humaine

Kandara est une terre de colonisation récente, qui remonte à 1969, date de l'ouverture de la piste Dimako-Batouri. On y trouve un peuplement cosmopolite de moins

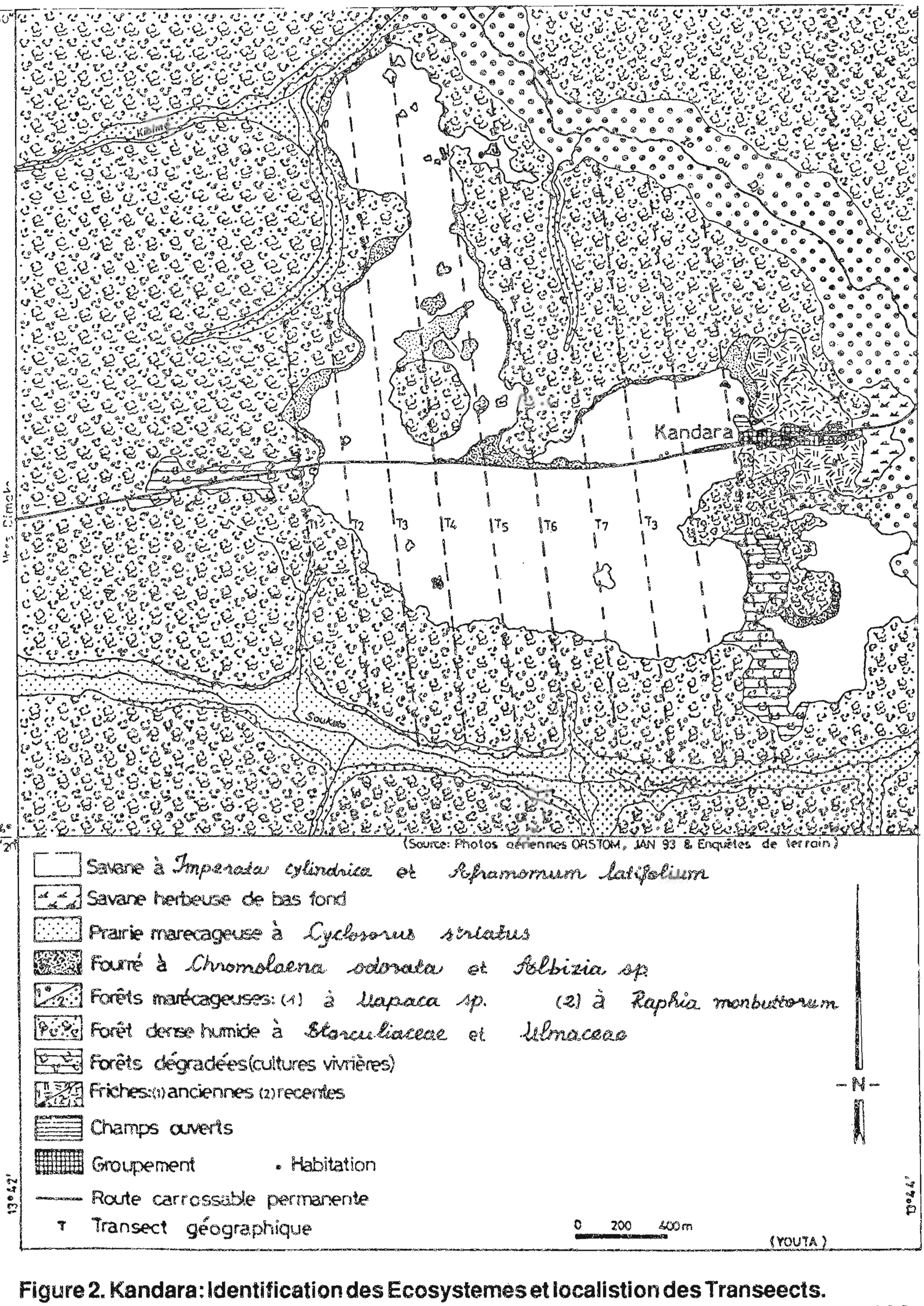


Figure 2. Kandara: Identification des Ecosystemes et localistion des Transeects.

de 100 habitants parmi lesquels l'ethnie kaka est dominante en nombre. La densité humaine de la zone est donc très faible.

La population tire l'essentiel de ses maigres ressources du milieu environnant le village et profite notamment de la mosaïque de formations végétales qui lui est offerte par les contacts forêt-savane. La forêt fournit l'espace nécessaire à l'agriculture itinérante sur brûlis: manioc, banane plantain, macabo, maïs, arachide et pistache. Quelques petites plantations de caféiers jouxtent les cases, à proximité du village. La forêt procure également de nombreux produits de cueillette ou de chasse: ignames sauvages en complément alimentaire, singes, antilopes de forêt et athérures pour la "viande de brousse", perroquets piégés pour la vente en ville ou l'exportation, miel, rotin pour la vannerie, liens divers, matériaux pour la construction des cases. La savane, milieu moins riche, fournit la "viande de brousse" chassée avec l'aide des feux, la paille pour la couverture des cases et le fruit de l'Aframomum considéré comme une gourmandise par les enfants du village.

Dynamique Des Contacts Forêt-Savane

Progression de la forêt

Letouzey (1968) signalait déjà que les forêts semi-décidues colonisaient progressivement les savanes guinéennes qui les bordaient au nord.

A Kandara, l'un d'entre nous a étudié plus spécialement l'évolution des contacts forêt-savane avec les documents dont il disposait: photographies aériennes de 1952, image Landsat TM de 1984, photographies aériennes de 1989 et 1993. Immédiatement à l'est de Kandara, une comparaison sur une zone de 59 km^2 entre les photographies aériennes de 1952 et l'image Landsat de 1984 montre, après calage des échelles des deux documents à la Station de Traitement d'Images Satellitaires de l'IRGM de Yaoundé, que la superficie des formations forestières est passée de 10 km^2 à 16 km^2, soit un rythme annuel d'accroissement de la superficie forestière de 20 ha (Fig. 3). Ponctuellement, à Kandara (Fig. 4), des avancées considérables de la forêt ont été notées entre 1952 et 1993 atteignant souvent plusieurs dizaines de mètres. La tendance générale de toute la zone semble donc être à une colonisation des savanes par la forêt, même si, localement, on a pu constater de légers reculs des lisières sous l'effet vraisemblable de feux de brousse particulièrement violents. Cette tendance est vérifiée dans d'autres régions du Cameroun étudiées dans le cadre d'ECOFIT, notamment dans la région de Massengam-Nditam, le long de la vallée du Mbam.

Rôle de *Chromolaena odorata*

Dans cette dynamique, *C. odorata* semble intervenir de façon particulière. Cette Astéracée est apparue à Kandara, vraisemblablement à la faveur de la création de la piste en 1969. D'après les témoignages des villageois, elle n'a envahi véritablement leur terroir qu'à partir de 1973, date à partir de laquelle elle a colonisé les champs établis en forêt et en savane.

La dissémination de *C. odorata* semble être avant tout le fait du vent, des déplacements d'air provoqués le long des routes par les véhicules et, dans une mesure qui

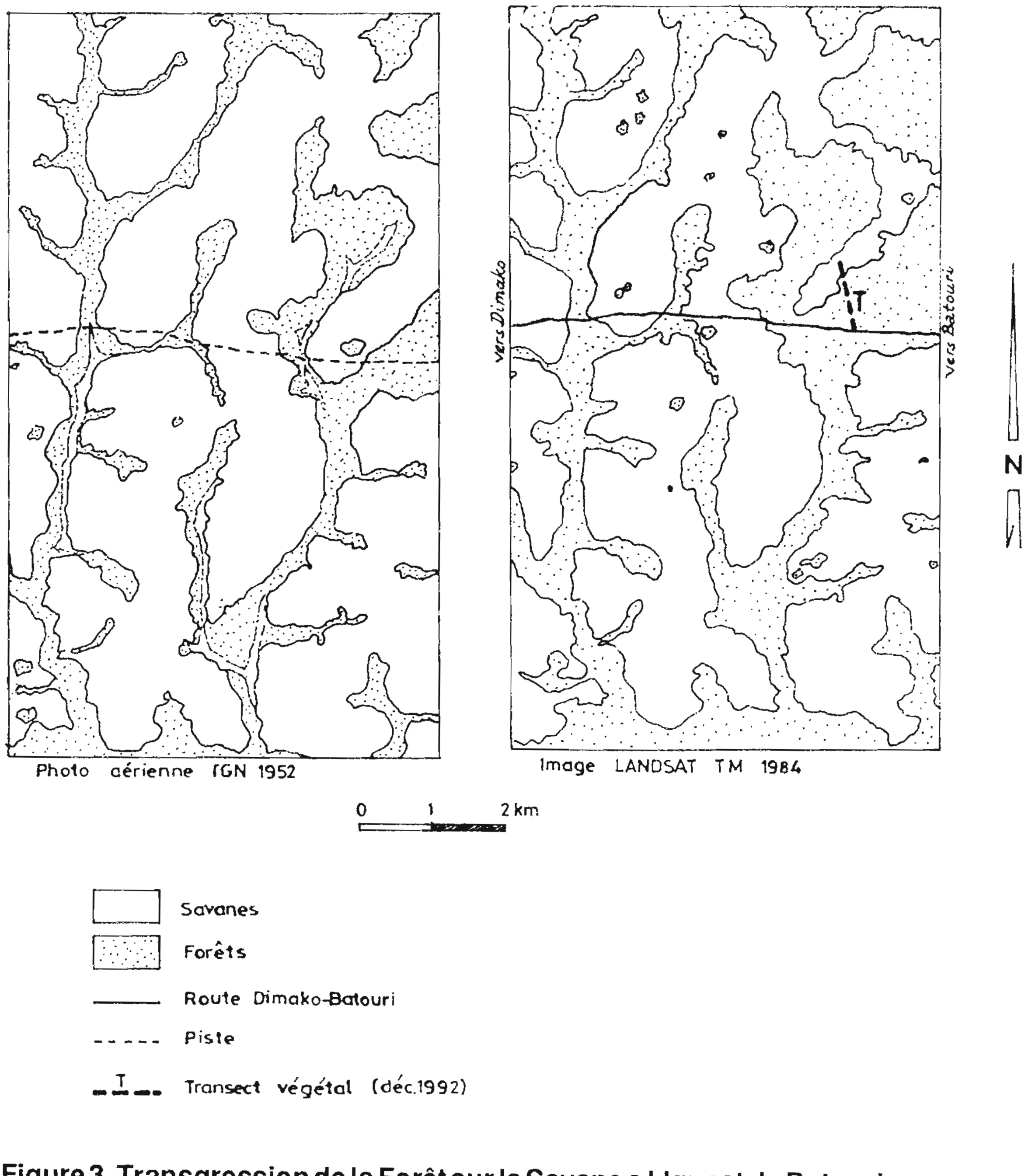


Figure 3. Transgression de la Forêt sur la Savane a L'quest de Batouri.

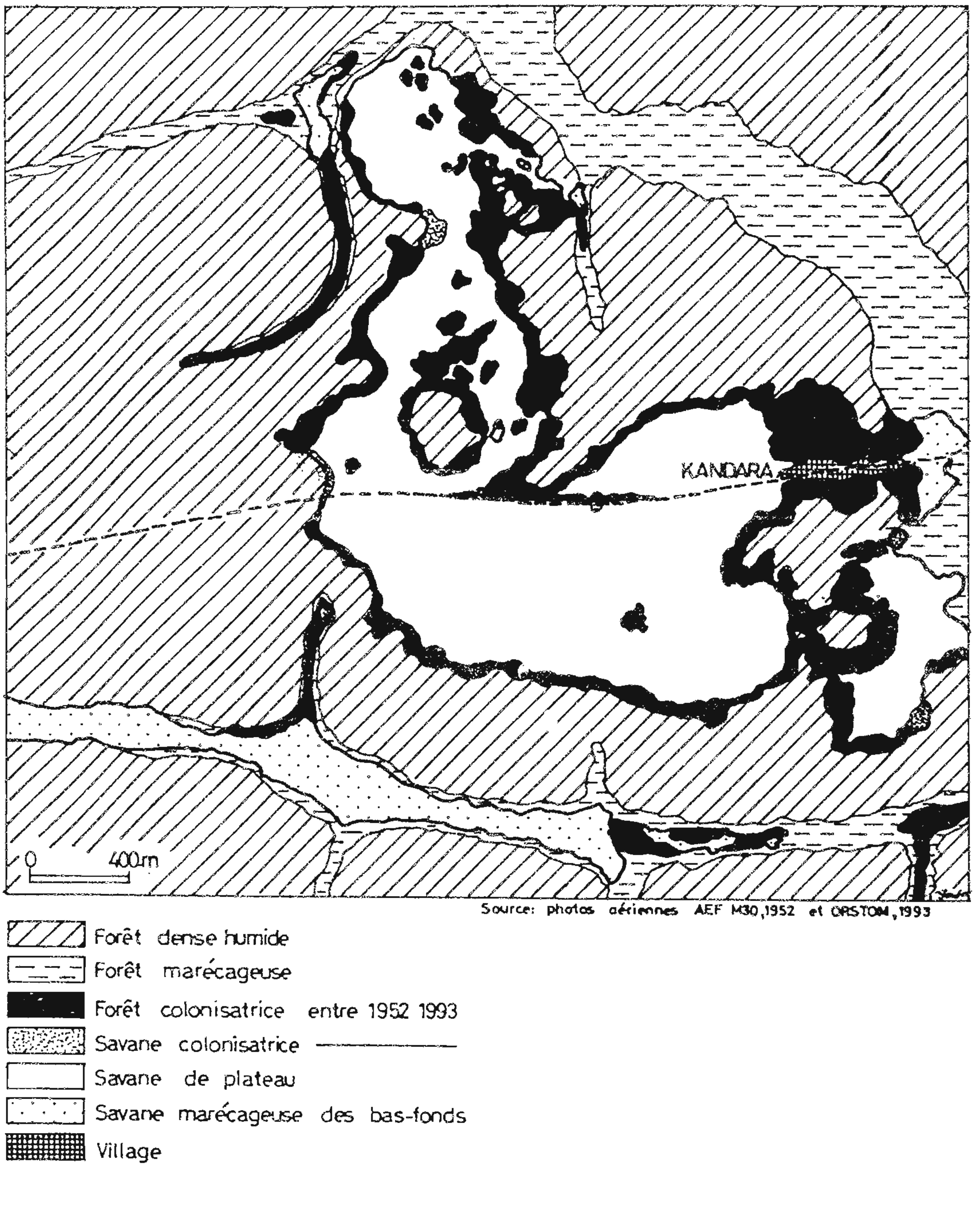


Figure 4. Le Dynamisme de Contact Forêt-Savane a Kandara.

reste encore à préciser, des oiseaux dont quelques espèces inféodées à la lisière, s'aventurent néanmoins à courte distance dans les savanes.

Elle est partout présente le long des lisières forestières, où, en raison de sa croissance rapide, elle avance progressivement sur les graminées qu'elle prive de lumière en s'élevant plus haut qu'elles. A Kandara, la bande de lisière occupée par *C. odorata* varie de 2 à 18 m de large. Elle peut cohabiter avec *Pteridium aquilinum* et plusieurs espèces de Zingiberacées du genre *Aframomum*, mais, le plus souvent, elle est en peuplement pur. Lors de la saison sèche, à la différence des espèces gramineennes de la savane, ses tiges sufrutescentes ne s'assèchent pas suffisamment pour casser et s'abattre au sol. Il en résulte que le feu qui dévore la savane ne pénètre que peu dans les bandes de *C. odorata*. Cette plante présente donc, face au feu, un écran protecteur à la forêt.

Elle colonise également les savanes en s'intallant en manchon au pied des arbres isolés. Les graines transportées par le vent et interceptées par le feuillage des arbustes, tombent au sol, germent rapidement et se multiplient par nombreux rejets. Là également, les graminées sont totalement éliminées, surtout sous *A. zygia* et beaucoup moins fréquemment sous *B. ferruginea*.

C. odorata a donc plusieurs rôles dans la dynamique des lisières: un rôle actif de plante pionnière éradicant les graminées et un rôle passif de protection des lisières vis à vis des feux de brousse. Mais elle a également un rôle actif de favorisation de l'installation d'espèces de forêt sous son couvert qui est révélé par les relevés botaniques effectués. Les espèces présentes sont les suivantes :

Albizia zygia
Albizia adianthifolia
Voacanga africana
Psychotria sp.
Cephaëlis peduncularis
Funtumia elastica
Lasianthera africana

De nombreuses plantes collectées lors de ces relevés n'ont pas encore pu être identifiées faute d'appareils floraux ou de fruits. On remarque que les espèces identifiées sont, soit des pionnières forestières en savane ou des espèces de lisière. *A. zygia* est le plus fréquemment représenté. Cette espèce présente, sous *C. odorata,* une forme étirée vers le haut, dans le but de surcimer le fourré qui l'abrite et s'étaler ensuite tel un parasol dès que la lumière est accessible. La tige molle qu'elle développe alors ne peut tenir verticalement qu'en s'appuyant aux tiges et aux rameaux de *C. odorata* bel exemple d'association antagoniste de deux espèces au cours de la compétition pour la lumière.

Dans d'autres régions du Cameroun, comme à l'ouest des contact forêt-savane, les relevés botaniques effectués près de Nditam (Achoundong 1988) montrent également que les espèces les plus fréquentes sous *C. odorata* sont les *Albizia*.

Il semble donc qu'il y ait une association efficace entre *C.odorata* et *Albizia* qui explique l'avancée progressive de la forêt sur les savanes à *I. cylindrica* de la zone de Kandara et d'autres régions des contacts. *C. odorata* protège du feu les jeunes tiges d'*Albizia* qui, non atteintes par les flammes et s'appuyant sur *C. odorata* surciment rapidement les fourrés et créent des conditions d'ombrage propices à l'installation de plantules d'espèces forestières.

Conclusions

Dans un contexte mégaclimatique général de réhumidification du climat de l'Afrique Centrale après une période sèche qui s'est étendue de 3 000 à 2,000 ans BP (Schwartz 1992, Maley 1992), il n'est pas étonnant d'assister à une avancée rapide des forêts denses semi-décidues sur les savanes comme c'est le cas au Cameroun. Cependant, cette avancée serait moins rapide sans *C. odorata* qui s'interpose avec efficacité entre la forêt et les feux de savane et favorise également l'installation d'espèces forestières en savane.

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Allelopathic Effects of Aqueous Extracts from Siam Weed on the Growth of Cowpea.

(Effets Allèlopathiques d'Extraits Aqueux d'Herbe du Siam sur la Croissance du Niébé)

L.S. Gill, G.O. Anoliefo and U.V. Iduoze
Department of Botany, University of Benin, Benin City, Nigeria

Résumé- Les effets d'extraits aqueux de tige, de feuille et de racine de *Chromolaena odorata* sur la croissance de *Vigna unguiculata* sont présentés. Généralement, les extraits de feuilles appliqués pendant 48 heures ont un effet inhibiteur significatif sur la croissance des racines, tiges et feuilles.

Abstract-This study reports on the effect of aqueous extract taken from the stem, leaf and root of *Chromolaena odorata*, on the growth of *Vigna unguiculata*. Generally, leaf extract for 48 hours had significant inhibitory effect on growth of the root, stem and leaf. However, results indicate that leaf growth was significantly inhibited by aqueous extract of root, stem and leaf.

Introduction

DeCandolle (1832) was probably the first person to suggest the possibility that many plants may excrete something from their roots which is injurious to other plants. Molisch (1937) proposed the term "allelopathy" for expressing the harmful effect that one plant species has on another through the formation of chemical retardants escaping into the environment. The concept of allelopathy was further supported and further developed by Bonner (1950), Grummer and Beyer (1960) Evenari (1961), Whittaker (1970), Pitman and Duke (1978) and Fischer *et al.* (1978). According to Lavabre (1991), allelopathic effects are controversial and still poorly understood. Allelo-chemicals (inhibitors) are produced by plants as end products, by-products, and metabolites, and are contained in the stem, leaves, roots, flowers, inflorescence, fruits and seeds of the plant. Of these plant parts, leaves seem to be the most consistent producers of these allelochemicals.

The four ways in which allelochemicals escape from a plant are: (i) volatilization, during which the terpenes are released from the leaves of some plant species; (ii) leaching (which has shown that living or dead leaves of many plants contain growth inhibitors); (iii) exudation by which case roots of several crop and non-crop species release large quantities of organic compounds that inhibit the growth of other plants; and (iv) decomposition, through which allelochemicals are released from plant residue.

Considerable research work has been done on the allelopathic effect of weeds on natural plant communities viz, abandoned fields or old fields (Abdul-Wahab & Rice 1967, Neil & Rice 1971). Although information on the allelopathic effects of weeds on many tropical crop plants is lacking, such information is available for some temperate crop plants. *Chromolaena odorata* is a troublesome weed of arable fields, roadsides and plantation crops such as oil palm, coffee and cashew (Eze & Gill 1992). The leaves of *C. odorata* contain a large amount of allelochemicals (Ambika & Jayachandra 1980), which may retard the growth of crop plants. Tijani and Fawusi (1989) have reported on the allelopathic activities of crude methanol extract of *C. odorata,* on seed germination and seedling growth of the tomato. A review of the literature indicates that work has not yet been done on the effect of aqueous extract of Siam weed on the growth of cowpea (*Vigna unguiculata).* Thus, the present study was undertaken in an attempt to record the effect of aqueous extracts on the growth of cowpea.

Materials and Methods

C. odorata was collected from University of Benin, Benin City (Lat. 6.5 N, Long. 6.0 W.), Edo State, Nigeria, and immediately brought to the laboratory where the leaves were removed from their stems. The roots and stems were then cut into 8 cm pieces. One kilogram each of leaves, stems and roots were soaked in 1 litre of distilled water, for periods of 36, 48 and 60 hours. The extracts were then filtered and stored in a refrigerator until they were to be used.

Seeds of two varieties of *V. unguiculata,* white and brown, purchased from the local market were used. These seeds were placed in petri dishes for germination. The seeds used in the study were steeped in water to determine their viability; those that floated were not used.

Sets of 10 seeds each with three replicates per treatment, were allowed to imbibe water on "Whatman No. 1" filter paper saturated with 4 ml. of respective extracts. This was done for a period of 36, 48 and 60 hours, for the leaf stem and root extracts. The seeds were allowed to germinate and grow in petri dishes. One set of petri dishes from each treatment was then put in the dark while the other received continuous light. The seeds which were maintained in a continuously dark area were kept in a cupboard, while those receiving continuous light were placed under a fluorescent lamp (1100 m/m at bench level). The filter papers were constantly moistened with the appropriate extracts. The seedlings were left to grow for four days at room temperature (28$\pm$2°C), and measurements were taken of the leaf, stem and root. The dishes in the dark were observed under red light. Emergence of 1 mm of the radicle was used as the criterion for germination.

Results and Discussion

The results of the effect of aqueous extract of leaf, stem and root of *C. odorata* on the root growth (cm) of *V. unguiculata* are shown in Table 1. The soaking of seeds in extracts for 48 hours seems to have given marked inhibition of root growth (1.80 and 1.29 cm., and 3.12 and 0.25 cm for light and dark, respectively). The same trend was observed for treatment of seeds with stem extract (2.48 and 0.41 cm, and 2.57 and 0.93 cm for mixed

Table 1. Effect of aqueous extract of *C. odorata* on the seedling growth (root) of *V. unguiculata*, by length (cm).

Treatment time (hrs.)	Mixed Light	Mixed Dark	White Light	White Dark
		Leaf Extract		
36	3.67 + 0.5	2.69 + 1.0	2.57 + 1.2	1.14 + 0.2
48	1.80 + 1.4	3.12 + 1.2	1.29 + 0.4	0.25 + 0.2
60	3.14 + 0.6	3.66 + 0.9	1.41 + 0.9	0.35 + 1.2
		Stem Extract		
36	2.73 +0.6	5.17 + 0.6	2.06 + 0.1	3.85 + 0.1
48	2.48 + 0.7	2.57 + 0.7	0.41 + 0.2	0.93 + 0.7
60	3.64 + 0.8	6.85 + 0.5	0.34 + 0.2	.20 + 2.7
		Root Extract		
36	3.28 + 0.5	3.50 + 0.2	1.79 + 0.4	3.41 + 0.5
48	4.04 + 0.5	4.49 + 3.1	2.36 + 0.4	3.92 + 0.8
60	3.64 + 0.6	2.70 + 0.5	3.56 + 0.4	2.70 + 0.4

and white seeds in continuous light and dark, respectively). However, there was no significant difference between the effects of leaf, stem and root extracts on the mixed and white seed varieties kept under continuous light. Leaf extracts saturated for 48 hours inhibited the height of the white more than the mixed variety of *V. unguiculata* (Tab. 2). In general, the root growth of white and mixed varieties was more affected by leaf, stem and root extracts (Tables 2 & 3). Table 3 also shows that leaf growth under continuous light was inhibited with seeds treated for 36 hours.

Eze and Gill (1992), report that *C. odorata* contains a large amount of allelochemicals especially in the leaves, which inhibit the growth of many plants in nurseries and plantations. The results of this study show that leaf extract of *C. odorata* had an inhibitory effect on the general growth of *V. unguiculata*. Pandya (1975) recorded similar results on the effect of *Celosia argentia* extract on root and shoot growth of *Sorghum vulgare* seedling. More recently, similar results on the effect of *Cyperus rotundus* leaf extract on seedling growth of both shoots and roots of wheat were found. Their results indicate that root growth may have been affected more than stem and leaves because roots were in continuous contact with the extracts. However, McCalla and Haskins (1964) suggest that allelochemicals or toxins are released from the weed by the action of microorganisms during decomposition. The growth inhibition caused by allelochemicals released from *C. odorata* may be due to its interference with the plant growth processes. Or the allelochemicals may be reducing cell division or auxin induced growth of roots.

Table 2. Effect of aqueous extract of *C. odorata* on the seedling growth of *V. unguiculata,* by height.

Treatment time (hr.)	Mixed Light	Mixed Dark	White Light	White Dark
		Leaf Extract		
36	1.90 + 0.2	2.83 + 1.1	1.08 + 0.1	1.85 + 0.3
48	1.74 + 0.1	2.81 + 0.5	0.95 + 0.2	2.13 + 0.3
60	2.28 + 0.3	3.80 + 0.6	1.79 + 0.8	2.12 + 1.0
		Stem Extract		
36	1.44 + 0.2	0.18 + 0.3	0.78 + 0.1	0.22 + 0.2
48	1.25 + 0.3	1.78 + 0.3	0.48 + 0.5	0.85 + 0.1
60	1.56 + 0.2	3.40 + 0.5	0	1.23 + 0.2
		Root Extract		
36	1.08 + 0.3	1.00 + 0.2	0.49 +0.1	0.34 + 0.1
48	1.18 + 0.3	0.97 +.03	0.57 + 0.1	0.48 + 0.1
60	1.17 + 0.4	0.87 + 0.3	1.01 + 0.1	0.78 + 0.2

Table 3. Effect of aqueous extract of *C. odorata* on the seedling growth (leaf) of *V. unguiculata,* by leaf size (cm).

Treatment Time (hr.)	Mixed Light	Mixed Dark	White Light	White Dark
		Leaf Extract		
36	1.39 + 0.2	0.40 + 0.2	0.24 + 0.1	0.07 + 0.07
48	0.58 + 0.2	0.45 + 0.2	0.31 + 0.2	0.14 + 0.1
60	1.10 + 0.2	0.87 + 0.7	0.50 + 0.1	0.44 + 0.1
		Stem Extract		
36	1.29 + 0.2	0.82 + 0.2	0.84 + 0.1	0.40 + 0.03
48	0.95 + 0.2	0.82 + 0.2	0.53 + 0.1	0.52 + 0.05
60	1.15 + 0.2	0.99 + 0.2	0.43 + 0.04	0.54 +0.08
		Root Extract		
36	0.93 + 0.2	0.58 + 0.2	0.77 + 0.04	0
48	0.98 + 0.2	0.78 + 0.1	0.58 + 0.1	0.77 + 0.2
60	1.16 + 0.2	0.60 + 0.1	0.90 + 0.03	0.56 + 0.1

The differential degree of inhibitory effect on leaves, stem and root at various durations (36, 48 and 60 hours), indicates that these 3 fractions have either different quantities of inhibitory allelochemicals, or that the nature of allelochemicals may differ. Based on this study, it is apparent that the leaf contains the highest inhibitory allelochemicals. The results demonstrate that Siam weed leaf extract has inhibitory effects on the growth of roots, stems, and the leaves of *V. unguiculata.* Thus it is recommended that the Siam weed should be physically removed from cowpea fields before the allelochemicals wash down with the rains.

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The Menacing Effects of *Chromolaena odorata:* a Case Study in the Brong Ahafo region of Ghana.

(Les Effets Négatifs de *Chromolaena odorata:* une Etude de Cas dans la Région de Brong Ahafo, au Ghana)

J.A. TIMBILLA, H. BRAIMAH
Crops Research Institute, Kumasi, Ghana

and

D. TOA-KWAPONG
Oslo, Norway

Résumé-Le présent article présente les résultats d'une étude sur l'introduction, le statut d'adventice et l'importance de *Chromolaena odorata* dans la région de Brong Ahafo au Ghana. L'espèce, de distribution irrégulière, fut introduite en 1974. Sur les 8 adventices les plus importantes relevées dans la région, elle occupe le premier rang. Six noms locaux lui sont attribués. Cette étude montre également que *C. odorata* est plus facile à nettoyer, plus lente a régénérer, nécessite de moins fréquents sarclages et présente un effet négatif moins marqué sur la production que les autres adventices. Dans les zones de savanes caractéristiques de la région, les paysans préfèrent *C. odorata* aux graminées telles qu'*Imperata cylindrica*, mais l'espèce demeure un problème dans les plantations. Etant une exotique, les méthodes de lutte biologique pourraient constituer les meilleures options pour son contrôle.

Abstract-An intensive survey was conducted in the Brong Ahafo Region of Ghana to ascertain the introduction, weed status and importance of *Chromolaena odorata*. The weed was first introduced in 1974. Distribution of the weed is irregular in the region. Of the eight major weeds recorded, *C. odorata* was ranked the most important. The importance of *C. odorata* has given rise to six local names. The survey also noted that *C. odorata* was easier to clear, was slower to rejuvenate, needed less frequent weeding, and its yield suppression ability was lower than other important weeds in the area. In typical savanna areas of the region, *C. odorata* was preferred to grasses such as *Imperata cylindrica*. However, it was a problem in plantations. Since the weed is exotic, biological methods may provide the best control options.

Introduction

Chromolaena odorata (L.) R. M. King and H. Robinson *(Eupatorium odoratum)*, generally known as the Siam weed, is a perennial scrambling shrub native to the neotropics where it is part of a very rich flora of Asteraceae [Compositae] (Muniappan 1988). The occurrence of the weed is limited to latitudes between 30°N and 30°S, and up to altitudes of 1000 m in locations with rainfall to about 2000 mm (Muniappan & Marutani 1988). It has become a major weed in parts of Asia, and West, Central and South Africa (*Chromolaena odorata* Newsletter 1991).

The spread and success of the weed in Africa and Asia is reported to be due to: 1) its genotype; 2) its ability to find and open new niches; 3) lack of resident predators; and 4) lack of competitors. Reports of successful species occurring in habitats other than their centers of origin or geographic range support this view.

In Ghana, the weed was first discovered in February 1969 in old abandoned experimental plots in the Legon Botanical Gardens (Hall & Enti 1972); by 1972 it had spread into the greater Accra, Central and Western regions. The present distribution of *C. odorata* in Ghana is as far north as 8° and 15' latitude (Timbilla & Braimah 1992). It is also known that farmers in the Brong Ahafo region have mixed feelings about the weed status of *C. odorata* (Timbilla & Braimah 1992).

Brong Ahafo is a region of Ghana where plantations such as cocoa, and arable crops, mainly yams, cassava, maize, groundnuts, cowpeas and vegetables, are cultivated extensively. An intensive survey was conducted in this area to re-examine some of the earlier findings. The survey aimed at ascertaining the historical background of the introduction of the weed, its distribution or spread, and its economic importance to land crop management.

Methods

A questionnaire was designed to interview farmers in eleven towns/villages in the region. In addition, for supplementary information, farmers were interviewed from eight other locations in the region at a market center in Techiman. Between two to four farmers were interviewed in two separate locations, in each of the eleven selected towns/villages.

A total of 56 farmers answered the questionnaires. This number includes a total of 22 groups from each town/village. The results were averaged from each village/town before the final compilation. On the market survey, 19 farmers were interviewed from 8 groups representing the locations mentioned above. A scale of 1-3 (1 being the least and 3 being the most important) was used to determine the three most important weeds in the region. A frequency table was used to analyze data on the management of *C. odorata* , looking at ease of clearing, rejuvenating rate, regularity of weeding, and yield suppression.

Results and Discussion

Farmer Populations and Acreages cultivated by Peasant Farmers

The sex ratio in the survey area was 55 male to 45 female farmers. From the market survey, it was found that male peasant farmers cultivated an average of 7.20 acres (range 3-15) while the females cropped some 3.14 acres (range 0.5-8). Therefore, males cultivated larger acreages than females in the study area. The larger farm size of the men probably reflects the difference in resources available to that gender group. In general, there were more male farmers in the study area than female farmers. However, in some villages the number of females were equal to or even higher than the males.

Introduction of *C. odorata*

The survey revealed that the earliest record of this noxious weed was about 1974. Since 1974, there has been a gradual and irregular spread of *C. odorata* into other parts of the region. Two hypotheses exist on how and when the weed was introduced. One hypothesis is that the government of the first republic brought the weed through Israeli experts to suppress the grass weeds in the Northern region. The northeast tradewinds then dispersed the seeds into parts of the region where they established. This is not very plausible since only recently has the weed begun rooting in most of the region. The second hypothesis claims that travelers and vehicles accidentally and or intentionally brought the weed into the region. This appears to be the more probable theory. It is also probable that the drier nature of some parts of the region has delayed the rapid spread of the weed.

Land area under cultivation in Towns/villages

Due to favorable climate (rainfall varies between 1300-1400 mm) and soil factors, farmers cultivate a variety of crops. It must be noted that the total land area under a crop is more important than the average acreages for that particular crop. For instance, the region is active in the production of tomatoes but the largest area devoted to tomato cultivation is only 15 acres. This suggests that most farmers are involved in cultivation of tomatoes.

Local Names of *C. odorata* in the Brong Ahafo Region of Ghana

The survey revealed various names by which *C. odorata* is known in the area. (Tab. 1). As in other parts of the country (c.f. Timbilla & Braimah 1992), the names given depend on the importance of the weed and its history of introduction.

Table 1. Local Names for *C. odorata*.

Name	Meaning/Significance of Name
Acheampong	Name of Head of State
Topaye	Spreader
Krawoni	Send for your mother
Woafa me fuo	You have taken my farm
Adiawuo	Killer
Woamaa me gye	I am taking over if you do not come

Weed status of *C. odorata*

Using a descending scale, with 1 being the most important, weeds were ranked in each locality. *C. odorata* was the most important of the three major weeds in the study area. (Tab. 2).

Table 2. Important weeds in the Brong Ahafo Region of Ghana.

Weed	Mean Weed Status	Rank
Chromolaena odorata	1.69	1st
Pennisetum purpureum	1.54	2nd
Imperata cylindrica	0.85	3rd
Euphorbia hirta	0.69	4th
Cyperus sp.	0.69	5th
Bidens pilosa	0.31	6th
Andropogon guyanus	0.23	7th
Sporobolus perimidalis	0.08	8th

Table 2 shows the three most important weeds in the study area are *C. odorata, P. purpureum* and *I. cylindrica*. They are followed by *Euphorbia hirta* and *Cyperus* sp. which are also important. The remaining three weeds, *Bidens pilosa, Andropogon guyanus* and *Sporobolus perimidalis* are of minor importance.

Generally, the distribution of weeds in the region was found to be irregular, particularly *C. odorata* . Its ranking in importance varied: it was the most important weed at three sites; second in importance at six sites; third in importance at one site; and not a major weed in the remaining three sites. This suggests distribution of the weed has not stabilized in some areas. Its importance probably depends on the location, type of other weeds present at the particular location, crops cultivated and land use practices. Its importance may also be determined by climatic factors that influence its establishment.

In areas such as Goaso, Dormaa Ahenkro, Sunyani, Techiman and Nkoranza, *C. odorata* is seen in dense populations. whereas in Sampa, Kintampo, Atebubu, Kwadwokrom and surrounding areas, weed populations range from patches to tufts and isolated stands. This variability is probably related to the climatic conditions in these areas since the latter areas are more northerly and drier than the former ones. The weed is not found beyond Gulumpe, which is at latitude 8°30' (Fig. 1). Still, farmers who had experience with *C. odorata* elsewhere see it as a serious threat to crop production.

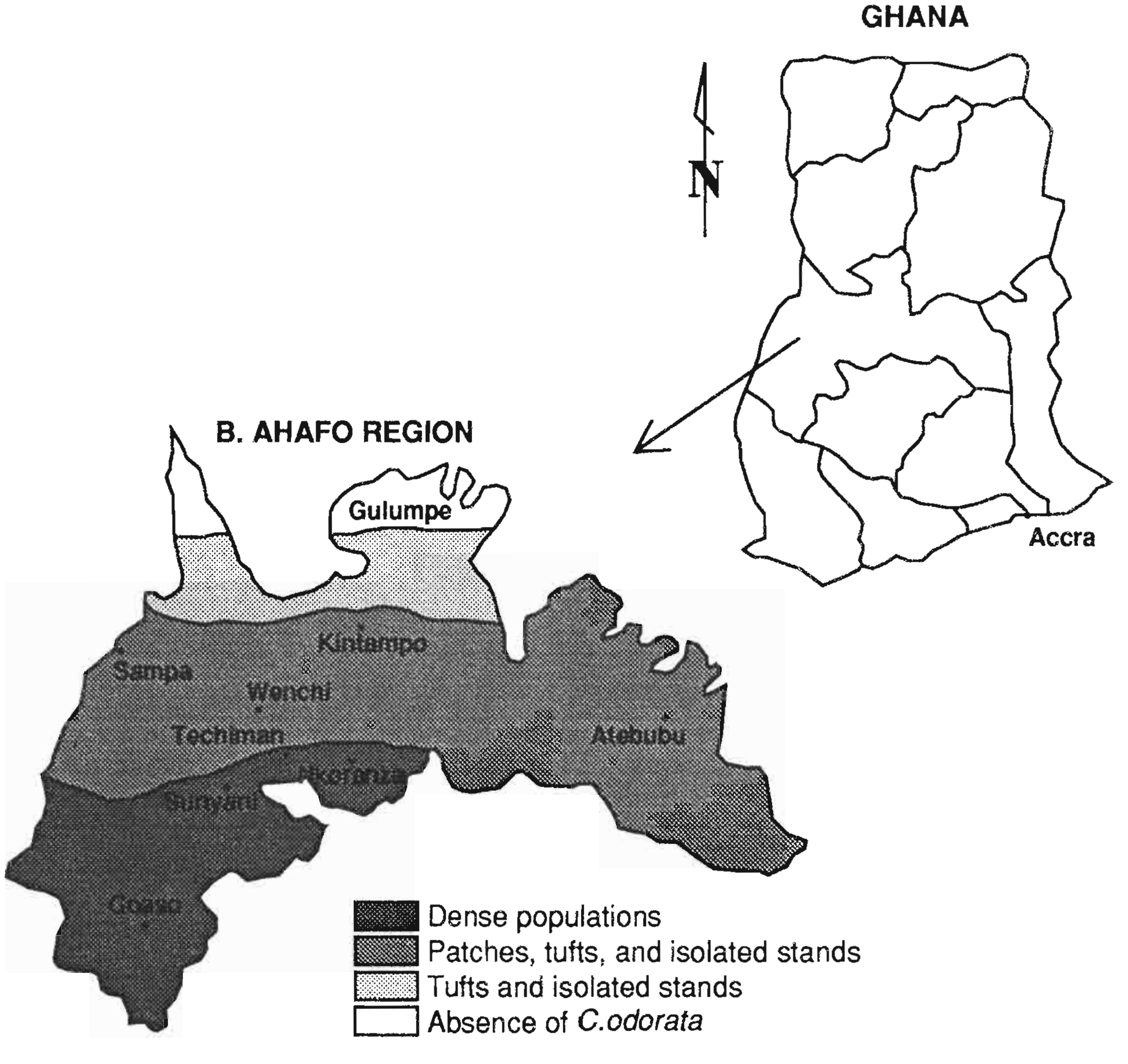

Figure 1. Distribution of *C. odorata* in the Brong Ahafo region on Ghana.

Sixty percent of farmers in the study area practice the slash and burn method of land preparation. This is twice as much as those who use hand hoeing. Chemical control and use of tractors are uncommon, with only five percent of farmers using either of these (Tab. 3, Fig. 2). The majority of the respondents (about 56%) said they do not use weedicides due to a lack of knowledge about these chemicals, while some 28% do not use them because of cost. The remaining 16% are simply not interested in using weedicides since alternatives such as slash and burn, and hand hoeing are equally effective. About 80% of the farmers in the study area stated that the presence of *C. odorata* has increased the frequency and severity of bush fires. *C. odorata* did not increase the frequency and severity of bush fires in areas dominated by grass weeds.

Table 3. Land clearing methods used in the study area.

Parameter	No. of farmers	% of groups interviewed
Weeding with Cutlass	12	60
Weeding with Hoe	6	30
Chemical control	1	5
Tractor plough	1	5
Total	20	100

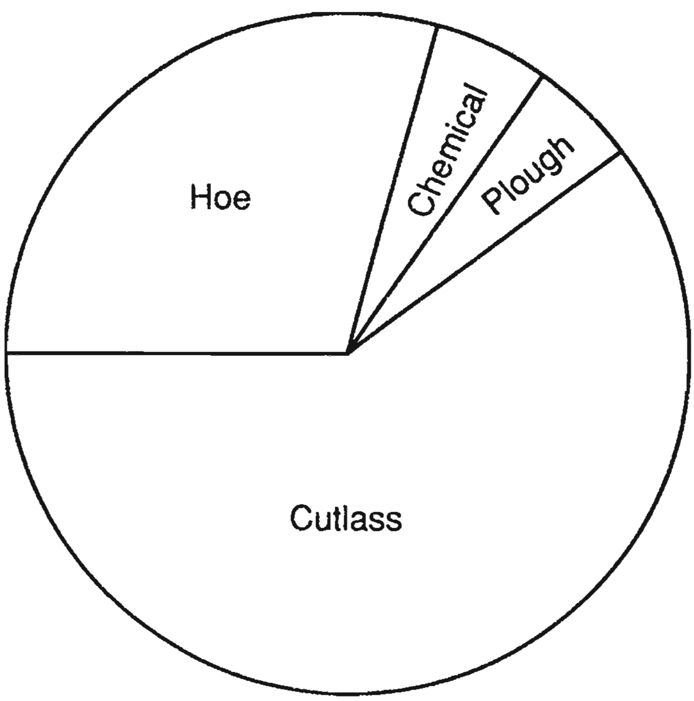

Figure 2. Methods for controlling *C. odorata*.

Farmers were divided on the need to control the weed on a national scale. While 45.5% agreed that some form of external control was necessary, the remaining 54.5% felt it was not necessary to institute any control measures. However, farmers from areas where the weed is established in dense stands do wish for its control. It was also found that areas where strong and high grasses such as *P. purpureum* were the major weed and *C. odorata* had a sparse distribution, the latter was the preferred weed. Control in these areas was not a priority since *C. odorata* is easier to manage than the grasses.

Management of *C. odorata* in the Brong Ahafo Region of Ghana

Data was also collected on the ease of clearing, rejuvenation rates, regularity of weeding, and yield suppression ability of *C. odorata*. These results are summarized in Tables 4a-4d.

Table 4a Farmer responses to clearing *C. odorata*.

Factors considered	No. of farmers interviewed	% of Respondents in favor
Easier to clear	10	72
Same as other weeds	2	14
More difficult to clear	2	14
Do not know	0	0
Total	14	100

Table 4b. Comparing regrowth rates of *C. odorata* with other weeds.

Rates Compared	No. of farmer groups interviewed	% of Respondents in favor
C. odorata faster than other weeds	4	33.3
C. odorata less rapidly	6	50.0
Same as other weeds	2	16.7
Do not know	0	0
Total	12	100

Table 4c. Weeding needs of *C. odorata.*

Factors considered	No. of farmer groups interviewed	% Respondents in favor
C. odorata needs more frequent weeding	2	14.2
C. odorata needs less frequent weeding	6	42.8
Same as others	2	14.2
Do not know	1	7.1
Needs much less frequent weeding when stumps are removed at initial weeding	3	21.4
Total	13	100

Table 4d. Yield suppression ability of *C. odorata* in comparison to other weeds.

	No. of farmer groups interviewed	Percentage
C. odorata suppresses yield more	3	23.1
C. odorata suppresses yield less	7	53.8
Same as other weeds	3	23.1
Do not know	0	
Total no. of farmers	13	100

It should be noted that using hoes to dig soil and maintaining arable crops by regular weeding, creates more problems with the grasses in large parts of the survey area. *C. odorata* seedlings on the other hand, are not a problem in field management. The weed is a major problem only when it is well established with an extensive root system.

Fifty percent of the farmers interviewed spend the same amount of money in clearing *C. odorata* fields as when clearing *P. purpureum*, the second most important weed. The remaining farmers said they spend higher amounts for clearing *P. purpureum* than *C. odorata*. Additionally, the survey revealed that *C. odorata* in some areas caused rapid disappearance and/or depopulation of important plants such as *Sorghum arundinaceum* (wild sorghum). Also, a report was made of a whole village burning down as a result of a bush fire attributed to *C. odorata.*

Conclusion

C. odorata is a new introduction to the Brong Ahafo region. In most parts its weed status has yet to finalize due to its irregular distribution. As a result, farmers have mixed feelings about its economic importance and management. In typical savanna areas of the region, *C. odorata* is preferred to grasses such as *I. cylindrica*. *C. odorata* is more problematic for plantation than arable crops since frequent weeding and fast growth of arable crops better suppresses weed growth. Also, fallow lands tend to get taken over by *C. odorata* if the weed has established. However, there is need to institute control measures for *C. odorata* to prevent the extinction of other weeds which are advantageous to the ecosystem. Since the weed is an exotic species, biological control may offer the best means for reducing its population below the economic injury level.

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Protection des Terroirs Pastoraux en Centrafrique, contre l'Embuissonnement des Savanes par *Chromolaena odorata.*

(Preventing *Chromolaena odorata* Invasion in Savanna Pastures of Central African Republic)

J. HUGUENIN
CIRAD-EMVT, France

and

BELDJE-BEDOGO
BANGUI, RCA

Abstract-From 1960 to 1963, *C. odorata* was introduced as a cover plant throughout the southwestern portion of the Central African Republic (CAR). In the thirty since its introduction, the plant has spread over half of the country. Since the 1980's, the impact of *C. odorata* on grazing lands has become acute. *C. odorata* gets established in range management systems that lack supervision by herdsmen and do not have planned rotation of savanna pastures. This also leads to the disappearance of other grasses. By applying constant pressure against *C. odorata* and maintaining savanna vegetation, expansion of the weed can be controlled without adversely affecting the pastures. This method will also prevent degradation of other forms of pasture. However, this requires new range management techniques such as farmers having to rotate their grazing lots.

Résumé-En Centrafrique, *Chromolaena odorata* a été introduite dans le sud-ouest du pays entre 1960 et 1963, comme plante de couverture dans des plantations. 30 ans après, elle est présente dans la moitié du pays. Son incidence néfaste, dans le domaine pastoral, a commencé à se faire sentir au cours des années 80. Le mode d'exploitation des parcours par les troupeaux, sans gardiennage ni rotation, favorise le développement de peuplements denses de cette composée, dans les savanes pastorales, au détriment de la strate herbacée. Toutefois, l'application conjointe, dans un terroir, de techniques de lutte curative contre des peuplements de C. *odorata* et de méthodes de protection et d'entretien des savanes peut main-tenir le développement de cette plante à un niveau sans incidence néfaste pour l'élevage. Cette approche de lutte intégrée, destinée à con-trôler le développement de cette plante dans les terroirs pastoraux, permet aussi d'éviter d'autres formes de dégradation des pâturages. Cependant, cela demande aux éleveurs d'adapter leurs prati-ques d'exploitation du milieu à des techniques de gestion de l'espace qui nécessitent, notament, des mises en repos fréquentes des parcours.

Development de *C. odorata* dans les Savanes Pastorales Subhumides CentraAfricaines et Problems Induits pour L'Elevage

Chromolaena odorata a probablement été introduite en République Centrafricaine (RCA) aux alentours de 1960. Le premier échantillon de cette plante en RCA a été récolté en 1963 à Berbérati, (sud-ouest du pays). Il est conservé en collection au.Département d'Elevage et Médecine Vétérinaire des pays Tropicaux (EMVT) du Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD) en France, à Maisons-Alfort (Audru *et al.* 1988).

En 1992, *C. odorata* est présente dans la moitié sud et ouest du pays (Huguenin & Beldje-Bedogo1992a) (Fig.1) où elle forme de nombreux peuplements denses (>25.000 pieds/ha). L'extension de cette plante est particulièrement spectaculaire dans les régions pastorales à régime semi-humide.

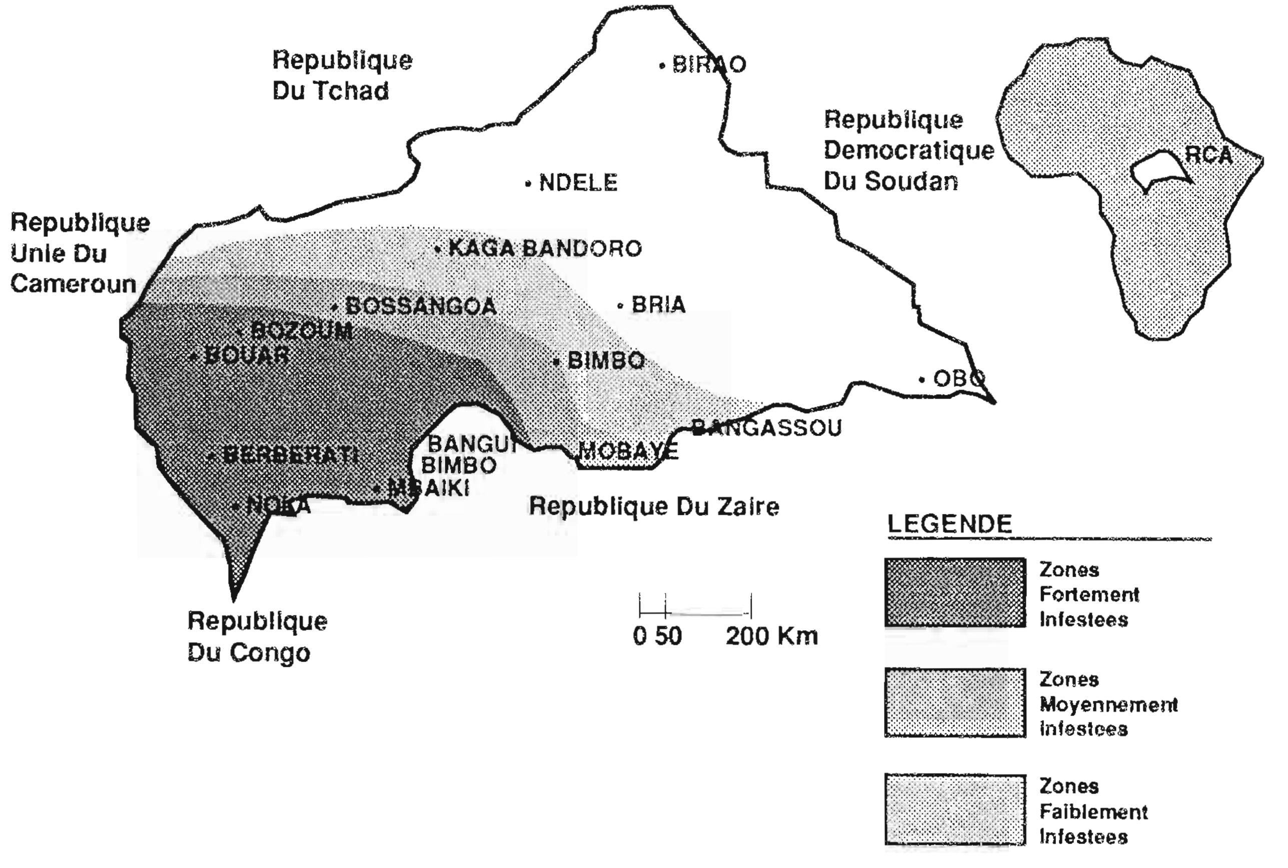

Figure 1. Etat de L'infestation par *Chromolaena odorata* en Republique Centraafricaine en 1992.

C. odorata est devenue une contrainte majeure dans ces zones, où le systäme d'élevage bovin traditionnel connaît une dynamique d'évolution qui voit diminuer les pratiques itinérantes d'exploitation du milieu et augmenter les éleveurs qui se fixent dans des "terroirs d'attache" (Marty 1992).

Les éleveurs qui ont le plus souvent investi dans les terroirs où ils se sont installés (résidences fixes, pistes, aménagement de zones d'abreuvement, marchés, liens sociaux avec le voisinage) rencontrent rapidement des difficultés considérables pour gérer 1"écosystème des savanes pastorales"[1].

La dégradation des savanes pastorales (décrites déjà par Koechlin 1961; 1962, Bille 1964) a atteint, avec le développement de *C. odorata*, des niveaux très préoccupants qui nuisent fortement à l'alimentation du bétail, car cette composée peut, en quelques années, éliminer toute autre espèce des savanes pastorales.

Développement de *C. odorata* dans les zones pastorales centrafricaines

Dans les zones d'élevage infestées, cette plante se diffuse surtout par ses akènes qui tombent du pelage d'animaux ayant traversé des fourrés en fructification (de janvier à mai).

La majorité des semences ainsi diffusée se concentre dans les endroits où les animaux stationnent. En conséquence, les fourrés infestants sont ceux que les animaux sont contraints de traverser ou de frôler en période de saison sèche (Huguenin & Beldje-Bedogo 1992b). Il s'agit notamment:

- de buissons en forme de "cordons-haies" épais de quelques mètres qui s'étendent tout le long des pistes et chemins pédestres que les animaux traversent lors de leurs parcours,
- de peuplements aux abords des campements et points d'abreuvements que les animaux sont contraints d'approcher.

En revanche, les fourrés denses isolés et de formes relativement circulaires qui peuvent couvrir plusieurs dizaines d'ha2 sont contour-nés par les animaux et donc peu dangereux pour la propagation des semences.

Ces "fourrés circulaires" croissant tant qu'ils ne rencontrent pas un tapis herbacédense. Les semences qui tombent à la périphérie de ces peuplements (comme celles qui tombent sous les fourrés) donnent des plantules qui s'étiolent et meurent. Une faible proportion de semences, propagée par les bourrasques et les eaux de ruissellemet peut être considérée comme dangereuse (FAC/CIRAD-EMVT 1993).

La formation des buissons de C. *odorata* le long des pistes dans les terroirs pastoraux provient:

- des engins de travaux public utilisés pour les travaux de réfection,
- du passage de véhicules en période de grenaison.

Pour les fourrés situés autour des points d'abreuvement, abords de campements, aménagements pastoraux (barrage, marché à bétail, bains déti-queurs), c'est la dégradation des pâturages due au systäme d'élevage traditionnel qui est en cause.

Le système d'élevage traditionnel en Centra-frique consiste, en saison des pluies[3] à laisser les bovins parcourir les alentours des campements sans gardiennage. En saison sèche une partie importante du cheptel est conduite en transhumance hors du "terroir d'attache".

En saison des pluies les animaux n'utilisent que le minimum de surface indispens-able, car ils sont assurés d' une repousse rapide fréquentent, donc, toujours les mêmes endroits (Koechlin 1962).

Cette pâture très sélective, avec des charges très variables, fortes aux abords des aires de repos(a) et des points d'abreuvement(b) et très faibles dans le reste du terroir pastoral, engendre des répercussions considérables sur la végétation des parcours. Aux abords des aires de repos, de traite, de distribution du natron, et d'abreuvement[4] s'ajoute l'action nocive du piétinement amplifie par les pluies.

A la périphérie de ces sites, la couverture herbacée en graminées vivaces (*Andropogon* spp., *Hyparrhenia* spp., *Loudetia* spp., *Panicum* phragmitoädes) diminue au profit d'annuelles (*Digitaria* spp., *Sporobolus* spp., *Eragrostis* spp.), Le tapis. herbacé s'amenuisant, les arbustes prolifèrent (*Annona sênêgalensis, Nauclea latifolia, Hymenocardia acida, Piliostigma thonningii, Vitex* spp., *Parinari curatellifolia, Terminalia* spp., *Harungana madagascariensis, Psorospermum* spp., *Crossopteryx febrifuga, Albizzia zygia, Syzgium guineense, Lophira lanceolata, Daniellia oliveri*, etc.).

En approchant des aires de stationnement des troupeaux, les grami-nées disparaissent, les plages de sol nu, enrichies en déjections, sont alors colonisées par des rudérales: *Sida* spp., *Cassia tora, Solanum torvum* et *C. odorata* qui arrivent à dominer toutes les espéces en formant des peuplements mono-spécifiques s'étendant rapidement.à toute la zone périphérique surexploitée.

Cette extension est essentiellement due à la dissémination des akènes par les animaux qui restent en saison säche dans le "terroir d'attache". Ces fourrés peuvent ainsi couvrir plusieurs centaines d'ha en quelques années (Huguenin & Beldje-Bedogo 1992b).

Incidence des invasions pour l'élevage en Centrafrique:

L'incidence néfaste sur le domaine pastoral a commencé à se faire sentir dans les années 80 vers Baboua (frontière du Cameroun) et à partir de 84-85 (Boutrais 1988) vers Bossembélé au centre du pays.

Dans un terroir pastoral envahi les campements deviennent insalubres pour les hommes et leur bétail en raison des insectes et des rongeurs qui abondent dans les fourrés. Ces peuplements denses deviennent un refuge pour certains prédateurs qui s'attaquent aux veaux et au petit bétail, notamment les hyènes (Audru *et al.* 1988).

Les peuplements de *C. odorata* qui encerclent les campements et points d'abreuvement gànent considérablement le déplacement des animaux (FAC/CIRAD-EMVT 1993). Les alentours de ces terroirs fortement infestés doivent àtre régulièrement entretenus par rabattage sinon les aménagements peuvent devenir rapidement inaccessibles. A 50 km à l'ouest de Bangui, un bain détiquerur abandonné est inaccessible depuis 1988, entouré par un peuplement de *C. odorata* dont le rayon dépasse 1.200 m.

Les pistes secondaires de ces terroirs peu fréquentées en hivernage se referment période de croissance de la végétation et elles doivent àtre réouvertes chaque année.

Après plusieurs années d'exploitation, les par-cours, màme mis en repos, n'arrivent plus àse régénérer et sont rapidement envahis par cette composée. Les cultures fourragères mises en place pour pallier au manque de pâturages en saison sèche, sont rapidement enherbées par *C. odorata* et doivent faire l'objet d'entretien particulier.

Après chaque saison des pluies, il est impératif de désherber ces pâturages artificiels soit manuellement, soit par traitement avant la floraison. En conséquence, le développement incontrìlé de *C. odorata* décourage les éleveurs qui souhaitent se fixer dans des "terroir d'attache" et ceux qui désirent limiter la transhumance.

Dans un terroir indemne, un campement peut res-ter en place 10-15 ans avant d'àtre déplacé vers un pâturage plus productif. Par contre, dans les terroirs infestés les éleveurs sont souvent contraints de déplacer leur campement hors du terroir 5-6 ans après leur installation, même si le pâturage reste relativement productif. La diminution du potentiel fourrager ne se réduit pas à la seule perte de surfaces occupées par ces peuplements, mais à la surface totale des parcours de ces terroirs qui sont considérés par les éleveurs comme inexploitables (Audru *et al.* 1988).

Lutte integree pour les Zones D'Elevage en CentraAfrique.

L'Agence Nationale de Développement de l'Elevage (A.N.D.E. centrafricaine) en collaboration avec le Département EMVT et le laboratoire de Malherbologie du CIRAD a conduit un programme d'études de 1989 à 1993 (sur financement FAC) en malherbologie agro-pastorale.

Aucune technique de lutte employée isolément, n'arrive à détruire un peuplement de *C. odorata* de façon durable (Huguenin & Beldje-Bedogo 1992a). Le maîtrise de cette plante dans certaines cultures pérennes, peut se faire par un désherbage chimique annuel, lorsqu'il est possible de répercuter le surcoût de cette intervention sur le prix de vente des produits.

En élevage exten-sif, une intervention doit tenir compte des différences d'échelles:

- dans l'espace car, contrairement à une opération de désherbage classique qui se raisonne généralement au niveau de la parcelle, une lut-te contre l'embuissonnement de parcours con-cerne l'ensemble d'un terroir, surtout avec une plante facilement disséminée comme *C. odorata.*

- dans le temps, car il n'est pas envisageable d'intervenir chaque année au niveau d'une région.

Un ensemble d'actions a été défini qui permete de con-trîler le développement de C. *odorata* au niveau d'un terroir pastoral (Huguenin & Beldje-Bedogo 1992b). Ces actions s'inscrivent dans une approche de lutte intégrée qui est la seule, dans le contexte pastoral à combattre effica-cement le phénomène d'embuissonnement des savanes par C. odorata. L'objectif est d'arriver en combinant plusieurs techniques de lutte à maintenir cette plante dans un terroir à un niveau de développement suffisamment bas pour ne pas nuire aux activités pastorales. Cet ensemble d'actions correspond aux principales zones d'élevage de RCA infestées par cette composée (Fig. 2).

Les sols de cette région sont essentiellement argilo-sableux: 50 à 60% d'argile et acide: 4,75 à 5,2 de pH Le climat est de type tropical semi-humide: 1.400 à 1.500 mm de pluies/an avec un indice des saisons pluviométriques (Aubreville 1950) qui varie de 6-3-3 à rue altitude supérieure à 1.000 m à 7-3-2 dans les zones altitude moyenne de 700 m.

A. Itinéraire technique pour éliminer les peuplements de *C.odorata* situés le long des pistes

- Vers la fin de la saison des pluies, avant la floraison de la plante les buissons sout traités avec une bouillie herbicide. La plante présente à cette époque un bon rapport feuille/tige et les plantules de l'année qui ne sont pas mortes après étiolement sont aussi atteintes.

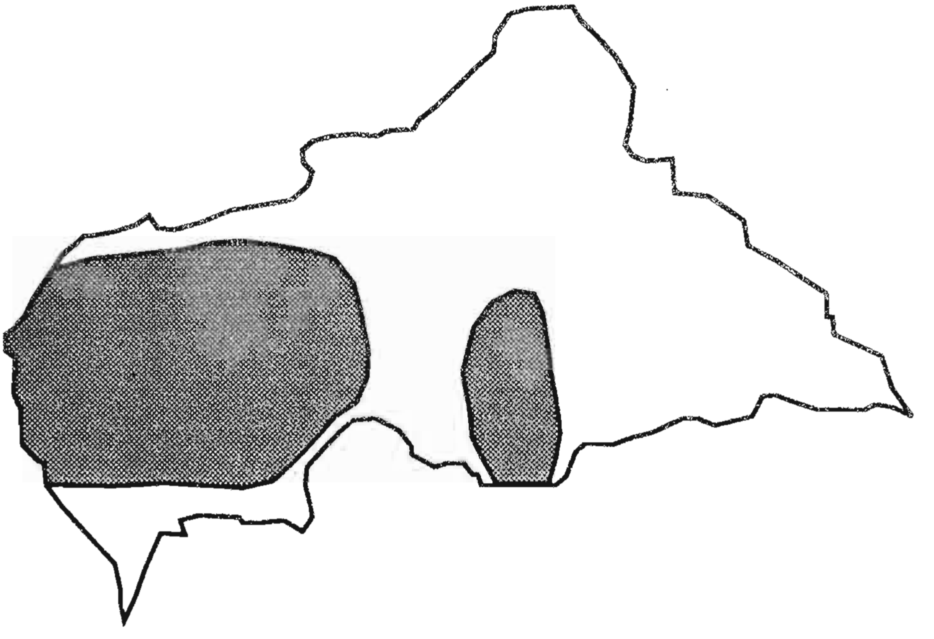

Figure 2. Aire de chevauchement actuelle de l'occupation spatiale: cheptel - *C. odorata* in 1992.

- L'herbicide recommande en le piclorame à raison de 360 g de m.a./ha, molécule sélective contre les graminées. D'autres produits se sont révélés efficaces commele TORDON SUPER (association du piclorame à 120 g de m.a./l de p.c. et du triclopyr à 240 g/l) et le 2,4-D à raison de 2.880 g de m.a./ha (Huguenin *et al.*1992).

- La bouillie est pulvérisée jusqu'à 40 m de chaque cìté de la piste avec des canons pneumatiques.

- Deux à tres mois après le traitement, les buissons sont morts; il est recommandé de les brñler afin d'éliminer cette végétation desséchée qui peut gêner les semis de plantes de couverture en début de saison des pluies.

- Lorsqu'une strate de graminées vivaces ne s'installer pas naturellement apräs la disparition de *C. odorata*, il faut procéder à l'implantation de plantes de couverture. Cela évite les réinfestations et protège les accotements de pistes de l'érosion.

En zone soudano-oubanguienne[5] *Calopogonium muconoïdes* semé à 5 kg de semences ha per-met en une saison des taux de recouvre-ment du sol supérieur à 80%. Un pied de cette plante peut couvrir 0,25 m^2 et produire 700 graines dès la première année d'implantation. Quelques semaines après le début de la saison des pluies, le taux de recouvrement du sol par cette plante peut atteindre 100%, ce qui empêche le développement de *C. odorata* a pentir d'akènes en dormance secondaire dans le sol depuis plusieurs années (Gautier 1992) où de nouvelles semences.

- Le coût de cette lutte en RCA se situe entre 18.000 à 20.000 FCFA/ha sans plantes de couverture (7.000 FCFA de plus/ha). Ce calcul inclut intrants (herbicides, semences, carburant), salaires, amortisement du matériel et des véhicules.

B. Itinéraire technique pour éliminer les buissons aux abords des campements, sites d'abreuvement et aires de repos

- Rabattre la végétation soit par le feu en fin de saison sèche, soit par voie manuelle si la superficie des fourrés n'est pas trop importante, soit par voie mécanique en milieu de saison des pluies.

- Traitement au piclorame (240 g de m.a./ha) lorsque les repousses atteignent 60 à 100 cm de hauteur (6 à 8 semaines après un rabattage manuel).

- Semer une plante de couverture en début de saison des pluies.

Il est possible de traiter à partir de layons dont l'écartement dépendra du type de pulvérisateur employé 6 m avec des pulvérisateurs à moteur portés à dos; 80 m avec certains canons pneumatiques. Lors de traitement par layons il faut également traiter l'intérieur des layons lorsque les repousses de *C. odorata* dépassent 60 cm.

C. Approche préventive

Le secteur exploité par le cheptel d'un campement est divise en zone.

Les zones très envahies sout interdites d'accès au bétail, surtout en saison sèche. En milieu ou fin de saison sâche, les fourrés sout brûlés s'ils ont encore suffisamment de graminées. Ces feux annuels peuvent épuiser à terme le peuplement, gâner sa reproduction par semences et limiter son développement.

Les parcours peu envahis sont fractionnés de faäon à en mettre une partie en défens de pâture. La mise en défens se fera par gardiennage avec des bouviers ou par enclosement (limites naturelles, haies vives[6], ou clôtures).

Les parties du terroir sont mises en repos doivent faire l'objet de travaux visant à entretenir un couvert herbacé dense (*Audru et al.* 1988, Huguenin & Beldje-Bedogo 1992a, Gautier 1992).

Ces travaux:

Comprenant l'élimination des arbustes et arbrisseaux pour éclaircir les savanes afin de diminuer l'ombrage et permettre ainsi aux grami-nées vivaces de se développer (Audru 1977;1983, Huguenin & Beldje-Bedogo 1992, Koechlin 1963),et la

régénération de la strate herbacée par une mise en défens de pâture qui nécessite parfois l'implantation d'espèces fourragères par sursemis (Dulieu 1987, Cesar 1992) (ex. *Stylosanthes hamata, S. guianensis, Aeschynomene histrix, Panicum maximum, Brachiaria ruziziensis).*

Lorsqu'un parcours restauré est ouvert de nouveau au bétail, son exploitation doit se réaliser en alternance minimum d'une année de pâture pour une année de mise en repos (durant laquelle un feu de brousse sera pratiqué le plus tard possible en saison sèche). Ainsi le développement de C. odorata dans les savanes peut être évité. Les quelques pieds survivants seront arrachés."

En RCA, la technique la plus économe en intrants et temps de travail consiste à éliminer les arbustes en les traitant avec des arboricides en fin de saison des pluies. Des annellations de 20 cm environ avec des entailles en "nid d'abeilles" sont pratiquées à la base du tronc. Sur la partie annelée une bouillie arboricide est appliquée avec des pulvérisateurs à main (0,5 à 1 l de contenance).

Cette bouillie peut àtre composée de triclopyr (à raison de 480 g/l) dilué à 50% dans du gasoil soit de piclorame (à raison de 240g/l) dilué à 50% dans de l'eau.

L'association de ces molécules peut permettre d'obtenir un spectre d'efficacité encore plus important sur les différentes essences d'arbustes envahissants des savanes semi-humides.

Les touffes de *C. odorata* sont brûlées après le traitement des arbustes. Les parcours ainsi traités seront mis en défens de pâture au moins deux années. Ensuite il est conseillé d'alterner une année d'exploitation pour une année de mise en repos. Il est préférable de ne pas intervenir dans des savanes qui dépassent 1.500 arbustes ha et qui ne présentent ps suffisamment de graminées vivaces. Cette technique coûte 24.000 F CFA/ha pour une moyenne.

Conclusions

Dans les savanes pastorales des régions semi-humides centrafricaine *C. odorata* ne se développe que dans les zones exploitées sans soucis de préservation de la strate herbacée.

Bien avant l'apparition de cette plante dans les régions d'élevage en RCA, les formations végétales des parcours surexploités se dégradaient déjà en savanes embroussaillées par tout un cortège d'arbustes envahissants. En une ou deux décennies les parcours se transforment en savanes arbustives denses, en savanes boisées ou en forêts claires.

Avec *C. odorata* la dégradation des parcours est accélérée. L'embuissonnements progresse de faáon "topocentrique" à partir des campements, des points d'abreuvement et des axes de circulation de véhicules et du bétail.

Cette nouvelle forme de dégradation et d'embuissonnement se caractérise par une occupation très rapide de l'espace libéré par les graminées surexploitées et gênées par l'ombrage des ligneux. "La restauration par mise en défens de parcours envahis en 5 ans par des peuplements denses de *C. odorata* devient inefficace. L'application de techniques de lutte contre les peuplements de *C. odorata* et de méthodes de protection des savanes peut maintenir le développement de cette plante à un niveau qui soit sans incidence néfaste pour l'élevage. Ces méthodes permettent d'éviter la dégradation des pâturages et d'améliorer leur productivité.

Cependant, la lutte intégrée contre l'embroussaillement des savanes pastorales ne peut être envisagée qu'à travers une dynamique globale d'évolution des modes d'exploitation des terroirs pastoraux. De nouvelles pratiques de conduite du bétail doivent être adoptées par les éleveurs. Pour espérer s'inscrire dans une évolution de "développement durable" les éleveurs doivent maintenant entretenir et màme améliorer les ressources fourragères naturelles de leurs terroirs.

En contrepartie, une reconnaissance foncière doit être accordée aux éleveurs. Le simple usufruit doit être remplacé par un "droit de maîtrise prioritaire" (LeRoy 1992, Marty 1992) du terroir pastoral exploité et entretenu par une communauté d'éleveurs.

Footnotes

1Si le feu est considéré comme un facteur naturel, on peut considérer que les savanes ont atteint un stade climacique. En effet, dans l'état actuel des choses, partout où le feu passe réguliärement, l'équilibre de la végétation parait stable. La mise en pâture d'une savane introduira naturellement un certain nombre de dacteurs nouveaux dont l'influence va se faire sentir su l'équilibre préétabli. Ces facteurs seront essentiellement: - le broutage, l'apport de matière organique - l'apport d'espèces nouvelles sous la forme de graines attachées au pelage des animaux (Koechlin 1963). Depuis l'introduction de *C. odorata* dans les zones d'élevage, ce dernier facteur est devenu encore plus inquiétant.

[2]le plus souvent il s'agit d'anciens campements.

[3]les Mbororo de l'ouest centrafricain divisent la saison des pluies (SP) en trois partie: début de la SP= Chéto, pleine SP= Ndoungou, fin de SP= Ndaboundé, l'ensemble couvrant 7 à 8 mois suivant les années et les régions (Avril-Mai à Oct.-Nov.).

[4]"doudale", "kobowol", et "régordé" en langue poular.

[5]1500 mm de pluie/an, avec un indice des saisons pluviométriques de 7-3-2.

[6]Pour les haies vives, il faut retenir Tithonia diversifolia qui gàne le développement de *C. odorata* par des phénomènes d'allélopathie (M. Deat, pers. comm.).

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The Management of *Chromolaena odorata* (L.) R. M. King and H. Robinson in Indonesia.

(La Gestion de *Chromolaena odorata* (L.) R. M. King et H. Robinson en Indonésie)

S. Tjitrosemito
Southeast Asian Regional Center for Biology, BIOTROP
Bogor, Indonesia

Résumé- Les problèmes posés par *Chromolaena odorata* ont été signalés pour des plantations (hevea, cocotier, palmier à huile, canne à sucre), des pâturages, des forêts et d'autres zones agricoles. En plantation, la gestion de *C. odorata* consiste à déraciner les plants de manière à garder un niveau faible d'infestation pendant la phase d'établissement des arbres. Lorsque la canopée de la plantation se ferme, la croissance de *C. odorata* est ralentie. Néanmoins, à la fin du cycle de la plantation (20-25 ans pour l'hevea), *C. odorata* peut redevenir abondant et le programme de lutte doit être rétabli. Dans les pâturages, les populations de *C. odorata* augmentent; des mesures de lutte chimiques ont été tentées mais n'ont eu que peu d'effets. La lutte biologique utilisant *Pareuchaetes pseudoinsulata* a été initiée par la station de recherche de Marihat à Sumatra, et le BIOTROP à Bogor est en train de multiplier cet agent en vue de lâchers immédiats sur l'île de Java. Un groupe de 500 adultes a également été envoyé sur l'île de Timor pour être multiplié et lâché dans un proche avenir. D'autres travaux sur la lutte biologique dans la région sont menés avec l'aide de l'ACIAR, y compris l'introduction en Asie du Sud-Est de *Procecidochares*, une mouche Tephritidae formant des galles, du foreur de tige *Mescinia parvula*, ou de l'Agromyzidae foreur de tige *Melanogromyza eupatoriella*.

Abstract-The problems of *Chromolaena odorata* have been reported in plantations (rubber, coconut, oil palm, sugarcane), pastures, as well as in forests and other agricultural areas. In plantations, management of *C. odorata* is carried out by uprooting the weeds to keep the population low during the early establishment of the plantation. When the canopy cover of plantations becomes closed, the growth of *C. odorata* is slowed down. However, at the end of the plantation cycle (20-25 years for rubber), *C. odorata* becomes very abundant again, and the control program has to be reinitiated. In pastoral areas, the population of *C. odorata* is increasing; chemical control measures have been taken but have shown minimal results. Biological control using *Pareuchaetes pseudoinsulata*

has been initiated by Marihat Research Station in Sumatera, and BIOTROP is in the process of rearing this agent for immediate release on Java Island. A batch of 500 adults has also been sent to Timor Island where it will be reared and field released in the near future. Further work on biological control in the region has been supported by ACIAR, including introducing either the stem-galling tephritid fly *Procecidochares*, the shoot-boring moth *Mescinia parvula*, or the shoot-boring agromyzid *Melanagromyza eupatoriella*, to the Southeast Asian region.

Introduction

As reported by Sipayung *et al.* (1991) and Tjitrosoedirdjo *et al.* (1991), *Chromolaena odorata* in Indonesia has spread from Sumatera in the west, to West Irian in the east. It is considered a noxious weed among various crops such as coconut, teak (Setiadi 1989), rubber and oilpalm (Syamsuddin *et al.* 1993), as well as in pasture lands.

In rubber and other plantations, farmers try very hard to keep the population of *C. odorata* to a negligible level, from the early stages of the plantation to about 15-20 years later. After this period, weeds growing between the rows are mostly left unattended since weed infestation will not harm the older, standing rubber trees. In subsequent re-planting activities, however, a considerable amount of labor has to be spent to control *C. odorata* and the associated weeds before crops can be planted.

Weed Management in Rubber Plantations

Table 1 lists the vegetational composition of weeds that are common in rubber

Table 1. Vegetation composition of weeds in rubber plantations.

Species	Summed Dominance Ratio (SDR)
Ischaemum timorense	16.2
Ottochloa nodosa	13.5
Borreria alata	11.2
Mikania micrantha	9.5
Tetracera scandens	8.3
Scleria sp.	7.5
Melastoma affine	4.1
Chromolaena odorata	6.1
Merremia sp.	5.3
Diodia sarmentosa	4.0
Paspalum conjugatum	4.0
Nephrolephis biserrata	3.4
Mimosa invisa	2.8
Axonopus compressus	2.7
Paspalum commersonii	2.4

plantations. This composition is normally managed and directed towards the eradication of woody weeds (*C. odorata*, *Melastoma affine*, *Tetracera scandens*, etc.), and to facilitate the domination of soft weeds such as *Ottochloa nodosa*, *Paspalum conjugatum*, or *Ischaemum timorense*. These soft weeds are preferred as soil cover since they prevent excessive soil erosion. However when left alone, the successional change leads to the domination of woody weeds, especially *C. odorata*.

Growth Analysis of *C. odorata*

The growth of *C. odorata* and other associated weeds was analyzed in a green-house using local soils (latosol) with adequate moisture, in an effort to understand weed behavior (Tab. 2).

Table 2. Growth of *C. odorata* and the associated weeds *Borreria alata* and *Ischaemum timorense* (Tjitrosoedirdjo 1992).

	C. odorata			*B. alata*			*I. timorense*		
Time(weeks)	4	8	12	4	8	12	4	8	12
Height(cm)	4.50	45.00	17.00	4.50	33.40	55.60	4.10	26.10	63.20
Total Dry Weight (W)(g)	0.03	2.97	19.46	0.15	2.86	9.29	0.025	0.69	4.94
Stem(S)(g)	0.005	0.89	8.34	0.026	1.42	5.77	0.010	0.23	2.56
Leaves(L)(g)	0.021	1.65	7.85	0.096	1.18	2.53	0.013	0.31	1.63
Root(R)(g)	0.004	0.43	3.21	0.028	0.26	1.00	0.002	0.15	0.75
Leaf area (cm^2)	20.90	745.8	1749.80	39.40	256.90	582.50	13.00	58.10	563.00
RGR ($g\ g^{-1}$ week)	1.15	0.50		0.74	0.29		0.83	0.50	
LAR ($cm^2 g^{-1}$)	317.50	134.20		126.27	72.83		69.70	103.10	
NAR ($g\ cm^{-2}$ $week^{-1}$)	0.36	0.37		0.59	0.40		1.19	0.49	

RGR: Relative Growth Rate ($g\ g^{-1}\ week^{-1}$) = $\frac{\ln W_2 - \ln W_1}{t_2 - t_1}$

LAR: Leaf Area Ratio ($cm^2\ g^{-1}$) = $\frac{(L_2 - L_1)(\ln W_2 - \ln W_1)}{(\ln L_2 - \ln L_1)(W_2 - W_1)}$

NAR: Net Assimilation Rate ($g\ cm^{-2}\ week^{-1}$) = $\frac{W_2 - W_1 (\ln L_2 - \ln L_1)}{(L_2 - L_1)(t_2 - t_1)}$

The growth of *C. odorata* proved to be very interesting. In the first 8 weeks it allocated a greater proportion of its biomass for producing leaves; however, in the later growth more biomass was allocated for stems which produced relatively tall and leafy weeds. This behavior supports the aggressive nature of *C. odorata* which shades out other shorter vegetation. The Relative Growth Rate (RGR) went down as *C. odorata* grew. Although the physiological index in term of Net Assimilation Rate (NAR) was low, it was compensated for by the leafy nature of this weed as is shown by the very high value of Leaf Area Ratio (LAR). Although the LAR went down in later growth, it was still higher than with other weeds that were tested (134.2 cm^2/g).

I. timorense had a very high physiological index, especially in its early growth; in later growth, a large proportion of older leaves were still attached to the stem reducing the value of NAR. *I. timorense* was able to grow fast, climbing over other weeds to dominate the area. *B. alata* had the lowest RGR. If either *C. odorata* or *I. timorense* grows freely, *B. alata* is not able to dominate the area.

C. odorata in Pasture

Work on the control of *C. odorata* in natural pasture was carried out in Jonggol, Bogor, West Java, at a site which was utilized as a common grazing area. The area was developed as an experimental station, administered by the Faculty of Animal Husbandry at Bogor Agricultural University. A strong fence was constructed around the area to prevent trespassing, thereby transforming it into a confined natural pasture. However, the intended livestock that were to graze the pasture were late, and the vegetation followed the natural succession into *Imperata*, and eventually into *C. odorata* dominated vegetation.

An experiment was carried out to find suitable methods to control *C. odorata* and to provide the development of natural pasture. The treatments consisting of 6 methods, were in randomized blocks and replicated 4 times in plots of 5 X 10 X 10 m^2. The application of treatments was estimated by analyzing the vegetation in a quadrant of 1 X 1 m^2. The results are shown in Table 3.

During the initial stage, the population of standing *C. odorata* under treatments of picloram (2.0 kg ai/ha), and 2, 4-D (3.0 kg ai/ha), did not differ from that of other controls since the herbicides were applied post-emergence. Also treatment by diuron (2.4 kg ai/ha) and alachlor (3.0 kg ai/ha), were not different from soil cultivation, since under these treatments the standing weeds were uprooted and the soil was thoroughly cultivated.

Two weeks after treatment, the seed of *C. odorata* started to germinate, and diuron (2.4 kg ai/ha) was able to reduce the emergence of seedlings while alachlor was not. Picloram (2.0 kg ai/ha) and 2, 4-D (3.0 kg ai/ha) were able to kill the standing weeds, but *C. odorata* sprouted from the base of the stem. The population, however, was still greatly reduced for up to 16 weeks after application. The yield of subsequent herbage (mainly *I. timorense*) is shown in Table 4.

Table 3. Mean number of *C. odorata* (per m^2), 0-16 weeks after treatments (data were transformed to x + 0.5).

Treatment	Weeks 0	2	8	16
1. Control (no treatment)	4.25a	4.04a	4.48a	4.94a
2. Soil cultivation	0.71b	2.15b	2.06b	2.48b
3. Soil cultivation + Diuron (2.4 kg ai/ha)	0.71b	1.43c	1.55c	1.46c
4. Soil cultivation + Alachlor (3 kg ai/ha)	0.71b	2.46b	2.80b	2.90b
5. 2, 4-D (3.0 kg ai/ha)	4.54a	1.18c	1.61c	1.34c
6. Picloram (2.0 kg ai/ha)	4.81a	1.27c	1.42c	1.28c

NB. Numbers followed by the same letter in a column do not differ significantly at 5%.

Table 4. Mean herbage yield (g fresh herbage/m2) under various methods of *C. odorata* control.

Treatment	Weeks 8	16
1. Control (no treatment)	110.80 b	97.60 a
2. Soil cultivation	150.70 c	171.60 b
3. Soil cultivation + Diuron (2.4 kg ai./ha)	50.10 a	69.00 a
4. Soil cultivation + Alachlor (3 kg i/ha)	43.20 a	74.00 b
5. 2, 4-D (3.0 kg ai/ha)	112.10 b	134.00 b
6. Picloram (2.0 kg ai/ha)	121.20 bc	147.70 b

NB: Numbers followed by the same letter in a column do not differ significantly at 5%.

Under control, the herbage tended to yield less with time (16 weeks after planting). This is presumably due to the severe competition imposed by *C. odorata*. While diuron was able to reduce the growth of *C. odorata*, it also damaged the grasses. The use of diuron in this particular situation seems to be inappropriate. Also, alachlor may not be appropriate since it was not able to prevent the germination of *C. odorata* seeds enough to allow natural grasses to proliferate.

Biological Control

Work on biological control of *C. odorata* in Java has been supported by ACIAR under the leadership of Dr. R.E. McFadyen of Alan Fletcher Research Station in Australia.. These efforts include:

1) Rearing Facilities

The rearing room is 4 X 7 m^2, air-conditioned, with aluminum screens on the windows that prevent the insects from escaping. The room is actually an insect quarantine facility. There are four sizes of rearing cages: 20 small cages (0.4 x 0.4 x 0.38 m), 6 medium cages (0.5 x 0.5 x 1 m), three big cages (0.5 x 0.5 x 1.75 m), and one aluminum cage. Rectangular plastic containers (37 x 27 x 8 cm) with big petri dishes are utilized to rear the young larvae of the insect. In addition to cages, plastic containers, and petri dishes, there is a confined area between two greenhouses, enclosed with a rough iron screen that is big enough to grow *C. odorata* on which *P. pseudoinsulata* can be released.

Light intensity during the day and night was not measured. In the daytime, indirect sunlight penetrates through the side glass of the room; at night, fluorescent light from outside of the building is the only light source.

2) Rearing of *P. pseudoinsulata*

The rearing of this insect began by acquiring 300 pupae from the Marihat Research Center for Plantation Crops. These were obtained with the help of Mr. A. Sipayung, Mr. Kasno (in March 1993), and the staff of ACIAR Project 9110 from BIOTROP.

The pupae were kept in petri dishes which were then placed in the small cages. About 250 normal moths emerged from 300 pupae; most of the remainder emerged with abnormal wings and 13 pupae did not emerge at all. Some of the moths were placed in the big cages where potted *C. odorata* was placed to provide oviposition sites. Some moths were also kept in glass jars containing tap water. The moths mated in both the small and big cages. The females oviposited on the leaves of *C. odorata* as well as on the screen.

The larvae originating from the eggs being laid on both leaves and screen were first reared together. Later, larvae originating from the eggs laid on the screen were no longer reared. The reason for excluding these larvae in the rearing activities was to avoid the production of lower quality generations. Afterwards, these eggs were rubbed off the screen.

Newly-hatched larvae were then reared in rectangular plastic containers until the second instar. During development, the larvae were provided with fresh leaves of *C. odorata* daily. Starting at the third instar, the larvae were transferred into the screened cages which contained fresh daily-cut *C. odorata*. The cages and containers were cleaned every 1-2 days. Thorough cleaning was done so as to prevent protozoan and bacterial diseases from infecting the larvae.

Three weeks after hatching, a sheet of manila paper was laid on the bottom of the floor board of each cage to provide space for pupation. Most final instar larvae pupated in the space between the bottom board of the cage and the paper sheet. Others pupated between the cut stem and the leaves of *C. odorata*.

The results of rearing the insect in big cages placed in a greenhouse was more or less similar to the laboratory results. The insect on *C. odorata* growing outside between the two greenhouses was also reared. In such an open area, most of the larvae tended to disperse even though there was enough food at the site. Since the site was not well protected with fine screen, most of the larvae dispersed while others were preyed on by ants. Only a very few were able to successfully pupate in the soil crevices.

Rearing these insects in screen cages, both under room and greenhouse conditions, with enough food material and good sanitation, gave satisfactory results. Based on earlier observations, the 100 newly-hatched larvae were reared in petri dishes through the first instar. They were then transferred into bigger plastic containers or cages, showing very low mortality. Out of the 100 hatched larvae, 92 survived and pupated.

From the 92 pupae, 87 adults emerged producing a total of 6988 eggs. Assuming the sex ratio is 1:1, the average number of eggs oviposited by each of the 43 adult females was 162.5 per female. Based on the number of larvae that emerged, only 2% of eggs did not hatch. Therefore, it seems that rearing in cages had satisfactory results.

3) **Release Tests**

Release tests were undertaken by releasing eggs, larvae and adults moths into the field. Thousands of eggs and larvae of *P. pseudoinsulata* were released at rubber plantation sites where *C. odorata* grows abundantly. Another several thousand eggs, larvae and moths were released around the BIOTROP complex; this was done several times.

Releases were made by the following procedure: (i) Leaves of *C. odorata* bearing eggs of *P. pseudoinsulata* were clipped to the underside of the leaves of a growing *C. odorata* plant; and (ii) the eggs were placed between the leaf laminae so as to protect them from direct sunlight, rainfall and predators.

Leaves or stems of *C. odorata* bearing third and fourth instar larvae were placed on *C. odorata* plants. Cages or plastic containers bearing one day old adult moths were opened in the field, to allow the moths to fly out and disperse. Egg and larvae releases were made in the morning; moth releases were made in the evening. Inspections to evaluate the possible establishment of *P. pseudoinsulata* were made several days after releasing. While the eggs hatched well, as indicated by the leaf damage of larval feeding, no young larvae were observed.

The evaluation of larval releases had similar results, i.e. no *P. pseudoinsulata* larvae were observed on the plants. Evaluations of the moth releases were estimated by moth appearance and egg occurrence. During the evaluation no moths were found, but there were two batches of eggs oviposited on different *C. odorata* plants. The location of the *C. odorata* on which the eggs were oviposited, was about 600 m from the release site. The eggs were then collected to check if they were those of *P. pseudoinsulata*. However, in investigations since that time, no eggs were found.

The results of the release tests indicate that *P. pseudoinsulata* has not been able to establish itself at the field release sites or within the vicinity of these sites. It was strongly suspected that most released insects had fallen victim to predators. Casual observations showed that red ants were attacking a larva of *P. pseudoinsulata,* between two of the greenhouses where insect rearing was being done. Along with the possible attacks by natural enemies, the number of insects released was probably too small. Therefore, in further tests, a larger number of insects will be released at one time. Also, adults will be used instead of larvae.

4) **Distribution**

BIOTROP has sent eggs, larvae and pupae of *P. pseudoinsulata* to Soeprapto Mangundihardjo, senior entomologist, Faculty of Agriculture, Gadjah Mada University, Yogyakarata, Java, for further rearing. In addition, BIOTROP has also sent the same insect to Eko Budiwahyono, at the Faculty of Agriculture, Nusa Cendana University, Kupang, Timor.

Further work will involve the introduction of stem-galling tephritid fly *Procecidochares*, the shoot-boring moth *Mescinia parvula*, and the shoot-boring agromyzid *Melanagromyza eupatoriella*, to Indonesia and the Southeast Asian region.

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The Use of Signalgrass (*Brachiaria decumbens* Stapf.) and Legumes to Control Feijicao (*Chromolaena odorata*).

(L'Utilisation de *Brachiaria decumbens* Stapf (Signalgrass) et de Légumineuses pour Lutter contre *Chromolaena odorata* (Feijicao))

W. Renrun
Lanzhou Institute of Animal Science, Chinese Academy of Agricultural Sciences
Lanzhou, Gansu, P.R. China

H. Bizhi
Yunnan Provincial Livestock and Pasture Research Center Xiaoshao
Kunming, Yunnan, P.R. China

and

G. Zhengyun
Sumao County Bureau of Agriculture and Animal Husbandry Simao
Yunnan, P.R. China

Résumé-Dans la région subtropicale de Manzhongtian (MZT), Comté de Simao, dans le Sud-Est du Yunnan, l'utilisation de *Brachiaria* parait être une mesure culturale efficace pour lutter contre *Chromolaena odorata*. Six ans de culture de *Brachiaria* ont considérablement réduit l'importance de *C. odorata* dans les pâturages. *Brachiaria* présente une très faible proportion de protéines (CP) de seulement 3,13%; néanmoins, certaines cultures associées ont permis d'augmenter la proportion de protéines jusqu'à 5,65%. *Arachis pintoi,* une arachide pérenne introduite d'Amérique Latine, semée en larges bandes en alternance avec *Brachiaria,* permet d'accroître le contenu en protéine jusqu'a 17,46%. Des pâturages mixtes peuvent ainsi non seulement arrêter l'infestation d'adventices mais aussi augmenter les bénéfices économiques et promouvoir l'élevage dans la région de Manzhongtian.

Abstract-In subtropical areas of Manzhongtian (MZT) in Simao County, Southern Yunnan, the use of signalgrass was found to be an effective cultural control measure to suppress *Chromolaena odorata* (feijicao). Six years of signalgrass planting has considerably reduced feijicao in the pastures. Signalgrass has a very low crude protein (CP) content of only 3.13%; however, by using an alternate planting method, the CP content has been increased to 5.65%. *Arachis pintoi* c.v. Amarillo, an introduced perennial peanut from Latin America, seeded in wide

alternate rows with the signalgrass, was found to increase the CP content from 5.65% to 17.46%. Thus mixed pastures not only replaced the noxious weed infestation but also resulted in increased economic benefit and promoted the local animal raising industries in MZT.

Introduction

Chromolaena odorata (L.) R.M. King and H. Robinson (known as feijicao in China) infestation in the pasture lands of Southern Yunnan has seriously affected the animal raising industry, causing heavy losses to farmers. From 1985 to 1990, experiments were conducted by planting signalgrass (*Brachiaria decumbens* Stapf cv. Basilisk) on a large scale basis. During the final three years of the experiments, feijicao was considerably reduced in these pastures (Wu *et al.* 1991).

Although the crude protein (CP) content of signalgrass has been 3.13%, by planting a mixture of the grass seeds and legumes on sloping areas, the CP content can be increased (Kui Jiaxiang *et al.* 1990). To increase the CP content and to improve the pasture lands, it was necessary to identify an suitable legume partner to use with signalgrass.

Tests were conducted using several different tropical legumes in combination with signalgrass in the pasture lands. The legumes included *Centrosema pubescens* Benth. cv. Centro, *Flemingia macrophylla* Merr., and a local wild species. Of these, *Arachis pintoi* cv. Amarillo, a perennial peanut introduced from Latin America in 1991, performed better than any of the other legume species that were tested. It was found that other grass species in the pasture lands were highly aggressive and they eventually overtook the trial legume species. Therefore, in order for the alternative method to be effective, only signalgrass and the legume can be planted together.

Materials and Methods

From February to March of 1991, feijicao infested lands at the experimental site were first burned and then stubbles were manually dug out. Before the advent of the rainy season, the seeds of *B. decumbens* and *A. pintoi* were sown in the cleared lands at a rate of 10kg/ha. The ratio of legume seeds to grass seeds was 6:4. Fertilizers in rates equivalent to 20kg P/ha, 9kg S/ha, 22kg K/ha, and 92kg N/ha, were also applied. Two different methods of sowing were used:

1. A direct mixture of legume perennial peanut seeds and signalgrass seeds.
2. An alternate seed planting method with signalgrass and the perennial peanut in separate parallel contour rows, which were 5 meters wide.

A random sample of 1m^2 quadrats were studied in order to show the ratio of legume to signalgrass, and the percentage of feijicao infestation.

Results and Discussion

Table 1 shows the different results using the mixed seed method vs. the alternating parallel planting of legume and grass from 1991 to 1993. Using the first method, the ratio of legume to grass was 41.2:58.8 in the first year. By the third year, the ratio had changed to 4.3:95.7. Using the second method, the ratio of legume to grass was 43.3:56.7 in 1991; this changed to 36.5:63.5 by the third year.

Table 1. The Growth Rate of perennial Peanut cv. Amarillo mixed with Signalgrass cv. Basilisk under different sowing treatments.

Treatment	1991	1992	1993
Mixed planting	41.2 : 58.8*	16.2 : 83.8	4.3 : 95.7
Alternate parallel rows of grass and legume	43.3 : 56.7	38.9 : 61.1	36.5 : 63.5

*Ratio of legume: grass in %, calculated on dry matter basis with mean values from 10 samples.

Table 2 shows the changes in the CP content using the two different planting methods. The results show that the directly mixed vs. the alternating planting methods yielded a 7.21:17.46% of CP content by 1993. This was a sharp decline from 1991, when the CP content was 20.74:21.93%. There was no significant difference in the CP content of the signalgrass from 1991 to 1993. The results also show that the CP content decreases through time using either of the two planting methods or signalgrass alone. This reduced percentage in CP content is due to the fact that signalgrass demands higher levels of nitrogen. As shown, the CP content declines much faster with the mixed method (7.21% in 1993), than with the alternate planting method (17.46% in 1993).

Table 2. Crude Protein content in Pastures with mixed and alternate plantings.

Treatment	1991	1992	1993
Mixed planting	20.74%	10.53%	7.21%
Alternate parallel rows of grass and legume	21.93%	18.75%	17.46%
Signalgrass Sward (1985-1990)*	5.87%	——	5.65%

* No record from 1992.

Table 3 shows the impact of the two different planting methods on the percentage of feijicao in the pastures. Over the 3 years, both planting methods led to continual decrease in the percentage of feijicao in the pasture lands. These test results show that by 1993, only 12.1% of feijicao was found in the mixed method, and 13.7% in the alternate planting method.

Table 3. Percentage of Feijicao in Pastures using different planting methods.

Feijicao in treatments	1991	1992	1993	Feijicao in wasteland
Mixed planting	40.1*	27.4	9.5	78.6
Alternate parallel rows of grass and legume.	48.6	30.6	10.8	

* Plants/m^2 mean of 10 samples.

After three years (1991 to 1993) of investigation, the results show that different sowing methods cause different relative plant densities of legume and signalgrass. The CP content of the pasture also varies with the changing conditions of the legume and grass mixture. Based on these results, it can be concluded that signalgrass possesses a high competing ability and when mixed, increases the growth vitality of the legume. The legume grows well in a short time however, disappears after the third year; this was seen with *C. pubescens* which failed by 1993.

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Controlling Regrowths of *Chromolaena odorata*(L.) R. M. King and H. Robinson, Using Herbicide Mixtures in Young Oil Palm Plantations in Nigeria.

(La Lutte contre les Recrûs de *Chromolaena odorata* (L.) R. M. King et H. Robinson. L'Utilisation de Mélanges d'Herbicides dans les Jeunes Plantations de Palmier à Huile au Nigeria)

S.N. Utulu
Nigerian Institute for Oil Palm Research (NIFOR)
Benin City, Nigeria

Résumé- Les effets du Roundup (glyphosate) et du Garlon (triclopyr), mélangés dans des citernes à différentes proportions d'Asulox (asulam), sur la suppression des recrûs de *Chromolaena odorata* ont été évalués par l'Institut Nigerian de Recherche sur le Palmier à huile (NIFOR). Les herbicides ont été appliqués à l'aide d'un pulvérisateur Berthoud. Les effets ont été évalués sur la base d'une réduction (en %) du poids sec des recrûs échantillonés 2, 4, 6, 8 et 12 semaines après traitement. L'activité d'un mélange d'asulam et de triclopyr est renforcée par rapport aux produits seuls. Une réduction de 95% des recrûs fût obtenue avec un mélange d'asulam et de triclopyr, alors que l'utilisation de glyphosate seul (plus efficace qu'en mélange avec l'asulam) permet une réduction de 80%. Une deuxième application 12 semaines après le premier traitement est nécessaire pour atteindre une mortalité totale, quel que soit le mélange. Bien que la croissance et les premières récoltes de régimes de palmier ne soient pas affectées par le traitement soigneux des interlignes, on observe des changements dans la composition floristique de ces interlignes.

Abstract-The effects of Roundup (glyphosate) and Garlon (triclopyr), in tanks mixed with Asulox (asulam) at various rates, were evaluated for the suppression of regrowths of *Chromolaena odorata* at the Nigerian Institute for Oil Palm Research (NIFOR), Benin City, Nigeria. A Berthoud Knapsack sprayer was used to apply the herbicides. Efficacy was assessed on the basis of the percent of dry weight reduction of regrowths sampled at 2, 4, 6, 8 and 12 weeks after treatment (WAT). There was enhanced activity when a mixture of asulam and triclopyr as opposed to individual products was applied. A 95% reduction of regrowths was achieved using a mixture of asulam and triclopyr, while over 80% reduction was achieved using glyphosate alone. However, glyphosate applied alone was more efficacious than when it was mixed with asulam. A repeat application by the 12 WAT was necessary for a complete kill using either of the two packages above. Although growth and early bunch yield of the palms were not affected by the carefully applied interrow treatments, there were shifts in the botanical composition of the vegetation in the interrow.

Introduction

Common weeds of oilpalm plantations include trees providing heavy overhead shade, regrowth from stumps, shrubs, climbers and uncontrolled legume covers (Utulu & Onwubuya 1986). In the rain forest zone where oilpalm is predominantly grown, plantation weeds are mainly broadleaved. It is at the periphery of the plantations or along the road-sides that grasses predominate. A shift in the type of broadleaves takes place as the plantation ages. In young oilpalm plantations there is a high infestation of *Chromolaena odorata,* which, if not properly managed, results in poor early growth, flowering and bunch yield of the oilpalm (Ojuederie *et al.* 1983). A series of studies have shown that certain herbicides may be effective in the control of *C. odorata* (Sheldrick 1968, Aya 1977).

Since herbicides have become expensive, careful thought has to be given in recommending their use in weed control, especially in situations where labor is cheap and available. However, for a more prolonged suppression of regrowths in the interrow spaces between palms, herbicides and/or herbicide mixtures usually offer a better alternative. Herbicide mixtures are commonly used in agriculture to broaden the spectrum of weed species that can be controlled. In some situations, mixtures or combinations provide good control at considerably lower dosages than dosages utilized in single applications (Dickerson & Sweet 1968, Lynch *et al.* 1970)

The present study was carried out to evaluate the effects of Roundup (glyphosate) and Garlon (triclopyr) mixed with asulam at various rates, in the suppression of regrowths of *C. odorata.*

Materials and Methods

A one year old oilpalm plantation at the NIFOR Main Station, Benin City, Nigeria, infested mainly by *C. odorata* was acquired for this study. The trial was set up as a randomized complete block design with 3 replications. Before application of herbicide treatment, the entire interrow vegetation was slashed to a height of 30 cm. Application of herbicides was delayed for 2-3 weeks to allow for fresh regrowths. The herbicides were applied using a Berthoud Knapsack sprayer which was earlier calibrated to deliver 250 liters of spray solution per hectare.

Glyphosate and triclopyr were applied individually and in combination mixtures with asulam. Glyphosate was applied at 1.2 and 2.4 kg a.i./ha, triclopyr at 0.54 and 1.08 kg a.i./ha, while Asulox (asulam) was applied at 1.5 and 3.0 kg a.i./ha.

The untreated area comprised plots where vegetation was slashed but the regrowths were not sprayed with herbicides. Data collection included dry weight of regrowths taken from above 30 cm from the ground level in quadrants measuring 30 cm long x 30 cm wide and 30 cm high. Regrowth samples were taken at 2, 4, 6, 8 and 12 weeks after treatment (WAT). Following the initial collection, a repeat application was made using Glyphosate alone at 1.2kg/ha, and a mixture of asulam and triclopyr at 1.5kg/ha + 0.54kg/ha a.i.; regrowth samples were taken accordingly.

The fresh samples were dried in the oven at 80°C for 72 hours, to determine their dry matter content. Care was taken to ensure that the droplets from the herbicide spray solutions did not come into contact with the fronds of the young oilpalm. Regrowth samples from the sprayed plots were then compared with those from manually maintained plots. The percent of Growth Reduction was calculated using the following formula:

$$\% \text{ Growth Reduction} = 100 - \frac{(\text{dry wt* of samples from treated plots})}{(\text{dry wt* of samples from untreated plots})} \times 100$$

* dry weight was measured in grams.

where:

0% Growth Reduction	=	No weed control
10% Growth Reduction	=	Very poor weed control
20% Growth Reduction	=	Poor weed control
30% Growth Reduction	=	Poor to deficient weed control
40% Growth Reduction	=	Deficient weed control
50% Growth Reduction	=	Deficient to moderate weed control
60% Growth Reduction	=	Moderate weed control
70% Growth Reduction	=	Weed control somewhat less than satisfactory
80% Growth Reduction	=	Satisfactory to good weed control
90% Growth Reduction	=	Very good to excellent weed control
100% Growth Reduction	=	Complete weed destruction

The palms were ringweeded manually following the recommendations of Ojuederie *et al.* (1983). Also, a shift in botanical composition of the treated interrows was assessed. The trial was terminated after obtaining data on the development and early yield of the palms.

Results and Discussion

Figure 1 shows the treatment effects of asulam and Roundup, applied both singly and tankmixed, on the regrowth of *C. odorata* over a 12 week period. Roundup at 1.2kg a.i./ha was outstanding in the reduction of the regrowths, with about 87% reduction being recorded by the 4th week after application. The activity of Roundup, however, was reduced when it was tankmixed with asulam. Also, asulam alone was not efficacious in the control of the regrowths. As figure 1 shows, 12 weeks after treatment, regrowths had commenced even in the plots treated with roundup at 1.2kg/ha.

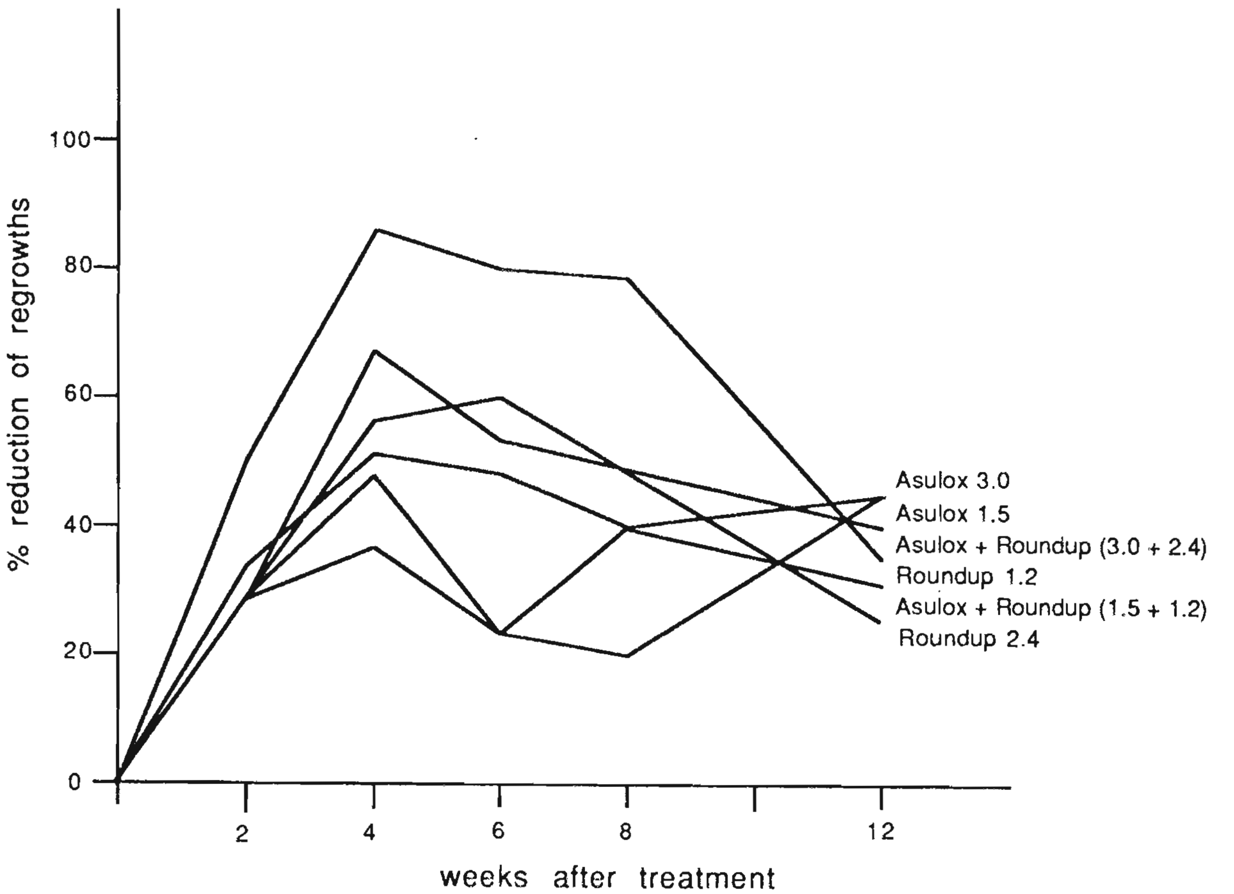

Figure 1. Effect of Asulox, Roundup and Mixtures on Regrowth of *C. odorata*.

Figure 2 shows how results differ with the use of asulam, garlon and mixtures. The activity of triclopyr was enhanced when tankmixed with asulam. By tankmixing asulam with triclopyr, it was possible to obtain 95% reduction in the regrowth of *C. odorata.* By using triclopyr alone, it was possible to obtain up to 70% reduction in the regrowth of *C. odorata.* As evident in figure 2, the tankmixed combination of asulam and triclopyr significantly enhances the effects of herbicides. Herbicide mixtures are commonly used in agriculture to broaden the spectrum of weeds controlled and in the case of one weed species, to alter the rate of kill of such a noxious weed. Sometimes, particular mixtures give spectacularly good control at dosages considerably below those normally utilized in single applications. This information can help herbicide manufacturers in the formulation of new, more effective herbicides.

The results of the study show a synergistic affect when asulam and triclopyr are tankmixed. At the same time, the results indicate an antagonistic effect when asulam and glyphosate are tankmixed.

Figure 3 shows that a repeat application of Roundup at 1.2kg a.i./ha, or a tankmixture of asulam and triclopyr at 1.5kg a.i./ha + 0.54kg a.i./ha., may be necessary in order to achieve a 100 percent success rate of controlling the regrowth of *C. odorata.*

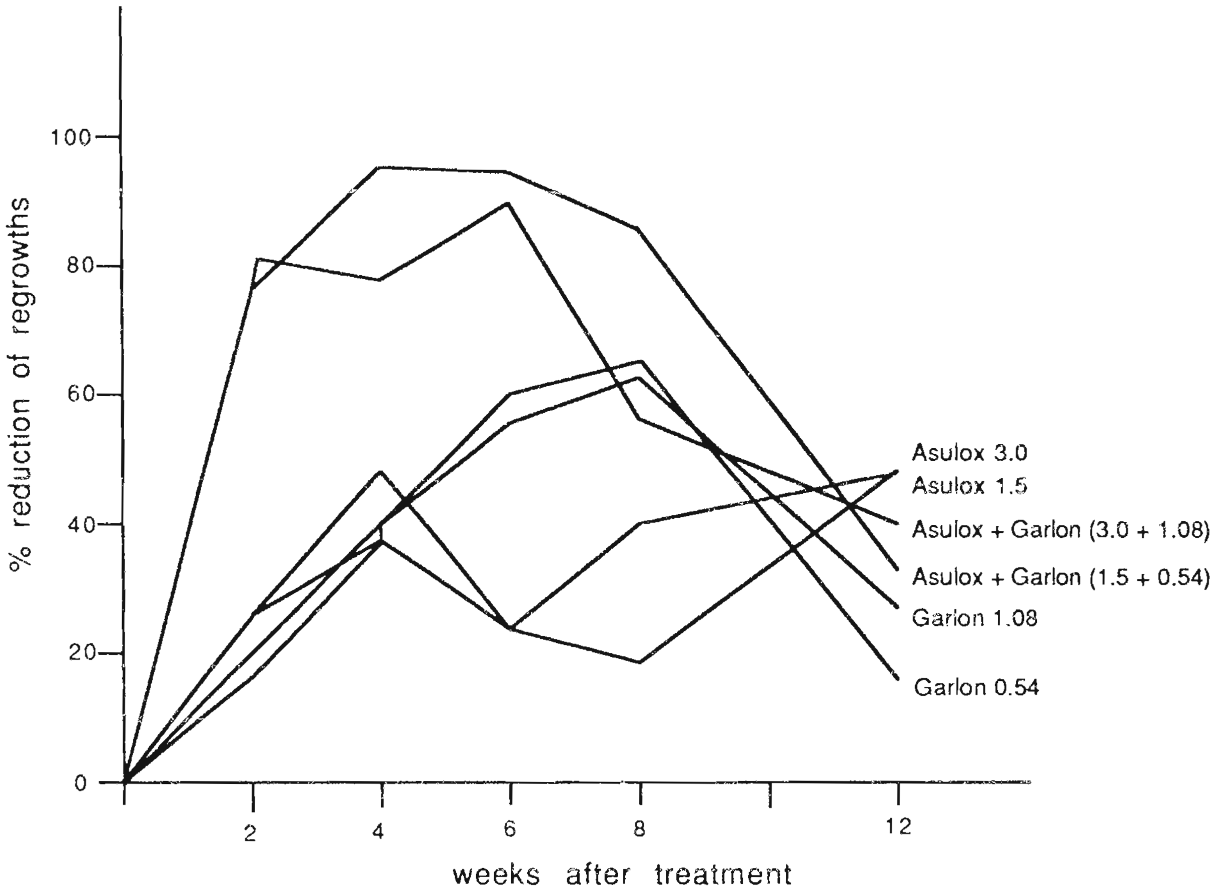

Figure 2. Effect of Asulox, Garlon and Mixtures on Regrowth of *C. odorata*.

Table 1 shows the effect of the interrow treatments of *C. odorata* on the growth and first true bunches of the palms. Both growth and early bunch yield were not affected by the carefully applied interrow treatments. Since spray droplets were prevented from touching the palm fronds at the time of application, and since the bases of the palms were manually ringweeded with cutlasses, it is not surprising that herbicide treatment of *C. odorata* did not have a significant effect on the palms.

Table 1. Effects of Interrow treatment of *C. odorata* on growth and early bunch production of Palms in a 3 year old plantation.

Interrow treatment	Mean Height per palm (cm)	Mean Girth per palm (cm)	Mean Sex ratio of palm (%)	Mean Bunch wt. (kg/ha)
Slashing	260.5	34.5	39.0	484.4
Asulam @ 3.0 kg a.i./ha	267.0	41.2	40.6	410.3
Asulam @ 1.5	248.7	37.6	39.2	416.1
Roundup @ 2.4	181.4	42.4	39.3	468.3
Roundup @ 1.2	244.6	35.3	38.4	473.5
Triclopyr @ 1.08	262.4	34.8	39.7	475.2
Triclopyr @ 0.54	278.3	32.8	36.3	450.5
Asulam + Roundup (3.0+2.4)	275.2	40.4	34.3	439.3
Asulam + Roundup (1.5+1.2)	280.2	38.4	37.5	420.3
Asulam + Triclopyr (3.0+1.08)	279.3	39.3	36.2	461.5
Asulam + Triclopyr (1.5+0.54)	269.0	40.1	37.3	483.1
LSD (0.05)	NS	NS		NS
CV (%)	22.3	17.8		24.3

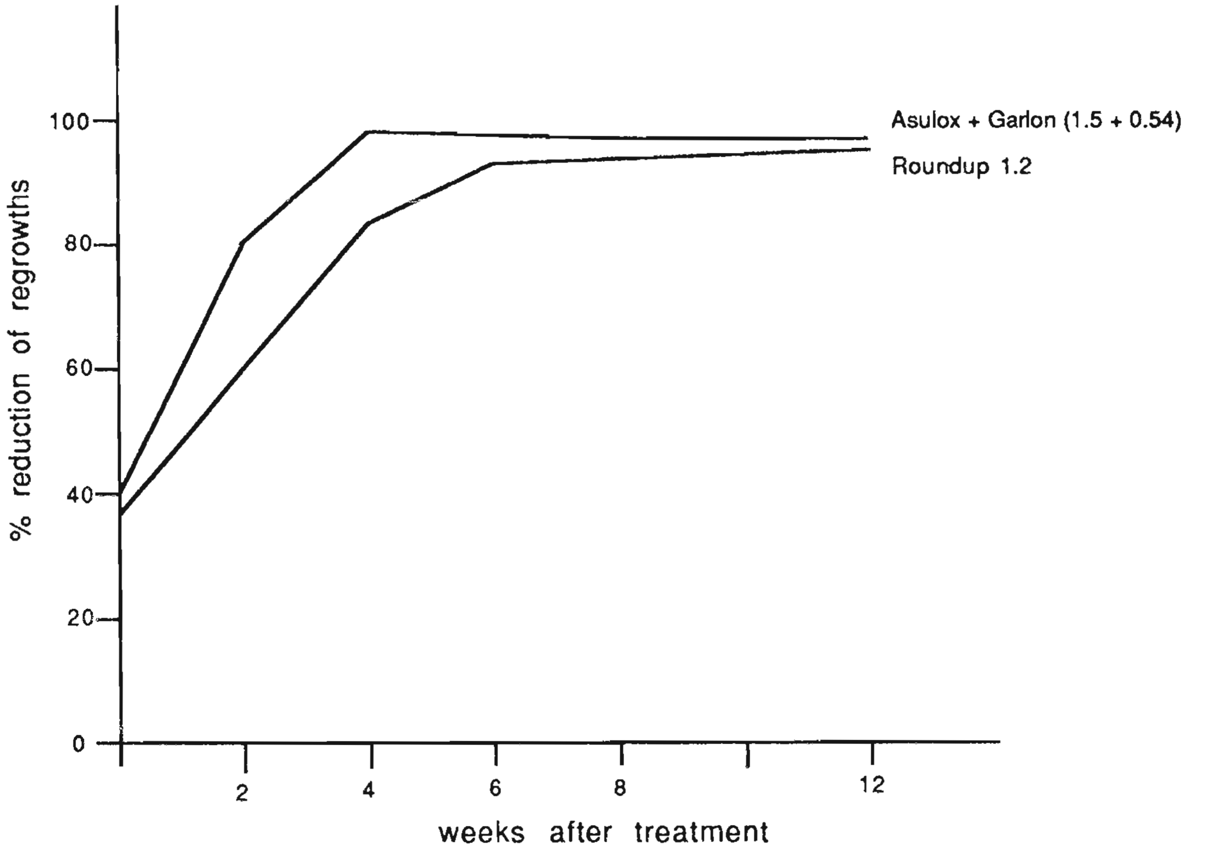

Figure 3. Effects of Repeated Applications of Roundup and an Asulox+Garlon Mixture on Regrowth of *C. odorata*.

The effect of the various *C. odorata* treatments on the spectrum of weeds in the young plantation is shown in Table 2. In the plots that were slashed, *C. odorata* noticeably consolidated its stand. The broad leaf species other than *C. odorata* observed in these plots, were mainly creepers or climbers. In the plots that received repeated application of asulam + triclopyr and roundup, the regrowth was totally killed but other weeds comprising both grasses and broadleaf weeds took over. Considering the other benefits derivable from *C. odorata*, a choice would have to be made between managing the growth of *C. odorata* in oilpalm plantations, and eradicating it which in turn may allow succession by other seeds.

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Table 2. The Effects of treatments on Dominant Weeds

Treatment	Weed Species Grasses	Broadleaved Weeds
Slashing	*Paspalum conjugatum* Berg.	*Chromolaena odorata* (L.) R.M. King andH. Robinson
	Digitaria ciliaria	*Dissotis rotundifolia* (Sm) (Retz.) Koel
Asulox + Triclopyr (repeated app.)	*Paspalum conjugatum* Berg.	*Aspilia africana* (Pers.) C.D Adams
	Hyparrhenia rufa (Nees) Stapf	*Borreria scabra* (Schum & Thonn) *Diodia virginiana* L. *Ageratum conyzoides* L. *Clerodendron umbellatum* L. *Emilia sonchifolia* (L.) DC *Stachytarpheta cayenesis* (L.C. Rich.) Scham
Roundup (repeated app.)	*Pennisetum* spp.	*Emilia sonchifolia* (L.) DC
	Digitaria ciliaris (Retz.)Koel	*Physalis angulata* (L.)
		Ageratum conyzoides L. *Borreria* spp *Schewenkia americana* L.

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Does the African Grasshopper, *Zonocerus variegatus*, need *Chromolaena odorata*?

(Le Criquet Puant Africain, *Zonocerus variegatus*, a-t-il besoin de *Chromolaena odorata*?)

W.W. Moder
Visiting Scientist, Plant Health Management Division
IITA (International Institute of Tropical Agriculture), Cotonou, Bénin

Résumé- Ce n'est sans doute pas en raison de l'attraction pour ses fleurs que les premiers stades larvaires de *Zonocerus variegatus* se rassemblent sur *Chromolaena odorata*, mais plutôt parce que les sites d'oviposition se rencontrent fréquemment dans les fourrés à *C. odorata*. Bien que consommée par tous les stades larvaires, *C. odorata* ne supporte seule ni la croissance ni la reproduction; *Z. variegatus* accumule plus d'aliments lorsque sa nourriture est composée d'un mélange d'espèces végétales. Les alcaloïdes pyrrolizidine (PAs) de *C. odorata* ne sont apparemment pas fixés dans les glandes répulsives du criquet; d'autre part ces alcaloïdes se retrouvent quelle que soit la plante consommée. Quarante pour cent des oeufs produits en saison sèche disparaissent en raison de la prédation, ce qui suggère que les PAs mis en réserve ne permettent pas d'assurer leur protection. Le développement de l'agriculture en Afrique de l'Ouest a entraîné la formation de nombreuses clairières forestières qui représentent des habitats idéaux tant pour *C. odorata* que pour *Z. variegatus*. Ainsi, même en l'absence de *C. odorata*, *Z. variegatus* serait probablement une peste. *C. odorata* présente le double avantage d'attirer les criquets hors des cultures et de les rassembler sur des sites précis qui peuvent alors être traités avec des insecticides sans trop de risques.

Abstract-The attraction of *Zonocerus variegatus* to the flowers is probably not the reason why its early instars aggregate on *Chromolaena odorata*, but rather because its oviposition sites frequently occur with *C. odorata* thickets. Although eaten by all instars, *C. odorata* does not alone support growth or reproduction; *Z. variegatus* accumulates more nutrients when fed a mixture of plant species. Pyrrolizidine alkaloids (PAs) from *C. odorata* apparently are not sequestered in the grasshopper's repellent gland; alkaloids occur regardless of the food plant. Forty percent of dry season eggs are predated suggesting that stored PAs give no protection. Agriculture in West Africa has resulted in forest clearings which are ideal habitats for both *C. odorata* and *Z. variegatus*. Therefore, even without *C. odorata*, *Z. variegatus* would probably be a pest. *C. odorata* is useful in attracting the grasshopper away from crops and for safe insecticide application.

Introduction

At the last Workshop on *Chromolaena odorata,* a presentation was made on the relationship between it and the African pest grasshopper, the pyrgomorph *Zonocerus variegatus* (L.) (Boppré 1991). Recent studies allow fresh insights into that relationship. According to Odukwe (1964), seeds of *C. odorata* were inadvertently introduced into Enugu, south-eastern Nigeria from Ceylon (now Sri Lanka) in 1936-37, during the importation of seeds of *Gmelina arborea* Roxb. for timber plantations. From Enugu, the weed spread westwards into southern Nigeria during the 1950s and 1960s. Lowe (pers. comm.) first noticed and recorded *C. odorata* (then *Eupatorium odoratum*) in Ibadan on January 7, 1968; this is the first record from the area. It is now found throughout West Africa (Cruttwell-McFadyen 1988).

Like certain other plant species, *C. odorata* contains repellent or bitter-tasting, and toxic, pyrrolizidine alkaloids (PAs) (Bull *et al.* 1968). Therefore, it is not fed on by herbivores with the exception of specialized insects and mites (Cruttwell 1974) including *Z. variegatus*, which is apparently its major predator (Marks & Seddon 1985).

Attraction of *Z. variegatus* to *C. odorata*

The work of Modder (1984b) showed that all instars and both sexes of *Z. variegatus* are attracted to the open inflorescences of *C. odorata*, but not to the buds or leaves. This attraction, acting over distances of 1 m and more, is an olfactory and not a visual response. It is made within minutes and may be described as purposeful; it is not a gradual aggregation from random wandering. The attractive principle is concluded as being a volatile chemical (or mixture of volatiles), and the *C. odorata* flowers are nicely adapted for broadcasting this by means of their stigmas, which stand well above the capitula.

What is this attractive principle? Boppré *et al.* (1984) found that some other PA-containing plants, either dried or as methanol extracts, were attractive to the other *Zonocerus* species, *Z. elegans,* of southern Africa. *Z. elegans* were even attracted to pure PAs in powder form, which they ingested. Later, Boppré (1991) reported similar observations with *Z. variegatus:* nymphs and adults were attracted to " dried parts of various PA-plants, and certain pure PAs". Dry leaves of *C. odorata* were not attractive but the roots were. The highest concentrations of PAs occurred in the roots and inflorescences, while the concentrations in stems and leaves were very low. The conclusion is that PAs (or perhaps their breakdown products since most PAs are not volatile) attract *Z. variegatus* to *C. odorata.*

Feeding of *Z. variegatus* on *C. odorata*

Both leaves and flowers of *C. odorata* are eaten by all nymphal stages and adults of the grasshopper (Modder 1984b, Marks & Seddon 1985). Hatchling *Z. variegatus* move directly onto *C. odorata* thickets from their hatching sites, which are often at the base of the thickets (Modder 1984a, Tamu 1990). The appearance of hatchlings and early instars on *C. odorata* seems to be a consequence of hatching in its shade, and not purposive movement in response to floral attractants. Indeed *C. odorata* is not yet in full flower when the year's mass hatching occurs, during late October and November.

According to Marks & Seddon (1985), "first and second instar nymphs fed on leaves of *C. odorata* and of other plants, but did not eat *C. odorata* flowers although they were present". According to Modder (1984b), the larger leaves of *C. odorata* were extensively fed on by the first- to third-instar nymphs; some of the flowers were also eaten, but others close by were left intact even though they were near nymphal aggregations. Feeding was not confined to *C. odorata;* large numbers of feeding nymphs could be observed crowded onto leaves of *Acalypha hispida* Burm. and *A. wilkesiana* Müll. Arg., right next to empty expanses of *C. odorata* including flowers. When flowering becomes extensive in December and January, the third- to fifth-instar nymphs move purposefully on to the flowers, most of which are eaten if grasshopper numbers are large. However, feeding on the leaves of *C. odorata* as well as the leaves of other plant species continues. Marks & Seddon (1985) also referred to the greater damage done to the flowers by the later stages of nymphal instars.

Despite their feeding on the *C. odorata* flowers, dissections of first to fifth instar nymphs revealed that only 14-22% of them had flowers exclusively in their guts; the rest had leaf-material, or leaves mixed with *C. odorata* flowers (Modder 1984b).

To summarize; leaves of *C. odorata* are extensively eaten, particularly by the early instars, but the leaves or flowers are not fed on exclusively and the leaves of other plants are eaten at the same time.

Comparing the nutritional value of *C. odorata* to *Z. variegatus*

In assessing the nutritional value of a food-plant to a phytophagous insect, the practice is to allow it to feed on that plant alone and then to assess its growth, longevity or reproductive performance, usually in comparison to that on other food plants. When caged *Z. variegatus* are fed *C. odorata* alone, they do not grow well, nor do they have normal longevity or produce eggs. Thus, development of the early instars was slow and only 13% of hatchlings survived to the third instar (Bernays *et al.* 1975). Survival is also poor in the later instars (McCaffery & Page 1978). Adults not only die early but they also do not produce eggs (McCaffery & Page 1978, Iheagwam 1979). The flowers of *C. odorata,* despite having a special attraction which the leaves do not have for *Z. variegatus,* are even poorer food than the leaves. Fourth and fifth instar nymphs on the leaves survive, while those confined to the flowers do not (R.F. Chapman pers. comm.).

Based on the results of these cage experiments, it has been concluded that "*Chromolaena* is unlikely to be important as a food plant" (Chapman *et al.* 1986), and that *Chromolaena* is not eaten by *Z. variegatus* for its food value (Chiffaud & Mestre 1990). The question remains that if this plant is of no nutritional value, why does *Z. variegatus* feed on it? The answer by Boppré (1991), that *Z. variegatus* feeds on it in order to obtain PAs to which it is demonstrably attracted, seems the obvious one. The relationship between the grasshopper and the plant is thus seen as non-nutritional, the PAs being needed for a function other than nutrition.

However, it must be emphasized that a polyphagous insect in nature feeds on a mixture of plants and not just on one species. Could it be that *C. odorata* (leaves or flowers, or both) is of some nutritive value when fed on together with other plants? This is plausible in the light of the observations on naturally-feeding *Z. variegatus,* where it appears that *C. odorata* is only one item in a mixed diet (Modder 1984b, Marks & Seddon 1985). Significantly, Tamu (1990) found that sixth-instar *Z. variegatus* fed on a mixture of *C. odorata, Vernonia amygdalina* Schreb, and cassava, developed faster and gained more weight, accumulated more protein and carbohydrate in the haemolymph, and stored more of these as well as lipids in the fat body, than those fed on each of these plant species alone. These results suggest that *C. odorata* might be a useful, albeit dispensable, component of the diet of *Z. variegatus.* It is possible that, at the same time, the plant has a non-nutritional function. Does not the exceptional attraction of the flowers and the PAs suggest their special role in the life of this grasshopper?

PAs as a toxic component of the repellent fluid?

Three other pyrgomorph (*Poekilocerus*) species sequester the so-called heart poisons (cardenolides) present in their food-plants, for use as the major deterrents in the fluid ejected from characteristic repellent glands in the abdomen (Rothschild 1972). Perhaps *Z. variegatus* can, in analogous fashion, sequester PAs from *C. odorata* and use them as a toxic component of its repellent fluid.

B.A. Idowu (unpublished) identified alkaloids in the wall and secretion of the repellent gland of *Z. variegatus* by spraying chromatograms with Dragendorff's reagent (Furniss *et al.* 1984). These alkaloids were present whether the food-plant was *C. odorata,* cassava, or *A.wilkesiana.* Dragendorff-positive spots were also obtained with leaf extracts from *C. odorata,* but not from cassava or *A.wilkesiana.*

It thus appears that the alkaloids in the repellent gland are synthesized *in situ* and not sequestered from the food, since they were present even when the grasshoppers were fed on non-PA plants (cassava and *A. wilkesiana*). Also, haemolymph and fat body, the likely routes for sequestered molecules going to the gland, did not contain alkaloids (Idowu, unpublished).

On the other hand, Bernays *et al.* (1977) claimed that *Z. variegatus* does sequester PAs from a PA-containing food-plant, *Crotalaria retusa* L. Extracts of both the grasshopper and the plant contained the same PAs. Unfortunately, tissues of the insect (repellent gland, haemolymph, etc.) were not separated for analysis in this study. Macerates were apparently made of whole grasshoppers and, if they were not first degutted, ingested *C. retusa* leaves still present in the gut could have been a likely source of the PAs detected in grasshopper samples.

Boppré *et al.* (1992) also report PAs in *Z. variegatus* from a teak plantation, but this reference could be to whole grasshoppers. PAs were "not present in specimens raised indoors unless they had been given access to flowers of *Chromolaena*". If the grasshoppers were not degutted, previously eaten flowers in the gut could be the source of the PAs.

PAs as a deterrent to egg predators?

It has been hypothesized that PAs obtained from *C. odorata* may be stored in the eggs of *Z. variegatus,* where they serve as protection against predators and parasitoids when the eggs are developing in the soil (Boppré 1991). PAs were later found in the eggs (Boppré *et al.* 1992). Boppré (1991) suggested that this is the reason why *Z. variegatus* is more numerous in the dry season than in the wet since dry-season populations can obtain the egg-protectants from *C. odorata* which only flowers in the dry season.

However, at a *C. odorata*-rich locality near Ibadan, Tamu (1990) has estimated that as much as 40% of dry-season eggs were lost in the soil to natural enemies, suggesting that they had no protection from PAs. In fact, because they develop during the dry season wet-season eggs are more liable to desiccation than dry-season eggs which develop in the wet season (G.F. Tamu & W.W.D. Modder unpublished). This is perhaps one reason why wet-season populations are smaller. If PAs have a part in the biology of *Z. variegatus,* we do not yet know what it is. This is an on-going line of research.

C. odorata, the cause of *Z. variegatus* proliferation?

Since the spread of *C. odorata* in southern Nigeria in the 1960s and Côte d'Ivoire in the 1970s coincided with increasing outbreaks of *Z. variegatus,* the suggestion has been made that the spread of the plant was a factor in producing the grasshopper outbreaks (Toye 1974, Chapman *et al.* 1986, Popov 1988). It has even been suggested that without *C. odorata,* PAs would be a limiting resource restricting the grasshopper's success (Boppré 1991).

However, it is no coincidence that the years of *C. odorata* and *Z. variegatus* expansion were also years of extensive deforestation for agricultural purposes (e.g. Chapman *et al.* 1986, Popov 1988). Forest clearings happen to be the ideal habitats for both plant (Cruttwell McFadyen 1988) and grasshopper (Chapman *et al.* 1986). It is conceivable that *C. odorata* and *Z. variegatus* were merely colonizing habitats suitable to themselves.

Once established, the dense *C. odorata* thickets would prove excellent oviposition sites for *Z. variegatus.* As Chapman *et al.* (1986) and Chiffaud & Mestre (1990) mention, *Z. variegatus* frequently oviposits in the shade of these thickets. However, as they and other observers realized, this is merely a reflection of the ubiquity of the plant and does not indicate that the grasshopper deliberately seeks it as an oviposition shelter. There are many observations (W.W.D. Modder, unpublished) of *Z. variegatus* ovipositing under plants other than *C. odorata* even though ostensibly suitable *C. odorata* thickets were present a few meters away.

C. odorata thickets are frequently extensive and continuous. Since the thickets bear flowers which attract the grasshopper, they bring about dispersal of the numerically large dry season populations away from hatching sites, to locations where the grasshoppers can benefit from a variety of nutritious food-plants (G.F. Tamu & W.W.D. Modder unpublished). This is probably another reason why *Z. variegatus* are more widespread in the dry season than in the wet season.

Conclusion

Present knowledge suggests that the relationship between *C. odorata* and *Z. variegatus* is the result of a happy meeting in the forest clearings of West Africa. Although it is not a good food-plant by itself, *C. odorata* with its dense, extensive thickets provides the grasshopper with oviposition sites and a means of reaching other, more nutritive food-plants.

Does *Z. variegatus* need *C. odorata*? The answer is no. *Z. variegatus* would get along without *C. odorata* and probably continue to be an important pest given the present level of intensity of agriculture in West Africa. The qualification comes from the *C. odorata* volatiles: we do not know as yet the adaptive significance of the grasshopper's attraction to them. If for example PAs are needed by the grasshopper, then *C. odorata* would be needed because it is the most common PA plant in the habitat.

Do we need *C. odorata* in the management of *Z. variegatus*? Yes we do, especially when it is flowering and can draw *Z. variegatus* away from other crops as much as possible. It is also needed in integrated pest management programs as a holding site, where the grasshoppers which like to roost on it at night, might be conveniently and safely sprayed with insecticides (Modder 1986) or the recently developed mycoinsecticides (Lomer *et al.* 1993).

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Establishment of *Pareuchaetes pseudoinsulata* Rego Barros in the Eastern Carolina Islands: an Effort to Control the Siam weed, *Chromolaena odorata* (L.) R. M. King et H. Robinson.

(L'Etablissement de *Pareuchaetes pseudoinsulata* Rego Barros dans les Iles Carolines Orientales: un Effort de Lutte contre l'Herbe du Siam, *Chromolaena odorata* (L.) R. M. King et H. Robinson)

N.M. Esguerra, W.S. William and J.R. Smith
College of Micronesia, Land Grant programs, Kolonia, Pohnpei, FSM

Résumé- Deux ans après avoir été périodiquement relâché dans certaines zones du district de Kitti, Pohnpei, l'agent de lutte biologique *Pareuchaetes pseudoinsulata* s'est établi et contrôle l'herbe du Siam, *Chromolaena odorata. P. pseudoinsulata* a également persisté dans les zones brûlées où *C. odorata* est réapparu. Des lâchers de *P. pseudoinsulata* sur des zones envahies par *C. odorata* sont en cours à Madolenihmw. Des lâchers mensuels de *P. pseudoinsulata* sur des zones envahies par *C. odorata* à Kosrae ont débuté en Janvier 1992. Six mois après le premier lâcher, *C. odorata* était défolié près de l'aéroport et dans la région de Quarry, dans le district de Tafunsak. Des signes de dommages sur *C. odorata* sont également apparus sur la Station Agricole Expérimentale. D'autres lâchers continuent à propager *P. pseudoinsulata* sur toute l'île. Sur les deux îles, l'établissement de *P. pseudoinsulata* ne réussit que si les lâchers ont lieu là où *C. odorata* croît en plein découvert.

Abstract-Two years after being periodically released into some areas of Kitti Municipality, Pohnpei, the biological control agent, *Pareuchaetes pseudoinsulata*, became established and controlled the Siam weed, *Chromolaena odorata. P. pseudoinsulata* also persisted in burned areas where the Siam weed had reappeared. Releases of *P. pseudoinsulata* on *C. odorata* infested areas in Madolenihmw are currently being undertaken. Monthly releases of *P. pseudoinsulata* on *C. odorata* infested areas on Kosrae started in January, 1992. Six months after the initial release, defoliation of *C. odorata* occurred near the airport and the Quarry area in Tafunsak Municipality. Signs of feeding injury to *C. odorata* due to *P. pseudoinsulata* also appeared at the Agricultural Experiment Station. Further releases are continuing to enable *P. pseudoinsulata* to spread throughout the Island. On both Islands, successful establishment of *P. pseudoinsulata* occurred only if releases were undertaken on *C. odorata* growing under non-shaded conditions.

Introduction

In 1988, Siam weed became a target for biological control after it was observed to be widespread on Pohnpei and Kosrae States, Eastern Caroline Islands. On Pohnpei, the weed is abundant in the municipalities of Kitti and Nett (Esguerra *et al.* 1991). On Kosrae, the weed is abundant near the airport, at the Quarry area of Tafunsak Municipality, and at the Agriculture Station in Lelu Municipality. Patches of the weed are also beginning to appear in Utwe Municipality.

This paper reports the establishment of *P. pseudoinsulata* in several release areas on Pohnpei, and the progress of using the same biological control agent on Siam weed in Kosrae.

Materials and Methods

Introduction of *P. pseudoinsulata* to Pohnpei

With the assistance of the University of Guam, larvae of *P. pseudoinsulata* were brought to Pohnpei in 1988. Some of the larvae were immediately released on a *C. odorata* infested area near the Wenik Elementary School, Kitti; the remaining larvae were kept in the laboratory for rearing. Laboratory rearing and periodic releases of both larvae and adults of *P. pseudoinsulata* continued through 1992, as the control agent established itself in some of the release areas around Pohnpei.

Since an unusually long dry period occurred from January to April 1992, *P. pseudoinsulata* was continuously released into areas which would have otherwise required fewer releases. In addition, farmers burned roadsides and hilly areas where *P. pseudoinsulata* had already established and was maintaining control of *C. odorata*. As a result, these burned areas became open lands and *C. odorata* started to reappear.

Introduction of *P. pseudoinsulata* to Kosrae

Third and fourth instar larvae of *P. pseudoinsulata* from cultures maintained in the laboratory on Pohnpei were brought to Kosrae; twice these were hand carried, then shipped monthly for the remainder of the time.

Larvae of *P. pseudoinsulata* were placed in clean, gallon-size plastic ice cream containers. A select number of larvae were placed on the bottom with fresh, detached *C. odorata* leaves on top. This method of layering *C. odorata* on top of the larvae was repeated until approximately one thousand larvae were placed in each container. By using this method, the larvae had an ample food supply and did not attempt to crawl out.

Monthly releases of *P. pseudoinsulata* were made on *C. odorata* infested areas on Kosrae for 10 months. The dates, number of larvae, and places of release are shown in Table I.

Table I. Releases of *Pareuchaetes pseudoinsulata* on Kosrae during 1992.

Date	Place	Number of larvae
January 3	Tafunsak (near airport) and Agric. Station	3000
February 10	Tafunsak (near airport), Agric. Station and Tafunsak (Quarry)	4000
March 11	Tafunsak (near airport)	1000
March 16	Tafunsak (near airport)	1200
April 12	Tafunsak (near airport)	3000
May 26	Tafunsak (near airport), Lelu (Agric. Station) and Utwe Municipality	4000
June 17	Lelu	2500
July 15	Lelu	1500
August 19	Lelu and Utwe	1500
September 23	Lelu and Utwe	1000
November 11	Lelu and Utwe	1000

Results and Discussion

Pohnpei

In the latter part of 1991, extensive feeding injury and heavy defoliation occurred in four release areas in Kitti. Extensive damage on *C. odorata* and high populations of the different larval instars of *P. pseudoinsulata,* were also observed. Stems of damaged *C. odorata* began to dry and be overtaken by common grasses. In January through March 1992, Pohnpei experienced an unusually long dry period. Farmers burned hilly areas, roadsides, as well as non-cropped cultivated or cleared lands where *P. pseudoinsulata* had already established. As a result, these areas became open bare lands and *C. odorata* began to reappear. However, the young *C. odorata* also showed feeding injury and the presence of *P. pseudoinsulata* larvae. Therefore, despite the burning of weed areas, some *P. pseudoinsulata* survived and began to defoliate the young *C. odorata* Because of the low population of *P. pseudoinsulata* that survived, it was decided to continuously release the biological control agent on burned areas so as to create another epizootic population.

Releases of laboratory reared larvae of *P. pseudoinsulata* were also started in Madolenihmw Municipality.

Kosrae

Feeding injury on the leaves of *C. odorata* occurred after several releases of *P. pseudoinsulata*. Releasing was done in open areas where *C. odorata* was not shaded. The majority of *C. odorata* in these release areas was defoliated. High numbers of *P. pseudoinsulata* larvae were also observed. Despite releasing only in its early larval stage, *P. pseudoinsulata* readily established in the release areas. The success of *P. pseudoinsulata* establishing itself may be due to the low number of local predators in these release areas. Even if predators were present, it is probable that they were not active in the release areas during the sunny part of the day. Similar observations were made on Pohnpei where the majority of release areas in which *P. pseudoinsulata* established, *C. odorata* was growing under the sun. In the release area where *C. odorata* was growing under the shade, *P. pseudoinsulata* did not become established. In that particular release area, each release of *P. pseudoinsulata* fell prey to lizards, birds, and ants, which fed on both larvae and adults. In addition, following the release of adults, eggs of *P. pseudoinsulata* were preyed on by red and black ants.

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Failure and Frustration of Biocontrol of *Chromolaena odorata* in South Africa.

(Echecs et Frustrations Associés à la Lutte Biologique contre *Chromolaena odorata* en Afrique du Sud)

R.P. Kluge and P.M. Caldwell
Agricultural Research Council, Plant Protection Research Institute
Pietermaritzburg, South Africa

Résumé - Les papillons de nuit Arctiidae, *Pareuchaetes pseudoinsulata* et *Pareuchaetes aurata aurata* n'ont pas pu s'établir en Afrique du Sud, probablement en raison d'une prédation par des fourmis. Les tentatives de soigner *P. aurata aurata* contre une maladie microsporidienne sont un échec. On espère qu'une troisième espèce de *Pareuchaetes*, *P. insulata*, pourra être lâchée en 1994. Trois générations d'*Actinote anteas* ont pu être élevées, mais les élevages ont finalement disparu, peut-être en raison d'une maladie ou d'une incompatibilité avec la forme Sud-Africaine de *C. odorata*. Les autres candidats à la lutte biologique actuellement pris en considération sont: *Rhodobaenus* sp. nr *cariniventris*, *Melanogromyza eupatorii*, *Mescinia parvula*, *Septoria ekmaniana* et *Longitarsus* sp. nr *amazonus*. Pour assurer compatibilité et succés, il est important de définir l'origine exacte de la forme Sud-Africaine de *C. odorata*, qui bien qu'apparemment étroitement proche de celle existant en Asie, en est morphologiquement bien distincte.

Abstract-The arctiid moths, *Pareuchaetes pseudoinsulata* and *Pareuchaetes aurata aurata*, have failed to establish in South Africa probably because of predation by ants. Attempts to clear *P. aurata aurata* of a microsporidian disease were unsuccessful. It is hoped that a third species of *Pareuchaetes*, *P. insulata* will be released in 1994. Three generations of *Actinote anteas* were reared but the culture died out possibly due to disease or incompatibility with the South African form of *C. odorata*. Other biocontrol candidates presently under consideration are: *Rhodobaenus* sp. nr *cariniventris*, *Melanogromyza eupatorii*, *Mescinia parvula*, *Septoria ekmaniana* and *Longitarsus* sp. nr *amazonus*. To ensure compatibility and success, it is important to find the exact origin of the South African form of *C. odorata*, which although apparently closely related to that occurring in Asia, is morphologically distinct from it.

Introduction

In southern Africa, *C. odorata* is an alien invader which poses the greatest threat to nature conservation areas. In Natal, *C. odorata* suppresses the indigenous plant communities, posing a very real threat to species diversity (MacDonald & Jarman 1985). *C. odorata* is thought to have been introduced into South Africa in the 1940s (Pickworth 1976), but its exact origin is unknown (Kluge 1990; 1991). The plant has since spread rapidly and now occurs along most of the Natal and Transkei coastal belt, with an isolated inland infestation near Tzaneen in the Transvaal (MacDonald 1984). Progress towards the biological control of *C. odorata* in South Africa is marked by failures and frustrations.

Determining the origin of the South African form of *C. odorata*

The South African form of *C. odorata* is closely related to, yet morphologically distinct from, the Asian and West African form. Evidence such as flowering time of the S. African form, *Septoria* fungal inoculations, isoenzyme studies, and gross and scanning electron microscopy of leaf trichomes and glands, indicate that this form probably originated in the northern seaboard of South America and the Caribbean (unpublished data). In order to confirm its origin, collections of *C. odorata* will be made in Trinidad, Venezuela, Guyana, and possibly Surinam in early 1994. Prospective biocontrol agents will also be collected at this time.

Importing and releasing insect biocontrol agents

Pareuchaetes pseudoinsulata

Eggs and early instar larvae of a defoliating caterpillar, *P. pseudoinsulata*, were imported from the same disease-free stock used in Guam, where it has proven to be a successful biocontrol agent (Seibert 1989). The moth was mass reared, and 600-1000 moths and pupae were released at 11 sites in Natal in 1988. These 11 sites are climatically representative of the major distributions of *C. odorata* in southern Africa. The release sites included open grassland, forest, and riverine bushveld, which are the main habitats invaded by *C. odorata*.

P. pseudoinsulata failed to establish at any of these sites. Ant predation of the egg batches of *P. pseudoinsulata* was high. Chrysopid larvae and a mite were also found to be responsible for egg predation (Kluge 1993b).

P. aurata aurata

Another species of *Pareuchaetes*, *P. aurata aurata,* was released in an attempt to lessen predation by ants. Since *P. aurata aurata* scatters its egg on the ground, ants can only predate one egg (as opposed to batches) at a time. Permission for the release of this insect was obtained (Kluge & Caldwell 1993a). However, despite the 147,000 moths and pupae released at 17 sites on the north coast of Natal, it appears that *P. aurata aurata* has failed to establish.

Attempts to rid *P. aurata aurata* of a microsporidian disease also failed. Laboratory cultures have shown, however, that this specific microsporidian disease is not particularly virulent (Kluge & Caldwell 1992).

P. insulata

A third *Pareuchaetes* species, *P. insulata*, from Florida has been cleared for release (Kluge & Caldwell 1993b). Like *P. pseudoinsulata* this insect also lays its eggs in batches, on the underside of the leaves. However since *P. insulata* comes from an area that possibly has a richer ant fauna, it may also have evolved a resistance mechanism to ant predation of its eggs. Attempts are underway to introduce this insect in 1994.

Actinote anteas

Another leaf defoliator, *A. anteas*, was imported from Costa Rica. However, larval mortality as well as mating and egg laying problems eventually resulted in the laboratory culture dying out by the third generation. These results suggest that *A. anteas* is incompatible with the S. African form of *C. odorata* (Caldwell & Kluge 1993).

Dysschema sacrifica

D. sacrifica was found to be oligophagous and not host specific to *C. odorata*. It is therefore no longer considered as a biocontrol agent for *C. odorata* (Kluge 1993a).

Other candidates under consideration

Rhodobaenus sp. nr *cariniventris*

Although *Rhodobaenus* is mainly a pith miner, it prevents side branches from developing. Since side-branching is an important element in inter-specific competition with other plants, *Rhodobaenus* could have a significant impact as a biocontrol agent.

Melanogromyza eupatorii

This stem-boring insect is heavily parasitized in Trinidad but still has a significant impact on suppressing growth in *C. odorata*. Since it would probably not be subject to parasitism in South Africa, *M. eupatorii* could be a particularly good biocontrol candidate.

Mescinia parvula

M. parvula is another stem-borer and possibly a good candidate to suppress growth of *C. odorata*. Problems may arise since this insect is difficult to culture. Thus far, there are no records of laboratory cultures having been established.

Longitarsus sp. nr *amazonus*

This previously unreported candidate was collected on *C. odorata* in Manaus, Brazil. Preliminary studies show that the adults feed on the leaves and the larvae develop in the roots of the S. African form of *C. odorata*.

Septoria ekmaniana

This is a common pathogen of *C. odorata* in its native range, and causes leaf spots often leading to extensive leaf necrosis and defoliation. Isolates of the fungus have caused damage only on forms of *C. odorata* collected within the same area. So far no isolates have attacked the S. African form of the weed.

Conclusions

The future of control of *C. odorata* in S. Africa rests primarily on finding its exact origin to ensure compatibility and success with bio-control agents. In 1992, the Agricultural Research Council was formed as a semi-private organization which receives its funding from contract research. Due to the unpredictability and slow pace of biocontrol methods, funding for future research on *C. odorata* may present a problem.

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The Mycoflora of *Chromolaena odorata* in the Neotropics and its Potential for Biocontrol.

(La Mycoflore de *Chromolaena odorata* dans les Néotropiques et son Potentiel pour la Lutte Biologique)

R.W. Barreto
Departamento de Fitopatologia, Universidade Federale de Vicosa
MG, Brazil

and

H.C. Evans
International Institute of Biological Control (IIBC), Silwood Park
Ascot, Berks, UK

Résumé- Cet article présente les résultats d'une étude de deux ans sur les champignons associés à *Chromolaena odorata* dans le Sud du Brésil. Cette étude, menée principalement dans l'Etat de Rio de Janeiro, a permis de couvrir toute une série d'écosystèmes sur 70 sites. D'autres études *ad hoc* ont été entreprises en Amazonie Brésilienne, en Colombie, en Equateur et au Guyana. De plus, des relevés pantropicaux des associations fongiques sur *C. odorata* furent obtenus auprès des Herbiers et par des recherches bibliographiques. Sur les 17 espèces néotropicales relevées, les taxons suivants présentent un certain potentiel pour la lutte biologique dans l'Ancien Monde: *Anhelia niger* (Viègas) Arx (Dothideales, Ascomycotina); *Septoria ekmaniana* Petrak et Ciferri (Coelomycetes); *Mycovellosiella perfoliata* (Ell. et Ev.) Muntanola (Hyphomycetes); *Cionothryx praelonga* (Winter) Arthur (Uredinales, Basidiomycotina). Cette liste se fonde sur nos observations de terrain concernant la spécificité du parasitisme et l'étendue des dégâts sur la plante hôte. D'autres études sur ces espèces et sur d'autres pathogènes sont nécessaires pour pouvoir évaluer précisément leur potentiel. Des attaques combinées particulièrement sévères dues à *S. ekmaniana* et *A. niger* ont été observées dans les basses terres tropicales du Nord du Brésil et du Guyana. Ces deux pathogènes paraissent donc présenter le plus fort potentiel pour la lutte biologique dans les Paléotropiques. Au contraire, la rouille *C. praelonga* n'a été relevée qu'en altitude, au nord de l'Amérique du Sud. Cela pourrait être lié à un optimum de température bas pour l'infection. Cette rouille n'a pas été relevée dans les inventaires plus intensifs menés dans le sud du Brésil, où le climat est subtropical plutôt que tropical.

Abstract-This paper presents the results of a two-year survey of the fungi associated with *Chromolaena odorata* in southern Brazil. The survey, carried out mainly in the state of Rio de Janeiro, covered a range of ecosystems in 70 sites. Other ad hoc surveys were undertaken in the Brazilian Amazon, Colombia, Ecuador and Guyana. In addition, pantropical records of fungal associations with *C. odorata* were obtained from herbarium and literature searches. Of the 17 Neotropical species recorded, the following taxa show some potential for control of *C. odorata* in the Old World: *Anhellia niger* (Viégas) Arx (Dothideales, Ascomycotina); *Septoria ekmaniana* Petrak & Ciferri (Coelomycetes); *Mycovellosiella perfoliata* (Ell. & Ev.) Muntañola (Hyphomycetes); *Cionothrix praelonga* (Winter) Arthur (Uredinales, Basidiomycotina). This assessment is based on circumstantial field evidence relating to host specificity and damage done to the host plant. More studies on these species and other pathogens are needed before their true potential can be evaluated. Combined attacks of *S. ekmaniana* and *A. niger* were particularly severe in lowland tropical situations in both northern Brazil and Guyana. Therefore, it is concluded that these two pathogens offer the most potential for biological control in the Old World tropics. In contrast, the rust *C. praelonga* was collected only at higher altitudes in northern South America. This finding may be linked with lower temperature optima for infection. This rust was not recorded from the more intensive surveys in southern Brazil, where the climate is subtropical rather than tropical.

Introduction

The tribe Eupatorieae is predominantly New World in origin with no recognizably beneficial plants (crops or ornamentals) but contains several weed species of pantropical importance. In addition to *Chromolaena odorata* (L.) King & Robinson, two other plants of Neotropical origin, *Mikania micrantha* Kunth and *Ageratum conyzoides* L., have become major weed problems in the Old World tropics (Holm *et al.* 1977, 1979); there are no records of *C. odorata* as a serious weed in the Neotropics (Cruttwell-McFadyen 1991). The exotic nature of these weeds, combined with their taxonomic isolation from crop plants, makes them ideal targets for classical biological control using fungal pathogens (Evans & Ellison 1990).

Cruttwell-McFadyen (1991) discussed the natural range of *C. odorata* in the Americas, and considered it to be confined to the tropical zone and absent from subtropical humid areas, such as southern Brazil. However, *C. odorata* is a common but never dominant member of the flora of Rio de Janeiro state (Barreto 1991), and the above oversight is probably due to problems of synonymy. Lorenzi (1982) for example, lists the Brazil form of the plant as *Eupatorium maximilianii* Schrad, which is now recognized as a synonym of *C. odorata* fide (Barroso pers. comm.).

Although *C. odorata* has been the subject of a biological control program for over 20 years, the emphasis has been almost entirely on the use of arthropod agents (Julien 1992); only minimal attention has been paid to exploiting fungal pathogens (Ooi *et al.* 1991). Based on the need for additional studies of fungal pathogens, Evans (1987) carried out both a literature and herbarium survey of the fungi recorded on *C. odorata*, whilst Chacko & Narasimham (1988) highlighted the need for a systematic survey of pathogens in the centre of origin. This paper reports on the results of an intensive survey of the fungi associated with *C. odorata* in southern Brazil, as well as on opportunistic surveys in northern South America.

Material and Methods

Field Surveys

The main survey was conducted in the state of Rio de Janeiro (RJ), which although relatively small by Brazilian standards (43,300 km^2), has a diverse topography and vegetation. The climate ranges from tropical coastal to upland subtropical. Meteorological data were used in the selection of 70 representative sampling sites. Each site had an area of 0.5-1.0ha. The sites were visited two or three times from Oct. 1988 to Aug. 1989, and sampled for a standardized period (120 ±30 min.). Samples of all fungi suspected of being pathogenic to *C. odorata* were collected and dried in a plant press. Observations and collections of the weed were also undertaken during short visits to Espirito Santo, Paraná and São Paulo, southern Brazil, and Pará, Amazonas in northern Brazil. Additional material was collected in the Los Rios and Manabí Provinces in Ecuador, and the Cundinamarca Division in Colombia and coastal Guyana. Isolations from diseased plants were made on V8 juice agar or potato carrot agar in Brazil or in the UK. Fungal identifications were confirmed at the International Mycological Institute (IMI), Kew, UK. Full taxonomic and cultural descriptions of these fungi can be found in Barreto & Evans (1994).

Literature and herbarium surveys

In order to compile a worldwide check list, records of the fungi associated with *C. odorata* were obtained from a literature search (including CABI Database, Index of Fungi, Petrak's Lists), and from unpublished data in the following herbaria: Herb. IMI; Herb. URM, Depto. de Micologia, Universidade de Pernambuco; Herb. IACM, Instituto Agronômico de Campinas; Herb. IBSP, Instituto Biológico de São Paulo, in order to compile a worldwide check list.

Results and Discussion

Fungi collected during field surveys:

Alternaria zinniae M.B. Ellis (Hyphomycetes, Deuteromycotina)

This leaf-spotting fungus has not been recorded previously from *C. odorata*, although it appears to be a cosmopolitan pathogen with a wide host range (Herb. IMI). It was collected only in RJ and had a sporadic occurrence in sites situated far apart, all at or near sea level. The pathogenicity of *A. zinniae* to *C. odorata* was confirmed in greenhouse tests (Barreto 1991). However, until more is known about strain specificity, the potential of this fungus as a biological control agent remains low.

Anhellia niger (Viégas) Arx (Dothideales, Ascomycotina)

This fungus causes extensive brown, angular lesions on stems, leaves, petioles and flower peduncles, and is characterized by shiny, black, scab-like fructifications on the affected tissues. It was recorded from only two sites in southern Brazil, and appears to be uncommon in subtropical areas. However, confirming earlier reports (Stevens 1930), *A. niger* was prevalent and damaging in some lowland tropical regions in Brazil (Belém, Pará), and Guyana (Essequibo river). *A. niger* appears to be a highly virulent pathogen with a restricted host range, recorded only on a *Eupatorium* sp. (=? *Chromolaena*) and *C. odorata*. Its potential as a classical biological control agent for introduction into the Old World is high.

Cionothrix praelonga (Winter) Arthur (Uredinales, Basidiomycotina)

The rust was not recorded in RJ during the main survey nor was it observed in southern, subtropical, tropical, or northern Brazil. However, *C. odorata* was collected during the survey of the Cundinamarca region in the Andean foothills (ca. 850 m a.s.l.) of Colombia, where it was associated with a damaging leaf disease. *C. praelonga* is readily recognized by the long, yellowish-orange, hair-like chains of spores emerging from the lower leaf surface, making it unlikely to be overlooked in a survey. Its distribution on *C. odorata* appears to be restricted to upland habitats in northern tropical South America and the Caribbean (Ooi *et al.* 1991). The absence of this rust from the lowland tropics suggests that it is more adapted to subtropical climates and that its potential as a classical biological control agent in the Old World may be limited. This is supported by the findings of this survey and studies in Trinidad where *C. praelonga* is only found at higher elevations (>300 m), even though the weed host is common at sea level (D. Elango & A.N.G. Holden, pers. comm.). Preliminary data indicate that temperatures below 20°C are necessary for spore germination (Ooi *et al.* 1991). Despite not being found on *C. odorata* from upland habitats in southern Brazil, *C. praelonga* has been reported from this region on *Eupatorium dichotomum* Schulz-Bip. (Hennen *et al.* 1982), indicating, perhaps, the existence of a complex of rust pathotypes or ecotypes on Eupatorieae.

Mycovellosiella perfoliata (Ell. & Ev.) Muntañola (Hyphomycetes, Deuteromycotina)

M perfoliata was recorded from six sites in RJ, where it appears to be seasonal (not collected during the summer months), occurring only in climatic zones with a mean temperature above 21°C. Leaf symptoms were indistinct on the RJ collections; however, a specimen from Paraná was associated with a severe leaf disease, suggesting that different strains or pathotypes occur. This is the first report of *M. perfoliata* on *C. odorata* (Evans 1987). Much work on the pathogenic status and host specificity remains to be done before its potential as a classical biological control agent can be assessed.

Ophiociliomyces bauhiniae Batista & Lima (Sphaeriales, Ascomycotina)

This fungus produces a soot-like covering on aerial parts of *C. odorata*. It was frequently encountered in RJ throughout the year and in a whole range of climatic zones, as well as in the states of São Paulo and Paraná. However, *O. bauhiniae* is considered to be of minor importance as a pathogen of *C. odorata* since no visible damage was associated with its presence. Therefore, it has no potential for biological control.

Pseudocercospora eupatorii-formosanii (Sawada) Yen (Hyphomycetes, Deuteromycotina)

P. eupatorii-formosanii was collected from five sites in RJ. Each site had different climatic parameters, with mean annual temperatures ranging between 18-23°C, and rainfall ranging from 1080 to 2030 mm. This is the first record of *P. eupatorii-formosanii* from the Neotropics, previously being known only from South-east Asia and the Indian subcontinent (Yen & Lim 1980, Evans 1987). Although leaf necrosis may be severe, the prospects of using this pathogen as a classical biological control agent are remote, since the fungus already occurs in regions where *C. odorata* is an exotic weed. The fungus does not exert a significant effect on weed populations in these areas.

Redbia trichomambusta R W Barreto

This fungus is widely distributed in RJ and occurred throughout the range of climate types. While in some collections it was growing in abundance on the leaf trichomes without producing any symptoms on the colonised leaves, in others it was associated with apical leaf necrosis. The pathogenic status of *R. trichomambusta* therefore, remains unresolved and its biocontrol potential cannot be evaluated.

Septoria ekmaniana Petrak & Ciferri (Coelomycetes, Deuteromycotina)

S. ekmaniana was found in 45% of the *C. odorata* sites (31 collections) in RJ, and was present in all climatic zones throughout the year. It causes punctiform leaf spots which often coalesce to cover whole leaves, resulting in severe foliar damage and stunting of *C. odorata*. Further collections have been made in northern Brazil (Pará; Amazonas), Ecuador (Los Rios), Colombia (Cundinamarca) and Guyana (Essequibo river), from near sea level up to 1000 m. At Guyana, *S. ekmaniana* was in close association with *Anhellia niger* and the combined attack was severely limiting growth of the weed. While describing a disease of *C. odorata* in Guam caused by a *Septoria* sp., Russo (1985) commented that: "There is no report of a *Septoria* sp. causing disease in *Chromolaena*." From pathogenicity tests, Russo concluded that only the oldest leaves were affected and that the fungus attacked only senescing tissues. Based on his observations, it is highly unlikely, however, that the Guam fungus is *S. ekmaniana*. The identity of this Old World record requires confirmation.

Until recently, *S. ekmaniana* was known only from the Dominican Republic (Ciferri 1961). Based on the evidence from the current surveys, the fungus seems to have a wide distribution within the Neotropical range of *C. odorata*. Therefore, the prospects of employing *S. ekmaniana* as a classical biological control agent appear to be excellent.

Fusarium pallidoroseum (Cooke) Saccardo (Hyphomycetes, Deuteromycotina)

This fungus is usually considered to be epiphytic rather than pathogenic on a range of plants (Booth & Sutton 1984). However, during the RJ survey, *F. pallidoroseum* was isolated consistently from severely diseased *C. odorata* showing characteristic symptoms of black stromatic structures erupting through the epidermis of stems and branches. Nevertheless, pathogenicity of *F. pallidoroseum* to *C. odorata* has not been proven and doubts remain about its true role in the disease syndrome.

Fungi recorded from literature and herbarium surveys

The fungi collected during the surveys are listed in Table 1. Of the 39 fungal species recorded, 16 were found exclusively in regions where the weed is an alien plant, 18 were unique to the native range, and the remaining five species were common to both situations. The small number of species present in both the native and exotic ranges is an indication of the continuing isolation of the Neotropical mycoflora of *C. odorata*. Undoubtedly, the Old World taxa represent opportunistic, non-specific pathogens.

Conclusions

1. *C. odorata* has an exclusive guild of fungal pathogens in the Neotropics.

2. The mycoflora of *C. odorata* in exotic or Old World situations is more extensive but is represented predominantly by weakly parasitic or opportunistic species.

3. Few species are common to both regions showing the continuing isolation of the Neotropical mycoflora.

4. The prospects for classical biological control are good with two species, *Anhellia niger* (Ascomycotina) and *Septoria ekmaniana* (Coelomycetes), having the most potential in view of their apparent host specificity, high pathogenicity or disease rating, and wide climatic range.

5. The rust *Cionothrix praelonga*, may have a reduced potential in tropical situations due to its relatively low temperature requirements for spore germination, but may prove to be effective in subtropical and upland tropical areas.

6. Basic studies on pathogenicity and host range of these potential biological control agents of *C. odorata* are urgently required.

Table 1. Fungal Pathogens recorded on *C. odorata* (ex CABI Database, Herb. IMI).

Fungi	Distribution
Ascomycotina & Deuteromycotina	
Acrostalagmus albus Preuss (N)	South America (Viégas 1961)
Anhellia niger (Viégas) Arx (N)	Guyana (Stevens 1930), Brazil (new record)
Appendiculella sorocula (Spegazzini) Hansford (N)	Dominican Rep. (Ciferri 1961), Jamaica, (Leather 1967), Venezuela (Urtiaga 1986), Trinidad & Tobago (Baker & Dale 1951)
Byssosphaeria schiermayeriana Fuckel (N)	Brazil (IMI 157432)
Capnodium sp. (N)	Venezuela (Urtiaga 1986)
Cercospora sp. (O)	Malaysia (Johnston 1960), Thailand (Puckdeedindan 1966), Nepal (IMI 194503)
Cercospora aciculina Chupp (O)	Cambodia (Litzenberger *et al.* 1962), Nigeria (IMI 176830)
Cercospora eupatorii Peck (N,O)	Cambodia (Litzenberger *et al.* 1962), Cuba (Urtiaga 1986), India (Subramanian & Tyagi 1964), Ivory Coast, Nepal, Hawaii, North America (Evans 1987)
Cercospora eupatorii - odorati W.Y.Yen (O)	Malaysia (Yen 1968)
Chaetothyrium dominicanum Ciferri (N)	Dominican Rep. (Ciferri 1961)
Colletotrichum sp. (O)	Cambodia (Litzenberger *et al.* 1963)
Cylindrosporium sp. (O)	Cambodia (Litzenberger *et al.* 1963)
Didymosphaeria sp. (O)	India (IMI 312419)
Fusarium pallidoroseum (Cooke) Saccardo (N)	Brazil (new record)

Glomerella cingulata (Stonem) Spaud & Schrenk (N,O)	Cuba (Urtiaga 1986), Sri Lanka (IMI 145666)
Guignardia eupatorii Punithalingam (O)	Sri Lanka (Punithalingam 1974)
Hormodendron (Cladosporium) eupatorii Ciferri (N)	Dominican Rep. (Ciferri 1961)
Meliola sp. (O)	India (IMI 237720)
Mycosphaerella eupatorii W.Y.Yen (O)	Malaysia (Yen 1979b)
Mycosphaerella fungurahuana Sydow (N)	Venezuela (Urtiaga 1986)
Mycovellosiella perfoliata (Ell. & Ev.) Muntañola (N)	Brazil (new record)
Ophiobolus ipohensis W.Y.Yen (O)	Malaysia (Yen 1979a)
Ophiociliomyces bauhiniae Batista & Lima (N, O)	Cambodia (Litzenberger *et al.* 1962), Brazil (new record)
Ophiosphaerella eupatorii W.Y.Yen (O)	Malaysia (Yen 1979a)
Phaeosphaeria eupatoriicola W.Y.Yen (O)	Malaysia (Yen 1979a)
Phomopsis eupatoriicola Petrak (O)	Sri Lanka (IMI 145669)
Phloeospora sp. (N)	Venezuela (Urtiaga 1986)
Phyllosticta eupatoriicola W.Y.Yen (N, O)	Malaysia (Yen 1979a), South America (Viégas 1961)
Pseudocercospora eupatorii-formosanii (Sawada) Yen (N, O)	Borneo, Brunei (Peregrine & Ahmad 1982), Burma, India, Thailand (Evans 1987), Malaysia (Yen 1968), Bangladesh (IMI 262423), Brazil (new record)
Redbia trichomambusta Barreto (N)	Brazil (new record)

Septoria sp. (O)	Guam (Russo 1985)
Septoria ekmaniana Petrak & Ciferri (N)	Dominican Rep. (Ciferri 1961), Trinidad & Tobago (Ooi *et al.* 1991), Brazil, Guyana & Colombia (new records)
Septoria eupatorii Roberge & Desmazieres (N)	Venezuela (Urtiaga 1986)
Setella (=*Dysrhynchis*) *citricola* Sydow (N)	Dominican Rep. (Ciferri 1961)
Basidiomycotina	
Cionothrix praelonga (Winter) Arthur (N)	Dominica (Evans 1987), Mexico (Gallegos & Cummins 1981), Trinidad& Tobago (Baker & Dale 1951), Venezuela (Evans 1987), Colombia (new record)
Coleosporium steviae Arthur (N)	Mexico (Gallegos & Cummins 1981)
Thanatephorus cucumeris (Frank) Donk (as *Hypochmus sasakii*) (O)	Taiwan (Sawada 1931)
Uredo bullula Kern (N)	Dominican Rep. (Ciferri 1961)

N = Neotropical record, part of endemic mycoflora
O = Old World record, exotic or alien species.

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The ACIAR Project for Biological Control of *Chromolaena odorata* in Indonesia and the Philippines.

(Le Projet ACIAR de Lutte Biologique contre *Chromolaena odorata* en Indonésie et aux Philippines)

R. Cruttwell McFadyen
Alan Fletcher Research Station
Australia

Résumé - L'herbe du Siam, *Chromolaena odorata* (L.) R. M. King et H. Robinson, est une adventice majeure des pâturages et des plantations en Afrique de l'Ouest et en Asie du Sud-Est. De nombreux agents potentiels de lutte biologique existent, mais les essais n'ont porté jusqu'à présent que sur deux d'entre eux et avec un succés limité. En Asie, l'herbe du Siam continue à s'étendre vers le Sud et se trouve maintenant en Papouasie Nouvelle-Guinée, en Irian Jaya ainsi qu'à Timor, et menace de se répandre en Australie. Depuis 1993, le Centre Australien pour les Recherches Internationales en Agriculture (ACIAR) finance un projet sur 3 ans dans lequel sont importés des insectes d'Amérique du Sud pour des essais en quarantaine de compatibilité avec diverses plantes hôtes. Une mouche formant des galles, *Procecidochares connexa* sera testée ainsi en Indonésie. Ces tests seront suivis de lâchers en plein champs si les insectes s'avèrent convenir. Des essais sur d'autres insectes seront entrepris pendant les deux années suivantes.

Abstract-Siam weed, *Chromolaena odorata* (L.) R.M. King and H. Robinson, is a major weed of pastures and plantation crops in West Africa and South-East Asia. Many potential biocontrol agents exist but trials have been done on only 2 of these, both of which have had limited success to date. Siam weed continues to spread south, and is now in Papua New Guinea, Timor, and Irian Jaya, and is threatening to spread into Australia. Beginning in 1993, the Australian Centre for International Agricultural Research (ACIAR) funded a 3-year project which imports suitable insects from South America to Indonesia and the Philippines, for detailed host-testing in quarantine. A stem-galling fly, *Procecidochares connexa* will shortly be host-tested in quarantine in Indonesia. The testing will be followed by field release, if the insects prove safe. Trials will be done on other insects over the next two years.

Background

Siam weed is native to the tropical Americas, from Florida to northern Argentina, where except in undisturbed rainforest, it is found in most areas below 1000 m altitude. In its native range it is common but not a serious weed. Siam weed was introduced into Asia in the 1840s, probably via the Botanic Gardens in Calcutta, and has since spread from South-East Asia to the South Pacific (McFadyen 1989). In Asia, Siam weed is a major weed of pasture and plantation crops in areas receiving at least 1000 mm of rain annually. Thirty years after its introduction to the Philippines, it has become the worst weed of pasture and plantation crops after *Imperata cylindrica*. *C. odorata* is most competitive in tropical wet-dry climates, burning readily and surviving fires to regrow rapidly in the rainy season. Siam weed is now present in Timor, Irian Jaya, and Papua New Guinea, all of which are to the immediate north of Australia. Coastal northern Australia, from Arnhem Land in the Northern Territory to Cape York in Queensland, is threatened by Siam weed. In 1985, biological control for Indonesia and the Philippines was proposed which would benefit both countries, while also reducing the risk to Australia (McFadyen 1991). Funding for this project came from the Australian Centre for International Agricultural Research (ACIAR), in the amount of approximately US $263,000, for a 3 year period beginning in January 1993.

Australia. The Queensland Department of Lands Alan Fletcher Research Station (AFRS), with Dr. Rachel McFadyen as project leader and Brian Willson as entomologist, is the commissioned organization. The Northern Territory Department of Primary Industry and Fisheries with Colin Wilson as entomologist, is a collaborating organization.

Indonesia. The Indonesian Institute for Oil Palm Research (IOPRI) at Marihat Research Station in the northwestern island of Sumatra is the first collaborating institution. The project leaders are Ir. Sipayung, Dr. Roch Desmier de Chenon, and Dr. Djohan Pardede. SEAMEO BIOTROP in Bogor, on the main island of Java is another collaborating institution, with Dr. Soekisman Tjitrosoedirdjo as project leader and Kasno as entomologist. The University of Yogyakarta in eastern Java with Dr. Soeprapto as project leader, is also involved in the project through BIOTROP.

Philippines. The National Crop Protection Center at UPLB Los Baños, south of Manila on the main island of Luzon is the collaborating institution. Dr Dominador Torres is the project leader, and Emma Alforja and Amabel Capricho are the research assistants. The National Coconut Authority in Davao City in the southern island of Mindanao is also collaborating, with Dr. Reynaldo Abad as project leader and Emmanuel Aterrado as entomologist.

Procedures

Earlier investigations in the West Indies in the 1960s have provided the basic information on potential biocontrol agents (Cruttwell 1974, Cock 1984). We have selected a priority list of 2 or 3 of these agents, which are damaging, easy to rear, and host-specific. Scientists at the AFRS supply available information on these insects to the Indonesian and Philippine collaborators, who then apply for permits to import the insect into their quarantine for detailed host-testing. When permits are granted, the insects are sent from the AFRS field station in South America to quarantine in Marihat, where a parasite-free colony has been established. Insects from this colony are then sent to the Philippines.

Once a colony is established in quarantine, host-tests are carried out as required on the plants suggested by the country involved. After the tests are completed, and it is determined that the insect is safe to release, an application for permission to field release is made. Mass-rearing and field releases can then begin on all islands of the country involved.

The ACIAR project provides training and minor equipment for upgrading facilities to ensure safe and effective handling of insects in quarantine. Regular visits by entomologists from AFRS help to establish and maintain the quarantine colony and devise safe host-testing procedures for each insect. Field-monitoring methods are also being developed for evaluating the results of this project.

Insects to be Tested

The arctiid moth *Pareuchaetes pseudoinsulata*, already successfully used for the biocontrol of Siam weed in Guam, has been introduced, host-tested and field-released by the Marihat Research Station in Indonesia. Funding for the use of *P. pseudoinsulata* in Indonesia was provided by the EEC/IRHO project (Deat 1991). The ACIAR project is supporting continued mass-rearing and releasing of this insect to Java and Timor in Indonesia, and the Philippines. Although the moth has spread naturally from Sabah, Malaysia into these areas, the strain from Guam may prove to be a more effective control agent.

The second insect to be tested is the stem-galling tephritid fly *Procecidochares connexa* (Macq.), from South America. This insect is known to be host-specific and damaging. Two other species in this group, *P. utilis* to control Crofton weed *Ageratina adenophora,* and *P. alani* to control mistflower *A. riparia*, have already been used as biocontrol measures in Hawaii and elsewhere. Information on the biology and known host-specificity of this insect was sent to Marihat where scientists have applied for an import permit from the Government of Indonesia. This permit has just been granted and a colony will very soon be sent from South America to quarantine at Marihat. Once a quarantine colony is established at Marihat, detailed host-testing as required by the Indonesian Government will begin. This testing is likely to last about one year; if the results confirm that the insect is completely safe, Marihat will apply for a permit for field release. Mass-rearing and field releases will then be made in all the main Indonesian islands.

Meanwhile the Philippines has also applied for an import permit. After the permit is received, a parasite-free colony will be sent from Marihat to NCPC at Los Baños, for host-testing in quarantine.

As host-testing of *P. connexa* continues, a third insect, the tip-galling moth *Mescinia parvula* (Zeller) will be reared at the AFRS South American field station. Although for many years this insect has been identified as a promising agent (Ooi *et al.* 1991), attempts to obtain mating in cages have failed. Another effort to rear *M. parvula* will be made by Cesar Garcia, an experienced weed biocontrol entomologist who is based in the area where the moth originated. If successfully reared, *M. parvula* will then be brought into quarantine for detailed host-testing in Indonesia and the Philippines, followed by field releases in both countries. Following these efforts, other potential biocontrol agents can be tested if the results warrant extension of the project.

Collaboration with other projects

The ACIAR project will concentrate on known host-specific insects during the first three years. If other biocontrol agents are identified in the meantime, these will receive priority consideration for a trial within this project. Conversely, once a parasite-free quarantine colony of any new agent is established at Marihat or Los Baños, a nucleus colony of the insect can be sent to any other country which requests the agent for testing and release. Interim results will be made available through the *Chromolaena* Newsletter prior to publication in international scientific journals. *C. odorata* is such a serious problem and there are so many potential agents that it is important to share information and control agents with the scientific community.

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Histology of *Chromolaena odorata* Leaves Infested by *Pareuchaetes pseudoinsulata* Rego Barros (Lep.: Arctiidae).

(Histologie des Feuilles de *Chromolaena odorata* Infestées par *Pareuchaetes pseudoinsulata* Rego Barros (Lep.: Arctiidae))

I. U. Silva-Krott and R. Muniappan
Agricultural Experiment Station, University of Guam
Mangilao, Guam

Résumé-De vastes zones de l'ile de Guam sont couvertes par l'adventice des patûrages tropicaux *Chromolaena odorata. Pareuchaetes pseudoinsulata* a été introduit dans l'ile et a causé une large défoliation de l'adventice. Les feuilles de *C. odorata* ont développé une chlorose marquée lors de l'infestation par la chenille. Si l'on retire les insectes, la couleur des feuilles redevient verte avec une augmentation concommitante de la teneur en chlorophylle. La chlorophylle a été etudiée dans des sections histologiques de feuilles fraiches jaunes et vertes ainsi que dans les tissus foliaires enrobés de parafine. Les échantillons de feuilles jaunes montrent une perte diffuse de chlorophylle et de chloroplastes des cellules du mésophylle dans toute la feuille. Les cellules dépourvues de chloroplastes montrent une large variation de forme et de dimensions. Cependant, pendant la phase de convalescence des feuilles, une fois les insectes retirés, une augmentation lente du nombre de chloroplastes de distribution inégale dans les cellules du mésophylle, a pu être observée.

Abstract-Large areas of Guam are covered by the tropical pasture weed *Chromolaena odorata*. *Pareuchaetes pseudoinsulata* was introduced to the Island and caused widespread defoliation of the weed. *C. odorata* leaves developed marked chlorosis when infested by the caterpillar. After removal of the insect the leaf color returned to green with a concomitant increase in chlorophyll. Leaf chlorosis was studied in histologic sections of fresh yellow and green leaves as well as paraffin embedded leaf tissues. Histologic samples of yellow leaves showed diffuse loss of chlorophyll and chloroplasts of mesophyll cells in all portions of the leaf. Cells devoid of chloroplasts exhibited increased variation in shape and diameter. However, during the recovery stage of leaves, after removal of insects, a slow increase in numbers of chloroplasts with uneven distribution in mesophyll cells was observed.

Introduction

Guam is one of many Pacific Islands with widespread growth of *Chromolaena odorata* (L.) (Muniappan & Marutani 1988). *Pareuchaetes pseudoinsulata* Rego Barros (Lepidoptera: Arctiidae) was introduced to Guam in 1985 as a biological control agent (Seibert 1989). Repeated releases of larval and adult stages established the insect on the island and led to defoliation of large areas of *C. odorata* (Muniappan *et al.* 1989, Seibert 1989). Plants infested by *P. pseudoinsulata* developed severe chlorosis of remaining leaves. The chlorotic change was reversible when insects were removed (Marutani & Muniappan 1991).

The exact mechanism of *C. odorata* chlorosis secondary to infestation by *P. pseudoinsulata* is not known. In this communication we present photomicrographs of fresh and paraffin-embedded sections of green and insect-induced chlorotic leaves of *C. odorata*.

Materials and Methods

C. odorata plants were grown individually in pots next to the laboratory. Three to four *P. pseudoinsulata* second instar larvae were placed on each of two plants in order to induce yellowing. Plants were kept in a cloth cage.

Two more plants were placed in a second cloth cage and served as controls. Chlorotic leaves were sampled two to three weeks later. Insects were then removed, allowing plants to recover. Leaves changed back to green and were sampled two weeks later. In addition, yellow leaves from wild *P. pseudoinsulata* infested plants were collected and examined. All collected leaves were either freshly sectioned or fixed in FAA (50% Ethylalcohol [95%], 10% Formalin [39% Formaldehyde, 5% Acetic Acid, 35% H_2O, and stained with 0.01% Toluidine blue for two minutes. Stained sections were transferred to a microscope slide, coverslipped and immediately viewed through a Leitz BioMed Microscope with attached camera (Ernst Leitz, Wetzlar GmbH, D-6330 WETZLAR). Pieces of leaves fixed overnight in FAA were dehydrated and embedded in paraffin (Berlyn & Miksche 1976); 6 um sections were cut on a rotary microtome, transferred to glass slides and stained with 0.1% Safranine red and 0.1% Fast Green.

Results

All sections of chlorotic leaves, from plants kept in the laboratory and from insect-infested, wild growing plants, demonstrated similar changes. All layers of epidermal, palisading and spongiform mesophyllic cells remained intact. Mesophyllic cells contained markedly reduced chlorophyll. Parenchymal cells exhibited variable sizes and shapes. There were low numbers of chloroplasts within parenchymal cells; however, shape and size of chloroplasts did not change (Fig. 1). Fresh sections of green leaves showed a large amount of green chlorophyll within numerous chloroplasts in mesophyllic cells obscuring individual cell outlines (Fig. 2). In sections of leaves taken from plants in recovery there was an increased amount of chlorophyll compared to the chlorotic leaves. Chloroplasts were distributed unevenly (Fig. 3).

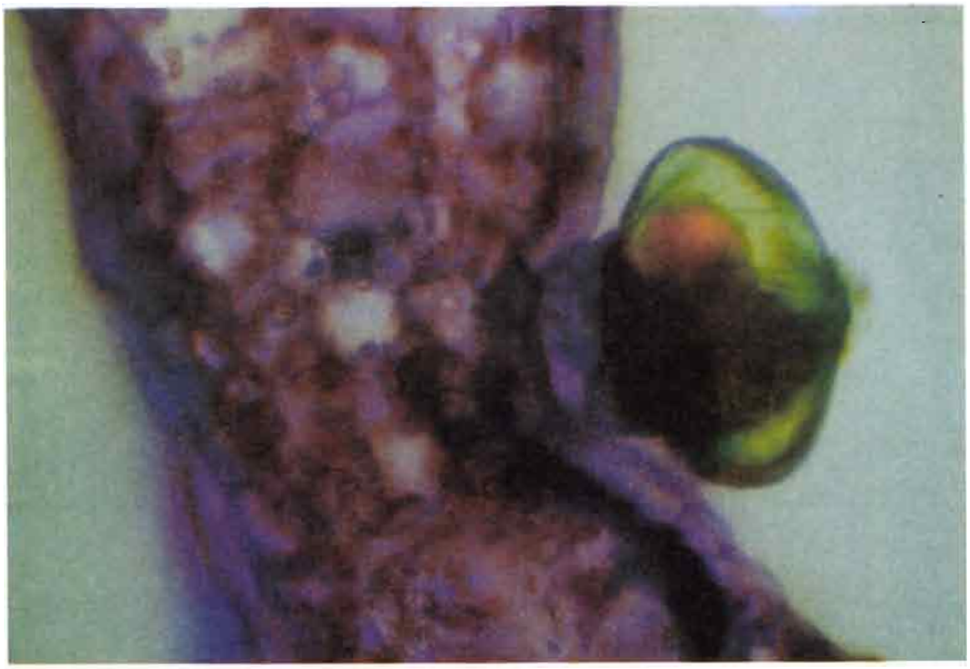

Figure 1. Histology of a chlorotic leaf sample of *C. odorata* secondary to *P. pseudoinsulata* infestation. Mesophyllic cells contain few chloroplasts. The droplet on the lower surface of the leaf is a secretion product.

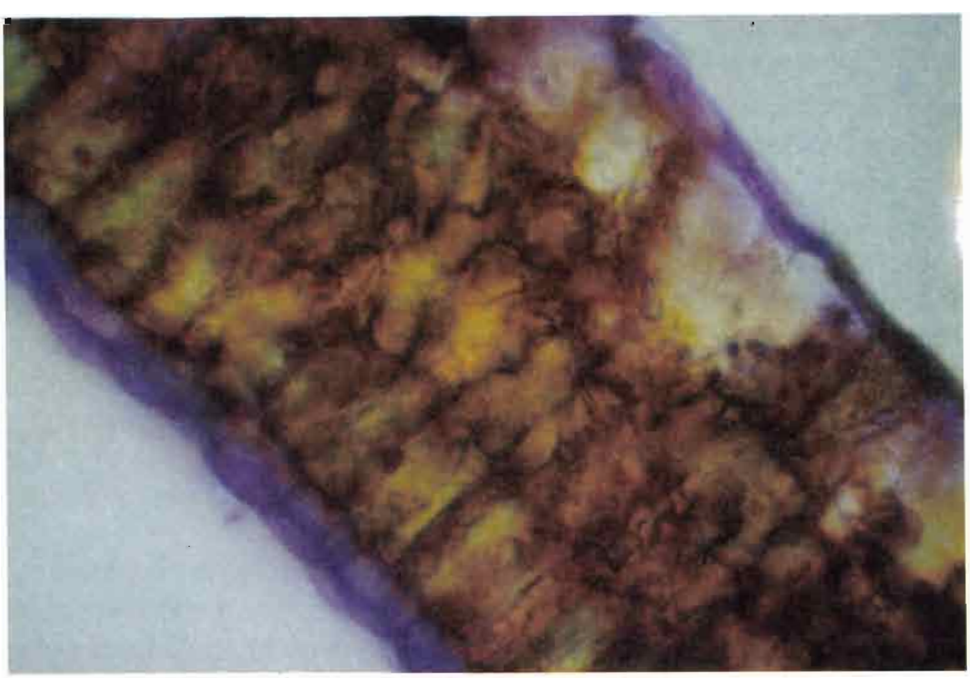

Figure 2. Histology of a green leaf of *C. odorata*. Mesophyllic cells contain abundant chlorophyll and chloroplasts.

Figure 3. Histology of a *C. odorata* leaf recovered from infestation by *P. pseudoinsulata*. Chloroplasts are unevenly distributed in mesophyllic cells.

Discussion

Histologic evaluation of insect-induced chlorosis of *C. odorata* leaves confirmed reduction of chlorophyll suggested by grossly visible yellowing of leaves, and previously found by spectrophotometric measurements of leaf extracts (Marutani & Muniappan 1991). Chloroplasts numbers in mesophyllic cells of chlorotic leaves were reduced transiently. During recovery from insect infestation, chloroplasts numbers increased again.

Chloroplasts are essential organelles of mesophyllic cells of higher plants and are the site of photochemical reactions. Chloroplasts contain photosynthetic pigments, i.e. chlorophyll and others, enzymes, electron carriers and cofactors within their lamellae. In addition, the chloroplast stroma contains enzymes important in carbon-reduction reactions, i.e. ribulose-1, 5-P2 carboxylase/oxygenase, lipids, starches and DNA and ribosomes. Chloroplasts multiply independently from cell divisions, although many necessary factors for multiplication are encoded by nuclear DNA. Degenerative changes of chloroplasts occur during senescence, mineral deficiencies and drought, and lead to disintegration of chloroplasts and chlorosis (Goodman *et al.* 1986).

So far, there are no reports of biochemical changes in leaves secondary to insect feeding. Morphologic findings of reversible chlorophyll decrease and chloroplast loss during yellowing of *C. odorata* secondary to *P. pseudoinsulata* could be due to factors produced by the insect or host factors induced by larval feeding. Electron microscope analysis of chlorotic leaves might further characterize the insect induced change in chloroplasts and suggest a mechanism of chloroplast damage.

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Paraiso, A. IITA, BP 08 0932, Cotonou, Benin. PhP: 35.01.88 Fax: (229) 30.14.66.

Slaats, J.J.P. Wageningen Agricultural University, PO Box 341, 6700 AM Wageningen, The Netherlands. Ph 31.8370.83040 Fax: 31.8370.84575.

Timbilla, J.A. Biocontrol Division, Crops Research Institute, PO Box 3785, Kumasi, Ghana. Ph: 051-6221

Tjitrosoedirdjo, S. BIOTROP, PO Box 17, Bogor, Indonesia. Ph (62) 252-323-848 Fax: (62) 251-326-851.

Tuo, N. IDEFOR/DRO, 08 BP 33, Abidjan, Cote d'Ivoire. Ph: 44.28.58.

Utulu, S.N. Nigerian Institute for Oil Palm Research, PMB 1030, Benin City, Nigeria. Telex: 41190 TDS 103.

Weise, S.F. Humid Forest Station IITA, B.P. 2008 (Messa), Yaounde, Cameroon; or c/o L W Lambourn & Co, Carolyn House, 26 Dingwall Road, Croydon CR9 3EE, UK. Ph: (237) 237 434 Fax: (237) 237 437. E-mail: S.WEISE@CGNET.COM.

Yehouenou, A. FAO, SRW-Ina BP 03, N'Dali, Rep. Benin. Ph:61.08.82.

Youta, H. Universite de Yaounde, BP 1857, Yaounde, Cameroun. Ph: (237) 20.15.08.

Zebeyou, M.G. IDEFOR, Station Principale, La Me, Cote d'Ivoire. Ph: (225) 39.11.89.57
Fax: (225) 22.69.85.

Zimmermann, H.Z. Plant Protection Research Institute, Private Bag X134, Pretoria 0001, South Africa. Ph: 012-329-3269 Fax: 012-329-3269 Fax: 012-329-3278.

Conclusions

1. Some countries in Africa, Asia and the Pacific consider *C.odorata* to be a serious noxious weed and have enacted biological control programs which they intend to continue.

2. Some countries are undecided on the status of *C.odorata* with regard to possible control programs.

3. Some research, though limited in scope, established that *C.odorata* has significant beneficial effects in some agro-ecosystems, due to its rapid growth and huge biomass potential. In order to objectively weigh the beneficial and detrimental impacts of *C.odorata*, some countries and organizations have deferred the introduction of biological control agents until further research is don. Research is especially needed in the following areas:

Assessment of the agronomic and soil conservation properties of *C.odorata;*
Assessment of the ecological impacts of *C.odorata* on ecosystems, particularly on the wildlife;
Assessment of all the economic impacts associated with the invasion of *C.odorata*, at various levels (land use system, social groups, country, region).

CONCLUSIONS

1. Certains pays d'Afrique, d'Asie et du Pacifique considèrent *C. odorata* comme une adventice importante et destructrice, et ont mis en place des programmes de lutte biologique qu'ils entendent poursuivre.

2. Certains pays n'ont pas pris de décisions sur le statut de *C. odorata* et sur l'opportunité de programmes de lutte.

3. Certaines recherches, bien qu'encore limitées, montrent que *C. odorata* a des effets bénéfiques significatifs dans certains agro-écosystèmes, en raison de sa croissance rapide et de sa productivité très élevée. De manière à pouvoir évaluer objectivement les effets positifs et négatifs de *C. odorata,* certains pays et certaines organisations ont reporté l'introduction d'agents de lutte biologique dans l'attente de nouvelles données. Des recherches paraissent particulièrement nécessaires dans les domaines suivants:

Evaluation des propriétés agronomiques de *C. odorata* ainsi que de ses propriétés quant à la conservation de la fertilité des sols;
Evaluation des impacts écologiques de *C. odorata* sur les écosystèmes, et notamment sur la biodiversité;
Evaluation de tous les impacts économiques associés à l'invasion de *C. odorata,* à différents niveaux (systèmes de production, groupes sociaux, pays, région).

Recommendations

1. The Workshop foresees the continued spread of *C. odorata* in sub-Saharan Africa, and recommends:

   i) that this spread be monitored by the countries concerned, and
   ii) that countries where *C.odorata* has not been reported be informed of the likely arrival of *C.odorata* , and be provided with balanced information on the potential ecological and socio-economic impacts of this weed.

2. The Workshop recognizes that, of the major land systems in the humid and sub-humid tropics of Africa:

   i) the arid savanna zone is not susceptible to invasion by *C.odorata*;
   ii) dense evergreen forests in the humid tropical zone are not susceptible to invasion when intact, but become very susceptible whenever disturbed;
   iii) the moist savanna zone is very vulnerable to invasion;
   iv) the native flora in the vulnerable ecologies is likely to be dominated and eventually suppressed by *C. odorata*, affecting the entire biodiversity;

The Workshop also encourages collection and synthesis of research in the management of *C.odorata* within these vulnerable ecologies.

3. The Workshop strongly recommends that where biological control of *C. odorata* is found necessary in Africa and elsewhere, it should be conducted according to the FAO Code for the Importation and Release of Biocontrol Agent. In particular, Article 3 which stipulates that importation can be made only with governmental consent from the importing country, that other countries in the region concerned be consulted, and that introductions should only be made when it is in the best interest of the public. Article 4 which stipulates that the host range of any potential agents must be adequately investigated before release should also be followed.

Since conflicts of interest are likely to occur, the Workshop also recommends that the different viewpoints and arguments expressed in the Proceedings of this Workshop be considered before any permits to import are issued.

4. The Workshop encourages African countries as well as international research agencies to initiate comprehensive research on the status of *C.odorata*, on its importance in the various agro-ecosystems, and on its impacts on native flora and fauna. The Workshop also encourages African countries to organize national meetings to document available information on the status of *C.odorata*, and its economic importance in the agro-ecosystems of each country.

The following scheme for co-ordinated research into the role of *C.odorata* in short-term fallow cropping systems is recommended to national and international research institutes in all of sub-Saharan Africa, and to associated donor institutions:

Chromolaena odorata: A valuable fallow species?

Goal:

Assess the role of *C.odorata* in short term fallow of West and Central African cropping systems.

Backdrop:

1. Smallholder agriculture food systems in the forest and moist savanna zones.
2. Slash and burn bush fallow cropping systems.
3. Shortening of fallow periods.

Objective:

1. Development of the fallow plant community in the absence of *C.odorata*.
2. Effect of *C.odorata* fallow on soil chemical, physical, and biological properties.
3. Presence of crop pests in *C.odorata* thickets.

Approach:

1. Multi-locational (i.e. across West and Central Africa).
2. Replicated factorial design.
3. Plot size: min. 10x10 m.
4. Site history:
   a) previous fallow <5 years.
   b) after a typical cropping cycle.
5. Minimum treatment set:
   a) presence/absence of *C.odorata* (manual removal)
   b) with/without a herbaceous/woody legume (slash, then seed)
6. Length of fallow 2-4 yrs.
7. Option: Cropping after fallow with test crop (e.g. maize).

Observations:

Develop a common minimum data set.
Study site description (soil type, climatic data)
Periodic observations should include:

a) Vegetation analysis (non-destructive, count by species; phenology; cover)
b) Biomass accumulation and litter accumulation (percentage *C. odorata*, nutrient content)
c) Soil chemical properties (e.g. pH, CEC, nutrients)
d) Soil physical properties (e.g. bulk density, aggregate stability)
e) Soil biological activity (e.g. worm casting)
f) Crop pest population in fallow vegetation (*Zonocerus*)
g) Location of study and available climatic data

RECOMMANDATIONS

1. L'Atelier prévoit une poursuite de l'expansion de *C. odorata* en Afrique Sub-Saharienne, et recommande:

   i) que cette expansion soit surveillée par les pays concernés, et

   ii) que les pays où *C. odorata* n'a pas encore été répertoriée soient informés de l'arrivée probable de *C. odorata*, et que leur soit fourni une information équilibrée sur les impacts écologiques et socio-économiques de cette espèce.

2. L'Atelier reconnait que, parmi les écozones des Tropiques Humides et Sub-Humides d'Afrique:

   i) la zone de savane aride n'est pas susceptible d'être envahie par *C. odorata;*

   ii) les forêts denses sempervirentes de la zone tropicale humide ne sont pas susceptibles d'être envahies lorsqu'elles sont intactes, mais que les perturbations importantes favorisent l'invasion;

   iii) la zone des savanes humides est très vulnérable à l'invasion;

   iv) la flore locale dans les écosystèmes vulnérables risque d'être dominée, voire décimée par *C. odorata,* affectant ainsi profondément la biodiversité.

   L'Atelier encourage également le regroupement et la synthèse des recherches sur la gestion de *C. odorata* dans le contextes de ces écosystèmes vulnérables.

3. L'Atelier recommande fortement que là où la lutte biologique contre *C. odorata* est jugée nécessaire, en Afrique et ailleurs, cette lutte soit menée en accord avec le code de la FAO sur l'Importation et l'Introduction des Agents de Lutte Biologique. En particulier, avec l'Article 3, qui stipule que l'importation ne peut être faite sans le consentement du gouvernement du pays importateur, que les autres pays concernés au sein de la région soient consultés, et que les introductions doivent être réalisées seulement s'il s'agît d'une mesure d'intérêt général. De même, l'Article 4 doit être respecté; cet article stipule qu'avant toute introduction soit évalué de manière adéquate l'impact de tout agent potentiel sur l'ensemble des hôtes possibles.

En raison de conflits d'intérêt probables, l'Atelier recommande également que les différents arguments et points de vue exprimés dans les Comptes Rendus de cet Atelier soient pris en considération avant d'accorder tout permis d'importation d'agent de lutte biologique.

4. L'Atelier encourage les pays Africains ainsi que les organisations internationales de recherche à mettre en place des recherches globales sur le statut de *C. odorata,* sur son importance dans les différents agro-écosystèmes, et sur son impact sur la flore et la faune indigènes. L'Atelier encourage également les pays Africains à organiser des réunions à l'échelle nationale de façon à réunir les informations disponibles sur le statut de *C. odorata,* et sur son importance économique dans les agro-écosystèmes de chaque pays.

Pour comprendre le rôle de *C. odorata* dans les systèmes de culture avec courtes périodes de jachère en Afrique Sub-Saharienne, le schéma de recherches coordonnées suivant est recommandé aux Instituts de Recherche Nationaux et Internationaux ainsi qu'aux donneurs de fonds associés:

Chromolaena odorata: une Espèce de Valeur pour les Jachères?

Objectif global

Evaluer le rôle de *C. odorata* dans les systèmes de cultures à courtes périodes de jachère en Afrique Centrale et Occidentale.

Contexte

1/ Systèmes d'agriculture vivrière dans les zones de forêt et de savane humide.
2/ Systèmes d'agriculture sur brûlis avec jachères arbustives.
3/ Raccourcissement des périodes de jachère.

Objectifs

1/ Préciser le développement de la végétation des jachères en l'absence de *C. odorata.*
2/ Quantifier les effets des jachères à *C. odorata* sur les propriétés physiques, chimiques et biologiques des sols.
3/ Définir l'importance des ravageurs des cultures dans les fourrés à *C. odorata.*

Approche

- Multi-sites (i.e. à travers l'Afrique du Centre et de l'Ouest).
- Expérimentation factorielle avec répétitions.
- Dimensions minimales des parcelles: 10 x 10 m
- Histoire des sites:
  / jachère précédente < 5 ans.
  / après un cycle de culture représentatif.
- Traitement minimum:
  / présence/absence de *C. odorata* (arrachage manuel)
  / avec-sans Légumineuses herbacées ou arborées (coupe, puis semis).
  - Longueur de la période de jachère: 2-4 ans.
- Option: culture-test après jachère (par exemple mais).

Observations

- Etablir une base de données communes minimum.
- Description du site d'étude (type de sol, données climatiques...)
- Les observations périodiques devraient comprendre:
  / analyse de la végétation (comptages par espèce; phénologie, recouvrement...)
  / évolution de biomasse et litière (pourcentage de *C. odorata*, éléments minéraux...)
  / propriétés chimiques du sol (par exemple pH, CEC, éléments minéraux...)
  / propriétés physiques du sol (par exemple densité, stabilité des aggrégats...)
  / activité biologique du sol (par exemple distribution des vers de terre...)
  / populations de ravageurs des cultures dans la jachère (*Zonocerus*...)

Coordination scientifique

IITA/Cameroun (contact: **S.F. Weise**)

List of participants:

Aeschlimann, J. P. CSIRO Biological Control Unit, Campus de Baillarguet,34982 Montferrier, France. Ph:(33) 67.59.31.01 Fax: (33) 67.59.90.40.

Akobundu I.O. IITA c/o L W Lambourn & Co., Carolyn House, 26 Dingwall Road, Croydon CR9 3EE, UK. Ph: (44-81) 686-9031 Fax: (INMARSAT) 874-1772276 or (44-81). 681-8583.

Andoli, V. Ministere de l'Agriculture, Direction de la Protection de Vegetaux, BP V7, Abidjan, Cote d'Ivoire. Ph: 21.08.33.

Anoliefo, G.O. Dept of Botany, University of Benin, Nigeria. Ph: 256200.

Barreto, R.W. Universidade Federal de Vigosa, 36570 Vigosa, MG, Brazil. Ph: (031) 899.2620 Fax: (031) 899.2240.

Beldje-Bedogo, ANDE/ CIRAD.EMVT, BP 1509, Bangui, Republique Centrafricaine. Ph: 236.61.61.69 Fax: 236.61.19.16.

Bonvallot, J. Herbier National du Cameroun, ORSTOM, BP 1857, Yaounde, Cameroun. Ph: (237) 20.15.08 Fax: (237) 20.18.54 Email: bonvallot @ yaounde:orstom.fr.

Boppré, M. Forstzoologisches Institut, Universitat Freiburg, Bertoldstrasse 17, D-79098 Freiburg, Germany. Ph (49) 761-203-3663 Fax: (49) 761-203-3661.

Boussienguet, J. Laboratoire de Zoologie Fundamentale et Appliquee, Universite Nationale du Gabon, BP 1886, Libreville, Gabon; Ph: (241) 734893/934 Fax: (241) 743499.

de Foresta, H. ORSTOM-ICRAF, PO Box 161, Bogor, Indonesia. Ph: (62) 251-315234 Fax: (62) 251-315567

de Rouw, A. ORSTOM, BP 11416, Niamey, Niger. Ph: (227) 73.39.63 Fax: (227) 72.28.04.

Durand, P. Dowelanco, 01 BP 7842, Abidjan 01, Cote d'Ivoire. Ph: 44.73.81/82 Fax: 44.73.84.

Ekeleme, F.E. IITA, c/o L W Lambourn & Co, Carolyn House, 26 Dingwall Road, Croydon CR9 3EE, UK. Ph: (44-81) 686-9031 Fax: (INMARSAT) 874-1772276 or (44-81) 681-8583.

Essomba, B.N. Centre IRA de Nkolbisson, BP 2067, Yaounde, Cameroun. Ph: (237) 23.31.05. Telex 1140KN.

Evans, H.C. IIBC, Silwood Park, Ascot, Berks. SL5 7TA, UK. Ph: (44) 344 872999 Fax: (44) 344 875007.

Fischer, O.A.Forstzoologisches Institut, Universitat Freiburg, Bertoldstrasse 17, D-79098 Freiburg, Germany. Ph (49) 761-203-3663 Fax: (49) 761-203-3661.

Gautier, L. CJBG, CP 60, CH-1292 Chambassy/ GE, Switzerland; Ph: (41) 22 732 6969 Fax: (41) 22 738 4597.

Gnanguenon, N. IITA, BP 08-0932, Cotonou, Benin. Ph: 35.01.88 Fax: (229) 30.14.66.

Hammond, W. IITA, BP 08-0932, Cotonou, Benin. Ph: (229) 350188 Fax: (229) 301466.

Hoevers, H. FAO Regional Office for Africa, PO Box 1628, Accra, Ghana. Ph: (233) 021. 666851-4 Fax: (233) 021 668427. Email: FAO-RAFR@cgnet.com Telex: 2139GH.

Houngnon, P. IITA, BP 526, Cotonou, Benin. Ph: 35.01.88 Fax (229) 30.14.66.

Huguenin, J. CIRAD-EMVT, 10 Rue Pierre Curie, 94704 Maisons-Alfort Cedex, France; Ph: (691) 320-2728 Fax: (691) 320-2726.

Jacquemard, J.C. IDEFOR/DPO, 13 BP 989, Abidjan 13, Cote d'Ivoire. Ph: 39.11.88.

Kouassi, N. IDEFOR/DPO, 13 BP 985, Abidjan 13, Cote d'Ivoire. Ph: 39.11.88.

Ladenburger, U. National Mango Research and Development Center, San Miguel, Jordan, Guimarai 5045, Philippines. Ph: (63) 912-5200878

Le Gall, P. ORSTOM, BP 181, Brazzaville, Rep. Congo. Ph: (225) 83 26 80 /81/ 82.

Lord, B.A. Recovery (ISN), 22 BP 170, Abidjan 22, Cote d'Ivoire. Ph: 20.58.63 Fax: 21.13.67.

Mariau, D. IRHO/CIRAD, BP 5035, 34032 Montpellier Cedex, France. Ph: 67615964 Fax: 67635100.

M'Boob, S. FAO Regional Office for Africa, PO Box 1628, Accra, Ghana. Ph: (233) 021 666851-4 Fax: (233) 021 668427. Email: FAO-RAFR@cgnet.com Telex: 2139GH.

Cruttwell McFadyen, R.E. Alan Fletcher Research Station, PO Box 36, Sherwood Q 4075, Australia. Ph: (61) 7-375-0739 Fax: (61) 7-379-6815.

Modder, W.W.D. IITA, Cotonou, Rep. Benin. Ph: (229) 36-01-88/ 30-19-94 Fax: (229) 30-14-66.

Muniappan, R. Agricultural Experiment Station, University of Guam, Mangilao, Guam 96923, USA. Ph: (671) 734-3113 Fax: (671) 734-6842.

Nguessan, B. IDEFOR/DPO La Me, 13 BP 989, Abidjan 13, Cote d'Ivoire. Ph:39.11.88.

Paraiso, A. IITA, BP 08 0932, Cotonou, Benin. PhP: 35.01.88 Fax: (229) 30.14.66.

Slaats, J.J.P. Wageningen Agricultural University, PO Box 341, 6700 AM Wageningen, The Netherlands. Ph 31.8370.83040 Fax: 31.8370.84575.

Timbilla, J.A. Biocontrol Division, Crops Research Institute, PO Box 3785, Kumasi, Ghana. Ph: 051-6221

Tjitrosoedirdjo, S. BIOTROP, PO Box 17, Bogor, Indonesia. Ph (62) 252-323-848 Fax: (62) 251-326-851.

Tuo, N. IDEFOR/DRO, 08 BP 33, Abidjan, Cote d'Ivoire. Ph: 44.28.58.

Utulu, S.N. Nigerian Institute for Oil Palm Research, PMB 1030, Benin City, Nigeria. Telex: 41190 TDS 103.

Weise, S.F. Humid Forest Station IITA, B.P. 2008 (Messa), Yaounde, Cameroon; or c/o L W Lambourn & Co, Carolyn House, 26 Dingwall Road, Croydon CR9 3EE, UK. Ph: (237) 237 434 Fax: (237) 237 437. E-mail: S.WEISE@CGNET.COM.

Yehouenou, A. FAO, SRW-Ina BP 03, N'Dali, Rep. Benin. Ph:61.08.82.

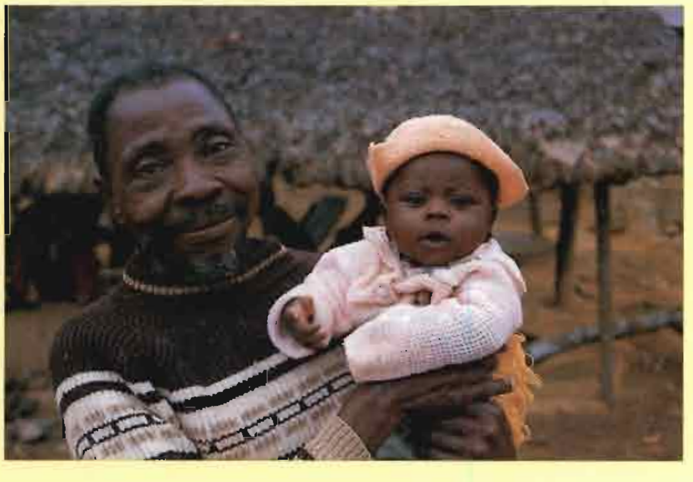
Youta, H. Universite de Yaounde, BP 1857, Yaounde, Cameroun. Ph: (237) 20.15.08.

Zebeyou, M.G. IDEFOR, Station Principale, La Me, Cote d'Ivoire. Ph: (225) 39.11.89.57 Fax: (225) 22.69.85.

Zimmermann, H.Z. Plant Protection Research Institute, Private Bag X134, Pretoria 0001, South Africa. Ph: 012-329-3269 Fax: 012-329-3269 Fax: 012-329-3278.

Chromolaena is a major weed in some cropping systems (here in a young coconut palm plantation, Sumatra, Indonesia).
Chromolaena *est une adventice majeure dans certains systèmes de culture (ici, dans une jeune plantation de cocotier, Sumatra, Indonésie).*

Swidden farmers claim that *Chromolaena* fallows improve soil fertility and allow to reduce the fallow period without decreasing yields (cassava swidden, with *Chromolaena* fallow in the background, Mayombe, Congo).
Les agriculteurs sur brûlis affirment que les jachères à Chromolaena *améliorent la fertilité du sol et permettent de réduire la période de jachère sans diminution du rendement des cultures (abattis à manioc, avec jachère à* Chromolaena *à l'arrière plan, Mayombe, Congo).*



New research is needed in order to assess *Chromolaena* /soil interactions and to clarify *Chromolaena* 's status. Millions of small farmers in the humid tropics are concerned (Mayombe swidden farmer, Congo).
De nouvelles recherches sont nécessaires pour préciser les interactions Chromolaena / *sol et pour clarifier le statut de* Chromolaena. *Des millions de petits paysans dans les Tropiques Humides sont concernés (paysan du Mayombe, Congo).*