Weed control in cereal cropfields in Côte d'Ivoire

In the western forest region of Côte d'Ivoire, rainfed rice is widely cultivated for domestic-consumption. Farmers, who traditionally practice shifting slash-and-burn cultivation, are forced to abandon their fields, even before soil fertility declines, due to serious weed infestation.

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The forest region of Côte d'Ivoire, with more than 300 000 ha of rice fields, is the most important rice-growing area in the country (Figure 1). The shifting cultivation system is similar to that found in all tropical regions (GUTELMAN, 1989). The dense forest is cleared manually. Plant debris is left to dry out, then burnt and the residues are piled up. All subsequent cultivation is done by women.

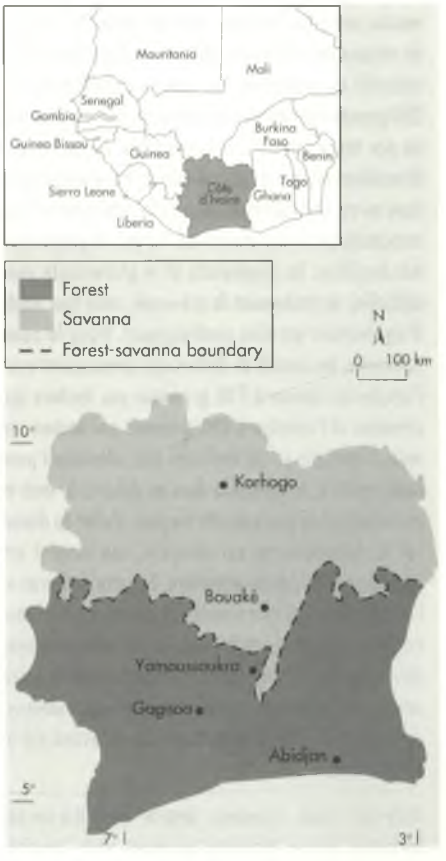


Figure 1. The forest region of Côte d'Ivoire.

From January or February, rice is sown directly in seed holes on cleared untilled land. The seeds germinate after the first rains, without any hindrance from the limited regrowth of woody plants. During the crop cycle (5-6 months), there is almost no weed growth and thus very little weeding is required.

The fields are often cropped subsequently with rice or maize for 1 or 2 more years. Weed cover then becomes an important constraint, mainly due to the spread of "Siam weed" *(Chromolaena odorata)*, a bushy Asteraceae species that can grow to heights of 3 m or more.

Available dense forest is also becoming scarce, and farmers are cultivating open woodland forest, or old clearings left fallow and on which weeds abound.

Most farmers also plant coffee and cacao. Revenue from these crops used to pay hired labour, which is sometimes required for clearing and then weeding the food cropfields. However, the yearly rise in labour costs and increasing weed control problem are forcing farmers to abandon their cropfields, long before soil fertility declines.

Weed control has therefore become a priority objective for the Institut des savanes (IDESSA, Côte d'Ivoire). From 1987 to 1991, a research programme was carried out in the Gagnoa region. The aim was to develop a chemical control strategy that would be cheaper than using hired labour, and compatible with manual shifting agriculture, involving no tillage and direct-sowing in seed holes.

A *Chromolaena odorata* population after a herbicide application.
Photo P. Vernier

Efficacy of chemical control

On-farm tests were carried out in fields cropped with rainfed rice (cv IAC 165) and maize (cv Ferké 7928), which are the main cereal crops in the region. The trials focused mainly on 2,4-D, an inexpensive herbicide that has been widely and successfully adopted under similar conditions by farmers in Brazil (SEGUY, 1982). Furthermore, this product is commonly used for the maintenance of oil-palm plantations in Côte d'Ivoire, and it can therefore be obtained through the usual herbicide distribution channels. The herbicide trials were carried out in 3 m x 8 m experimental plots (Fischer blocks in triplicate).

Weed control in rainfed rice fields

From 1989 to 1991, a series of on-farm trials was conducted in rainfed rice fields in the Gagnoa region. Rice was cultivated in the second or third year after clearing (Table 1). The plots had been infested with *C. odorata* during any prior fallows or between two successive crops.

Before sowing rice, Siam weeds were cut and burned by traditional techniques. The first trials tested the relative efficacy of one or two treatments with 2,4-D, with the first carried out when *C. odorata* plants were at the 3-4 leaf stage. At the same time, a more versatile product was tested (Table 2).

Treatment efficacy was assessed by visual estimation of weed coverage 60 days after sowing the crop, or by the relative weights of paddy rice and green weeds.

In the control plot, overgrowth of *C. odorata* was always very harmful to the crop. In the first trial, these weeds covered nearly 90% of the area (Figure 2). *C. odorata* was always the most invasive of all weeds present (e.g. the grass *Rottboellia cochinchinensis*).

After 2,4-D treatment, weed cover was 40% lower than at the same date without treatment. Combined treatments with triclopyr and propanil reduced weed growth to the same extent, with propanil acting more specifically against *R. cochinchinensis*.

Two 2,4-D treatments were required to achieve the same weed control results as obtained on the untreated control with careful manual weeding, with a weed cover of around 5%.

The results of the second trial were similar to those of the first, but only *C. odorata* was present (Figure 2). With a double 2,4-D treatment, chemical weed control was as effective as rigorous manual weeding, with identical paddy rice yields. On the weed-infested control plot, rice yields were twofold lower (1.54 t/ha compared to 2.97 t/ha).

The results of the two trials indicated that it could be interesting to test earlier dates for the first herbicide treatment. *C. odorata* occurred in two forms: new young seedlings and regrowth derived from older stock. The herbicide treatments destroyed the young seedlings but only caused withering on regrowth, without destroying the stock plant. However, regrowth from old stock plants could be eliminated through earlier treatments.

In the third trial, the first herbicide treatment was thus conducted when *C. odorata* plants were at the 2-3 leaf stage (instead of the 3-4 leaf stage as in the first two trials; Figure 3). *C. odorata* was particularly harmful in the weed-infested control plot, with fourfold lower paddy rice yields (0.5 t as compared to 2.04 t for the untreated control). The results of the different 2,4-D treatments equaled those obtained on the untreated control, with a few rice yield differences that were not significant on the basis of the level of accuracy of the trial.

It therefore does not seem worth doubling herbicide doses with this extent of weed cover. In practice, two 2,4-D treatments would be recommended to obtain satisfactory weed control: a first during post-emergence, when the *C. odorata*

Table 1. History of the experimental plots.

Test	1	2	3
Date of test	1989	1989	1991
Previous crop	rainfed rice	rainfed rice	rainfed rice
Year (n – 2)	forest	fallow	fallow

Table 2. Herbicide products.

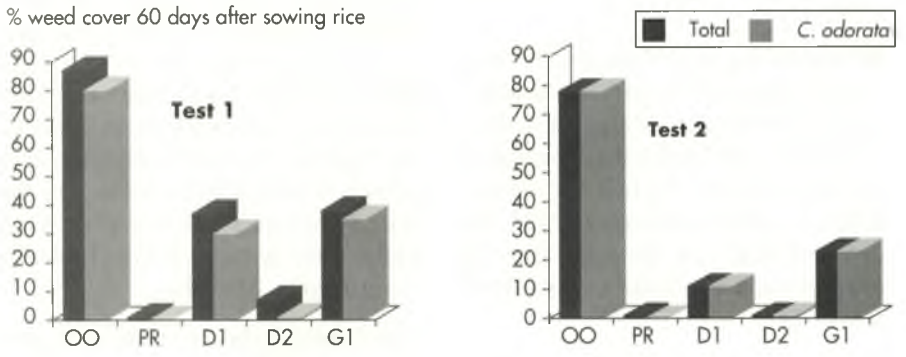
Active ingredient	Commercial product	Manufacturer	Composition (g/l)
2,4-D	Calliherbe	Calliope	720
Triclopyr + propanil	Garil	Dow Elanco	72 + 360
Triclopyr*	Garlon 4	Dow Elanco	480
Picloram + 2,4-D*	Tordon 101	Dow Elanco	60 + 240

*test 3 only.

Spraying equipment

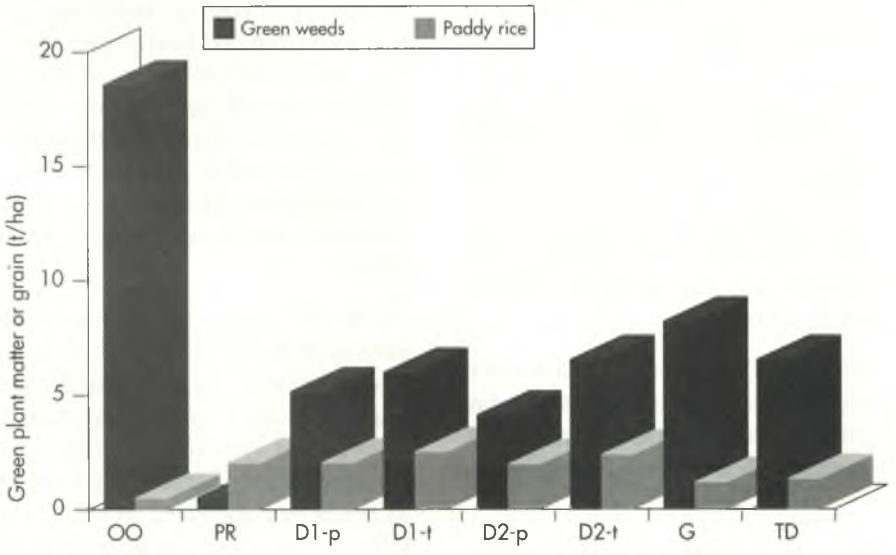
The treatments were carried out with manual knapsack sprayers (15 l capacity), which are commonly used in villages for anti-mirid treatments of cacao crops, fitted with low-volume nozzles. These nozzles, with a 3 m wide swath width range (compared to 80 cm for a normal nozzle), use only 30-40 l /ha of water (instead of 150-200 l), and 1 ha can be treated within 1-1.5 h (instead of 5-6 h). However, the most time is gained in water transport, i.e. only one trip is required with a knapsack sprayer to treat 0.5 ha, as compared to five or six previously.

Figure 2. Herbicide tests in rainfed rice cropfields in 1989.



OO: weed-free/unweeded control.
PR: weed-free/manually-weeded control.
D1: single treatment with 2,4-D at a dose of 720 g/ha (1 l commercial product) 15 days after sowing rice (*C. odorata* 3-4 leaf stage).
D2: two treatments with 2,4-D (720 g/ha/ treatment), the first 15 days after sowing rice, the second 15 days after the first.
G1: single treatment with a triclopyr + propanil blend (5 l commercial product), 15 days after sowing rice.

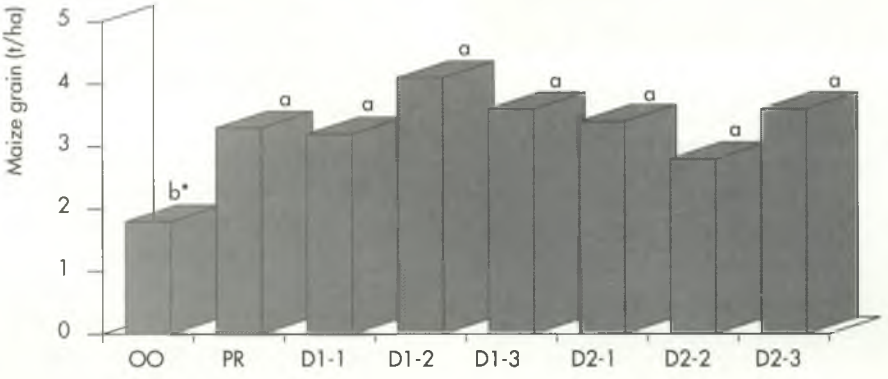
Figure 3. Herbicide test in rainfed rice cropfields in 1991.



OO: weed-free/unweeded control.
PR: weed-free/manually-weeded control.
D1-p: two early treatments with 2,4-D (720 g/ ha/treatment of active ingredient, i.e. 1 l commercial product) at dates d1 and d2
D1-t: two late treatments with 2,4-D (720 g/ha/ treatment) at dates d2 et d3.
D2-p: two early treatments with 2,4-D (1 440 g ha/treatment of active ingredient, i.e. 2 l commercial product) at dates d1 et d2.
D2-t: 2 two early treatments with 2,4-D (1 440 g/ ha/treatment of active ingredient, i.e. 2 l commercial product) at dates d2 et d3.
G: a single treatment with triclopyr (480 g/ha, i.e. 1 l commercial product) at date d2.
TD: a single treatment with a pichloram + 2,4-D combination (90 + 360 g/ha, i.e. 1.5 l commercial product) at date d2.

d1: 2 days after sowing rice (*C. odorata* 2-3 leaf stage).
d2: 11 days after sowing rice.
d3: 17 days after sowing rice.

Figure 4. Herbicide test in maize cropfields in 1991. Production expressed in t/ha maize grain at 14% moisture content (mean of results from two sites).



OO: weed-free/unweeded control.
PR: weed-free/manually-weeded control.
D1-1: single treatment with 2,4-D (720 g/ ha active ingredient), 10 days after sowing.
D1-2: single treatment with 2,4-D (1 440 g/ ha active ingredient), 10 days after sowing.
D1-3: single treatment with 2,4-D (2 160 g/ ha active ingredient), 10 days after sowing.
D2-1: two treatments with 2,4-D (720 g/ha), 10 and 20 days after sowing.
D2-2: two treatments with 2,4-D (1 440 g/ha), 10 and 20 days after sowing.
D2-3: two treatments with 2,4-D (2 160 g/ha), 10 and 20 days after sowing.

seedlings are at the 3-4 leaf stage, and a second 8 days later, at 720-1 440 g active ingredient/ha/treatment, depending on the weed density.

Weed control in maize cropfields

Competition with *C. odorata* is less of a problem with maize than with rice, but it is still a concern as maize yields can be cut by half (Figure 4).

Maize is sometimes cropped for domestic consumption, after rice. The weed problem is usually more serious in older plots. Maize is also intercropped with rice at around 20-30 seed holes/are. Unripe maize cobs are consumed by guards in charge of keeping grain-eating birds away from the rice at the end of the cropping cycle.

Considering these cropping practices and the efficacy of 2,4-D in rice fields, it was of interest to investigate the phytotoxic effects of this herbicide on maize.

All fields treated with 2,4-D were weeded manually throughout the cropping cycle to assess variations in maize yield linked with the direct phytotoxic effect of the product. 2,4-D showed no phytotoxicity to maize, even at high doses (2 x 2 160 g/ha). A wide range of herbicide doses are thus possible, depending on the extent of the weed cover. The recommendations for effective control of *C. odorata* given previously for rice also apply for maize.

Treatment *versus* weeding times

As the efficacy of chemical treatments was found to be equivalent to that of manual weeding, it was necessary to compare these two methods in terms of labour-time savings. Weeding times were therefore recorded in 1990 on 5-10 are fields cropped with rainfed rice (VERNIER & GBAKA, 1991). These fields had been cropped immediately after clearing of relatively dense forest or 5-6 years fallows infested with *C. odorata*.

Weeding time was longer with higher weed pressure and also varied with respect to the field cropping history. There was little weed growth after clearing of dense forest and manual weeding required only 2 days/ha with 8 h/day of labour. There was more weed cover when the field was formerly open woodland forest and weeding required 9 days/ha. Weeding took 21 days/ha after *C. odorata*-infested fallows.

In comparison, with suitable spraying equipment (low-volume nozzles), 1 ha could be treated within 1-1.5 h, with water-transport taking up to half a day (although highly variable, this rarely took longer).

Pueraria dominates *C. odorata* after cutting back.
Photo M. Déat

Siam weed

Chromolaena odorata (L.) King & Robinson (formerly *Eupatorium odoratum* L.) is a bushy, perennial Asteraceae species that can grow over 3 m high. This weed, of West Indian origin and commonly called "Siam weed", was introduced in Nigeria in 1937 with seeds of *Gmelina* sp. from Ceylon (IVENS, 1974). It was detected in Côte d'Ivoire for the first time in 1960, when there were tense relations with Guinea, thus explaining its local names of "Independence" and "Sékou Touré", the name of the former Guinean president (TCHOUME, 1980). Its spread has reached plague proportions throughout forest regions of western Africa (AUDRU *et al.*, 1988).

Chromolaena odorata (L.) R.M. King & H. Robinson (Asteraceae). (From L.R.G. HOLM, D. PLUCKNETT, J.V. PANCHO, J.P. HERBERGER: The World's Worst Weeds. Honolulu, Hawaii, East-West Center Book, 1977. Fig. 82, p. 213).

Cost-effectiveness

Rational herbicide treatments, conducted at the appropriate dates and doses, could replace manual weeding. Chemical weed control, with a product cost of 1 500 CFA francs/l of 2,4-D in 1991 in Côte d'Ivoire (i.e. 3 000-6 000 CFA francs/ha, depending on the extent of weed cover), was more cost-effective than manual weeding with salaried labour, evaluated at 15 000 CFA francs/ha for 10-15 days of labour (with moderate weed coverage). An accurate detailed study would now be required as herbicide and labour costs have fluctuated differently since the CFA franc devaluation (January 1994). Nevertheless, a quick estimate indicates that the same conclusions could be drawn.

This technique requires only standard knapsack spraying equipment and provides a practical and satisfactory response to Siam weed proliferation. Herbicide treatments are recommended during the first year after clearing to forestall weed establishment. The technique could now be implemented throughout forest regions of western Africa.

This represents a first step towards achieving the general agronomic research aim of stabilizing agriculture, along with the rational use of natural resources.

A herbicide treatment operation.
Photo P. Vernier

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Abstract... Résumé... Resumen

P. VERNIER, T.H. GBAKA, K.E. TEHIA, P. MARNOTTE –
Weed control in cereal cropfields in Côte d'Ivoire.

In forest areas of Côte d'Ivoire, rainfed rice is widely grown following slash-and-burn, and is sometimes intercropped with maize. However, smallholders are often forced to abandon their fields, even before soil fertility problems arise, because of the invasive weed *Chromolaena odorata*. From 1989 to 1991, IDESSA (Institut des savanes) conducted a herbicide control research programme using 2,4-D in smallholders' fields. The number, dosages, treatment dates and toxicity on maize were monitored. The results indicated that two 2,4-D treatments should be recommended, at 770-1440 g a.i./ha/treatment, depending on weed densities: the first at the *C. odorata* 3-4 leaf stage, the second 8 days later. There was no toxicity noted on maize plants. Nozzles on conventional spraying equipment were adapted for low-volume spraying to minimize water transport and working time. This technique is faster, cheaper and as efficient as manual weeding.

Keywords: *Chromolaena odorata,* rainfed rice, maize, herbicide, 2,4-D, forest area, Côte d'Ivoire.

P. VERNIER, T.H. GBAKA, K.E. TEHIA, P. MARNOTTE –
La maîtrise de l'enherbement des cultures de céréales en Côte d'Ivoire.

En zone forestière de Côte d'Ivoire, le riz pluvial est largement cultivé après défriche-brûlis, parfois en association avec le maïs. Mais l'envahissement des parcelles par *Chromolaena odorata* contraint les paysans à quitter leurs terres, avant même que des problèmes de fertilité du sol n'apparaissent. De 1989 à 1991, l'IDESSA (Institut des savanes) a réalisé un programme de recherche sur la lutte herbicide au moyen du 2,4-D en milieu paysan. Les expérimentations ont porté sur le nombre, les doses, les dates d'application et la toxicité sur maïs. Deux applications de 2,4-D peuvent être recommandées, à raison de 770 à 1 440 grammes de matière active par hectare et par application selon la densité des adventices : la première au stade 3-4 feuilles de *C. odorata,* la seconde huit jours après. Aucune toxicité sur maïs n'est observée. Le matériel de pulvérisation classique est adapté avec des buses à bas volume, pour minimiser le transport de l'eau et les temps de travaux. Cette technique est plus rapide, plus économique et aussi efficace que le désherbage manuel.

Mots-clés : *Chromolaena odorata,* riz pluvial, maïs, herbicide, 2,4-D, zone forestière, Côte d'Ivoire.

P. VERNIER, T.H. GBAKA, K.E. TEHIA, P. MARNOTTE –
El control del enyerbado de los cultivos de cereales en Costa de Marfil.

En la zona forestal de Costa de Marfil, el arroz de secano se cultiva extensamente después de una "roturación-quema", a veces en asociación con el maíz, pero la invasión de las parcelas por *Chromolaena odorata* obliga a los campesinos a abandonar sus tierras incluso antes de aparecer los problemas de fertilidad del suelo. Entre 1989 y 1991, el IDESSA (Instituto de sabanas) realizó un programa de investigación relativo a la lucha herbicida con 2,4-D en medio campesino. Las experimentaciones concernían el número, las dosis, las fechas de aplicación y la toxicidad para el maíz. Se pueden recomendar dos aplicaciones de 2,4-D utilizando entre 770 y 1440 gramos de materia activa por hectárea y aplicando según la densidad de los adventicios: la primera en la etapa de 3-4 hojas de *C. Odorata* y la segundo ocho días después. No se observa ninguna toxicidad en el maíz. El material de pulverización clásico se adapta con boquillas de bajo volumen para minimizar el transporte de agua y los tiempos de trabajo. Esta técnica es más rápida, económica y eficaz que la escardadura manual.

Palabras clave: *Chromolaena odorata,* arroz de secano, maíz, herbicida, 2,4-D, zona forestal, Costa de Marfil.