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Major factors influencing Cassava cultivation and impacts of weed management techniques on yield

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Abstract

Context : The impact of weed growth is one of the main factors reducing cassava productivity and producer profits.

Objective : This study is to identify the major constraints in cassava cultivation and to assess the impact of weed management strategies on the agronomic importance of weeds and on tuber production.

Methodology : 206 cassava producers were interviewed in their fields and an experiment was conducted on weed management practices.

Results : This study revealed that weeds followed by aulacodes are the main pests affecting cassava crops in the Mé region. The calculation of pest indices identified 37 weeds that are potentially harmful to cassava crops. Among these weeds, 8 have a partial harmfulness index (PHI) greater than 1000 and 29 have a PHI between 500 and 1000. In terms of experimentation, chemical weeding with oxyfluorfen in early post-emergence followed by manual weeding with a machete in the 16th week had the lowest recovery rates. In terms of average yields, plots that were chemically weeded in early post-emergence followed by manual weeding with a machete and those weeded three times with a hoe had the best yields.

Conclusion : Managing weeds at the right times and using appropriate methods can significantly reduce weed growth and increase cassava tuber production.

Keywords : Weeds; Agronomic Importance; Pests; Cassava; Côte d'Ivoire

1. Introduction

In sub-Saharan Africa, subsistence farming, which provides the basis for the population's diet, is generally practiced using a shifting cultivation system [1, 2]. Cassava is one of these subsistence crops. Cassava is a very important crop in several tropical and subtropical regions of the world, particularly in Africa (56 %), Asia (30 %), and Latin America (14 %). Its tuber is one of the most widely produced crops in the world, accounting for 32 % of global production of food

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roots and tubers, just behind potatoes [3]. West Africa accounts for more than 33 % of global cassava production [4]. Furthermore, in its production areas, cassava also plays an important role in the diet of local populations [5].

In Côte d'Ivoire, cassava is the second most consumed food crop after yams [6, 7], with an annual production of around 5 million tons. In addition, its cultivation has grown significantly over the last ten years, with production increasing at an annual rate of 8.5% between 2005 and 2015 [8]. Indeed, cassava plays a crucial role in both the food security of rural and urban populations and in job creation. It therefore contributes significantly to food and nutritional security, increased incomes, and improved socioeconomic conditions [9]. Today, the socioeconomic issues associated with cassava have led to it becoming a raw material for industries in Côte d'Ivoire, as in many other West African countries [10]. Unfortunately, in Côte d'Ivoire, more productive varieties developed and promoted among farmers [11] are unable to achieve their potential yields. There are many factors contributing to these yield losses, among which biotic factors are limiting factors. Indeed, several pathogens attack cassava, including bacterial and viral diseases [12]. According to the work [13], arthropod pests are the main biological obstacles to cassava cultivation. [14, 15] have shown that weeds are among the leading causes of crop production losses worldwide. The aim of this study was to identify the main biological constraints associated with cassava production in the Mé region, assess the damage caused by weeds in cassava crops in southeastern Côte d'Ivoire, and propose a weed management plan.

2. Materials and methods

2.1. Factors influencing cassava production

A survey was conducted among farmers using a questionnaire. The questionnaire focused on information relating to variables linked to access to agricultural inputs, the cost and method of weed control, and biological constraints. For all these variables, the percentages of responses were calculated and graphs were produced.

2.2. Phytosociological surveys

Surveys were conducted in three departments in the Me region. In the fields visited, an area of 900 m^2 was marked out in the center of the plot. In each elementary plot, all species were recorded and an abundance dominance score (Table 1) was assigned [16] [17]. This scale combines the + and 1 indices in the same class 1 in order to assign the same coefficient to species which, due to their low coverage or density, do not pose a direct threat to crops. In addition to these surveys, a field survey was carried out in the fields visited [18, 19]. A quantitative floristic analysis was used to assess the partial harmfulness index of each species, according to the following formula :

PHI = Sum of average recoveries for this type of case * 100 / Absolute frequency [20, 21].

Table 1 Transformation of abundance–dominance into average percentage cover [22]

Abundance-dominance index	Recovery class	Average recovery (%)
5	75-100	87.5
4	50-75	67.5
3	25-50	37.5
2	10-25	17.5
1	1-10	5.5

Impact of the technical itinerary on grass cover and yield

An experiment was set up using a Fisher block design with 5 treatments and 4 replicates (Figure 1) to evaluate the effect of weeding routes on weed coverage and cassava yield. The treatments defined were as follows:

- Control treatment (CT) : Two manual weedings were carried out with a machete, at 8 and 16 weeks after planting the cuttings (the most common method of weed management in the area).
- Treatment T1 : Two manual weeding operations were carried out with a hoe, at 8 and 16 weeks after planting the cuttings;

- Treatment T2 : Three manual weeding operations were carried out with a machete, at 6, 14, and 24 weeks after planting the cuttings ;
- Treatment T3 : Three manual weedings carried out, the first two with a hoe at 6 and 14 weeks, and the third with a machete at 24 weeks after cuttings were taken ;
- T4 : Two weeding operations were carried out, the first using an early post-emergence herbicide containing the active ingredient oxyfluorfen, at a concentration of 240 g/l, at a single dose of 2 liters per hectare, and the second carried out manually in the 12th week after chemical weeding.

In terms of plot coverage, abundance dominance indices were assigned based on the Biological Testing Commission's rating scale (Table 2). The average yield (Rm) was calculated for each treatment. It is equal to the sum of the masses of the harvested product (kg) in each plot divided by the sum of the areas (m^2) of the plots in that treatment.

$$Rm\ (Kg/m^2) = \frac{\sum \text{Masse du produit récolté (Kg)}}{\sum \text{Somme des surfaces } (m^2)}$$

Analysis of variance followed by Tukey's HSD test ($p < 0.05$) was performed on mean abundance-dominance, weeding times, and mean yield to classify homogeneous groups.

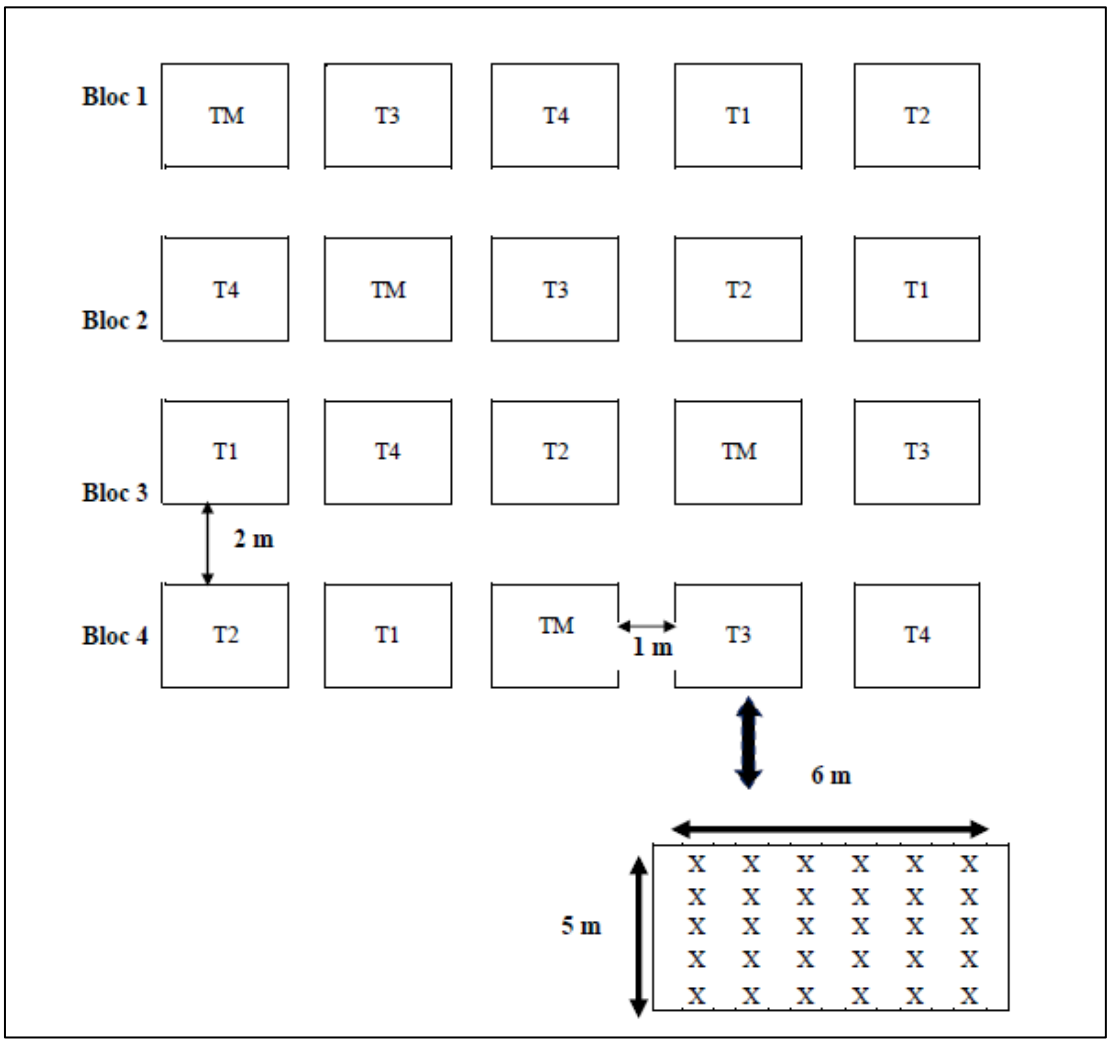


Figure 1 Experimental setup

Table 2 Scale of weed abundance-dominance indices according to the Biological Testing Commission

Abundance-dominance index	Observations
1	1 % recovery rate
2	7 % recovery rate (≤1 individual/m^2)
3	15 % recovery rate (>1 individual/m^2)
4	30 % recovery rate
5	50 % recovery rate
6	70 % recovery rate
7	85 % recovery rate
8	97 % recovery rate
9	100 % recovery rate

3. Results

3.1. Methods for managing grass growth

In the localities within the study area, more than 85.44 % of the producers surveyed practice manual weeding, compared to 14.56 % who use chemical weed control at least once on their farms. This proportion is practically the same in all the localities visited (Figure 2). Regarding weeding costs, the cassava farmers surveyed mentioned that manual weeding was more expensive than weeding with herbicides (Table 3).

3.2. Constraints related to access to herbicides

There were two types of difficulties associated with the use of herbicides. These were a lack of knowledge about the products and a lack of financial resources. The percentage of producers who mentioned a lack of knowledge about the appropriate herbicides for cassava cultivation was estimated at 59.84 %, compared with 40.16 % who mentioned a lack of financial resources. These different proportions varied from one locality to another (Table 4). In Adzopé and Alépé, the majority of producers cited a lack of knowledge about appropriate herbicides, while in Akoupé, producers were more likely to cite a lack of financial resources.

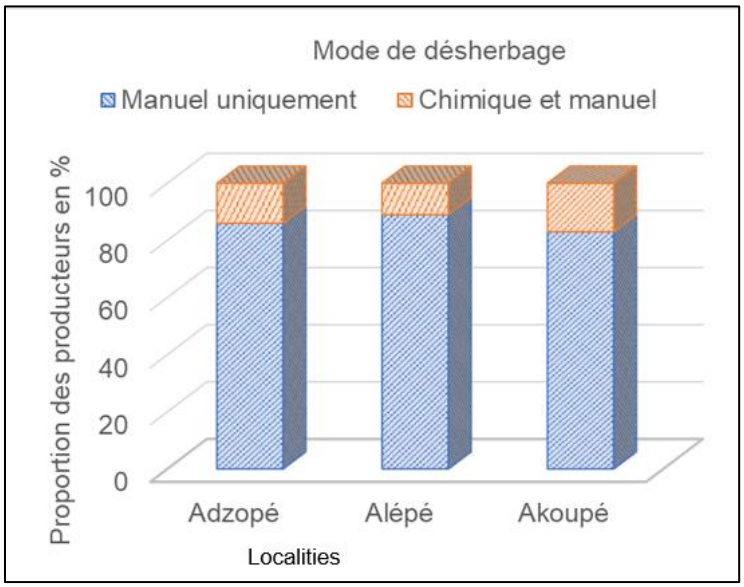


Figure 2 Histogram of the distribution of cassava producers according to weeding method

Table 3 Cassava producers' perception of manual weeding costs in the three departments

	Proportion of producers in %		
Departments	Expensive	Low cost	No opinion
Adzopé	77.68	11.54	10.77
Alépé	71.42	8.16	20.41
Akoupé	61.22	6.12	35.65

Table 4 Distribution of cassava producers according to difficulties related to access to herbicides.

Localities	**Lack of financial resources %**	**Lack of knowledge about herbicides %**
Adzopé	26.19	73.81
Alépé	37.14	62.86
Akoupé	57.14	42.86
Study area	40.16	59.84

Major biological constraints influencing cassava cultivation

In the cassava fields visited, weeds are the major biological constraint affecting production, with an estimated frequency of mention of 100 %. Next come grasses (40.63 %) and termites (19.39 %). Regardless of location, weeds and grasses are the two major biological constraints (Table 5).

As for weeds that are difficult to control, they varied depending on the location. In Akoupé, *Centrosoma pubescens*, *Croton hirtus*, and *Panicum maximum* were the most problematic. In Alépé, they were *Diodia rubricosa, Pueraria phasoeloides*, and *Panicum laxum*, while in Adzopé, they were *Panicum laxum, Calopogonium mucunoides, Croton hirtus, Chromolaena odorata,* and *Porophyllum ruderale*.

3.3. Partial Harmfulness Index (PHI)

Analysis of the partial nuisance index (IPN) for weeds indicates that 36 weeds were potentially harmful (Table 6). These weeds were grouped into two species groups.

Table 5 Distribution of cassava producers according to biological constraints

Localities	**Weeds**	**Aulacodes**	**Earthworms**	**Rottenness**	**Others**
Adzopé	100	40	15	4	5
Alépé	100	39.39	18.18	1.52	6.06
Akoupé	100	42.5	25	2.5	2.5
Study area	100	40.63	19.39	2.67	4.52

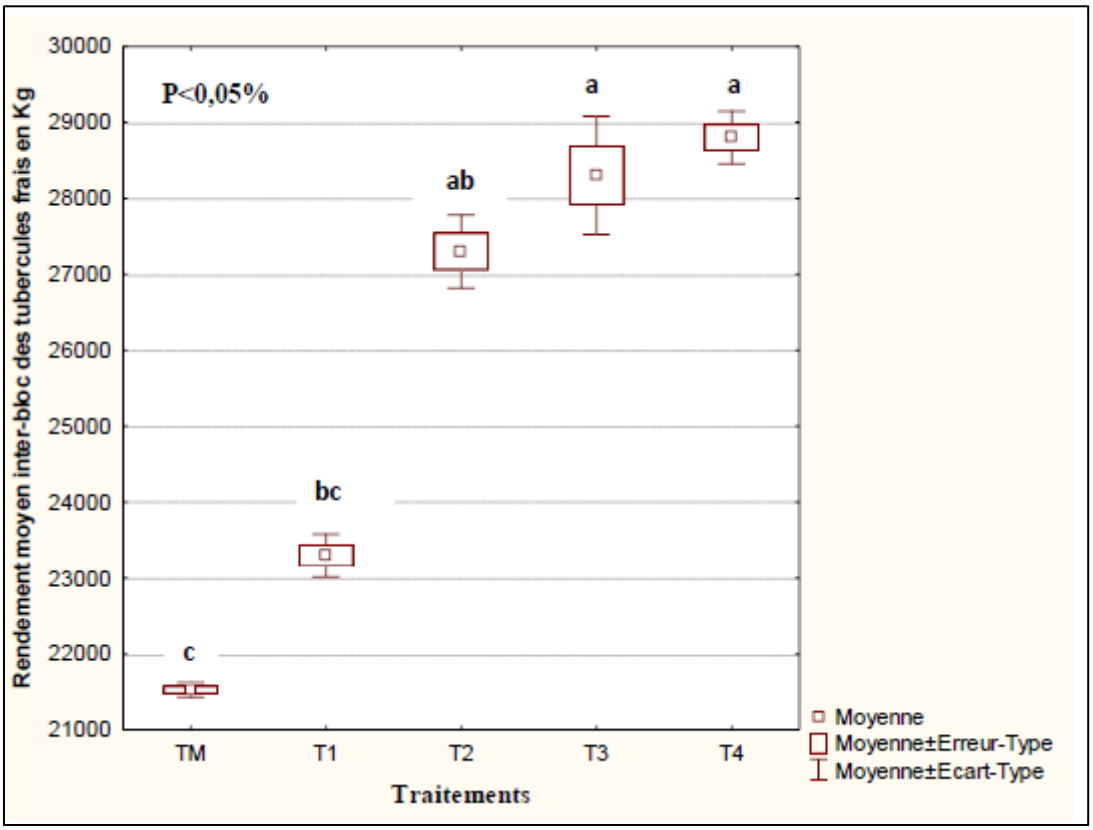
These were highly harmful weeds (PHI> 1000), with eight species, and harmful weeds (1000 ≤PHI> 500), with 28 species. No weeds were observed in the group of slightly harmful weeds (PHI ≤ 500). The eight weed species were both very common and very widespread in cassava fields. They were : *Ageratum conyzoides* (Asteraceae), *Croton hirtus* (Euphorbiaceae), *Diodia rubricosa* (Rubiaceae), *Euphorbia heterophylla* (Euphorbiaceae), *Panicum laxum* (Poaceae), *Panicum maximum* (Poaceae), *Porophyllum ruderale* (Asteraceae), and *Synedrella nodiflora* (Asteraceae).

Table 6 Partial weed harmfulness index

N	Species	Absolute frequency	∑ Recovery	PHI
1	*Ageratum conyzoides*	95	3062.5	3224
2	*Alchornia cordifolia*	54	297	550
3	*Calopogonium mucunoides*	105	781.5	744
4	*Centrosema pubescens*	93	511.5	550
5	*Chromolaena odorata*	142	862	607
6	*Commelina benghalensis*	78	429	550
7	*Commelina diffusa*	50	299	598
8	*Commelina erecta*	67	380.5	568
9	*Croton hirtus*	148	2398	1620
10	*Desmodium adscendens*	58	319	550
11	*Desmodium triflorum*	55	338.5	615
12	*Diodia rubricosa*	99	2964.5	2995
13	*Eragrostis tremula*	84	498	593
14	*Euphorbia heterophylla*	97	1312.5	1353
15	*Euphorbia hirta*	44	278	632
16	*Ipomoea involucrata*	64	376	588
17	*Lantana camara*	65	369.5	568
18	*Mallotus opposifolius*	52	286	550
19	*Mariscus cylindristachyus*	52	310	596
20	*Mimosa pudica*	74	455	615
21	*Momordica charantia*	87	478.5	550
22	*Panicum laxum*	174	3261	1874
23	*Panicum maximum*	99	1328.5	1342
24	*Passiflora foetida*	42	243	579
25	*Phyllanthus amarus*	80	464	580
26	*Porophyllum ruderale*	151	2198.5	1456
27	*Pueraria phasoeloides*	69	415.5	602
28	*Spigelia anthelmia*	64	352	550
29	*Sida acuta*	73	437.5	599
30	*Sida urens*	61	347.5	570
31	*Physalis angulata*	84	462	550
32	*Rottboellia cochinchinensis*	99	712.5	720
33	*Synedrella nodiflora*	114	3059	2683
34	*Triumfetta rhomboidea*	67	404.5	604
35	*Tragia benthamii*	78	453	581
36	*Trianthema portulacastrum*	55	302.5	550

3.4. Effects of weeding schedule on grass cover and yield

Analysis of the experimental data revealed that, in terms of grass cover, treatment T4 (chemical weeding with oxyfluorfen in early post-emergence followed by manual weeding with a machete in the 16th week) had the least weedy plots (coverage rate < 15%). It was followed by treatments T3 (three manual weedings, the first two with a hoe at weeks 6 and 14, and the third with a machete at week 24 after planting) and T2 (three manual weedings with a machete at weeks 6, 14th, and 24th week after cuttings). The weed coverage rate of the plots was greater than 15 %. In terms of yield, weighing the fresh cassava tubers after harvest made it possible to obtain the average yield for each plot and for each treatment. The TM and T1 treatments recorded the lowest yields, averaging 2.4 kg/plant. The T2, T3, and T4 treatments recorded average yields of fresh tubers between 2.69 and 2.94 kg/plant. The comparative analysis of average yields from the treatments showed significant differences ($P \leq 0.0001$). Four homogeneous groups were clearly identified (Figure 3). Treatments T4 and T3 produced the highest yields. The TM treatment (standard practice among producers : two weedings with a machete) recorded the lowest average yield, at 21,525 kg/ha.



Averages followed by the same letter are not significantly different (α = 0,05).

Figure 3 Average yield of fresh cassava tubers by treatment

4. Discussion

The study on weed management techniques in the Mé region showed that manual techniques (85.44 %) were the main method of weeding used by producers. The high proportion of this method of weeding could be explained by the fact that producers have no alternative to manual weeding. The results also showed that a small percentage of producers use a combination of chemical and manual weeding. This situation is justified by a lack of knowledge about herbicides used in cassava cultivation, as mentioned by 59 % of producers. In fact, with the exception of rice and maize crops, there is little or no range of herbicides dedicated to other food crops in Côte d'Ivoire [23]. Similar studies have shown that weed management in cassava cultivation is generally carried out manually [24]. Regarding producers' perceptions of the cost of weeding, the study revealed that the manual technique was the most expensive. In terms of biological constraints, weeds were the major constraint impacting production, with an estimated citation frequency of 100 %. Aulacodes (40.63 %) and termites (19.39 %) ranked second and third respectively after weeds. The prevalence of these three pests was virtually identical in all the locations sampled. The high number of mentions of weeds as the major constraint stems from the fact that they compete with cassava plants for water, nutrients, and light. In addition, they can also harbor aulacodes and other pests that can impact production. In terms of dominant weed flora, these were

weeds capable of producing large quantities of seeds. The evaluation of weeding techniques revealed that chemical weeding with oxyfluorfen in early post-emergence followed by manual weeding with a machete in the 16th week significantly reduced the weed infestation rate. When used at the beginning of the growing season, the herbicide prevented weeds from growing and spreading. This is what [25] explained in his work, stating that the purpose of chemical weed control was to promote crop growth by significantly reducing competition from weeds. Furthermore, the work of [26] indicated that cropping systems that advocate the total destruction of weeds use herbicides. The yield of fresh cassava tubers after harvest revealed that chemical weeding with oxyfluorfen in early post-emergence followed by manual weeding with a machete in the 16th week, and plots weeded three times manually, with a hoe at weeks 6 and 14 and a machete at week 24 after planting, were the most effective treatments. Indeed, as with herbicide treatment combined with manual weeding, fields weeded three times reduced competition and facilitated the growth of cassava plants.

5. Conclusion

The study revealed that only 14.56 % of cassava producers use herbicides at least once to weed their fields. However, the cassava producers surveyed mentioned that manual weeding was more expensive than weeding with herbicides. Weeds are the main biological constraint. Eight weeds were found to be highly damaging. The treatment “chemical weeding with oxyfluorfen in early post-emergence followed by manual weeding with a machete at week 16” proved to be the most effective in terms of weed management and fresh cassava tuber yields.

Compliance with ethical standards

Disclosure of conflicts of interest

No conflicts of interest to disclose.

statement of Informed consent

Informed consent was obtained from all individual participants included in the study.

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