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Storage Dynamics of Seeds of Croton Hirtus L'Herit (Euphorbiaceae) in crop Soils of Central Western Ivory Coast

Arsène Gué[1], Awa Touré[2] & Joseph I. Ipou[3]

Abstract

Croton hirtus is a major weed in food crops of Central Western Ivory Coast. The annual evolution of the soil seed bank of weeds in the Issia department was studied in order to predict infestations and to identify effective strategies for its management. The time variation of the soil seed bank was evaluated according to the mode of weeding control of plots and soil texture. In general, a strong increase of the seed storage of Croton hirtus was noted. However, it is the tilled land containing soils with clay texture that have recorded the greatest soil seed bank with respect to the dynamic evolution of Croton hirtus with averages of 8,647 seeds/m^2 and 11,316 seeds/m^2, respectively. These results suggest that the adoption of crops promoting the reduction of the seed stock would be effective against Croton hirtus. Hence, one should undertake tilling before fructification of Croton hirtus to avoid re-infestation of plots.

Keywords: Croton hirtus, soil seed bank, soil texture, weed control, food crops, Central Western Ivory Coast

1- Introduction

In Ivory Coast, food crops are generally produced by the itinerant cultivation system. Traditionally, this agricultural system is characterised by clearing and burning; a culture of short duration and a long-term fallow (De Foresta, 1995) which restores soil fertility and controls weeds (Cuero, 2006). However, currently, the availability of land suitable for food production in the forest zone is an increasingly pressing subject, due to the impacts of population growth and the expansion of perennial crops (N'Cho, 2001). The Central Western forest country has the highest rural density with 50.9 inhabitants/km^2 in the Haut-Sassandra region and 49 inhabitants/km^2 in the Marahoué region (Ministère d'Etat Ministère du Plan et du Développent, 2010). Faced with this land constraint, we are witnessing a shortening of the fallow period (Gbakatchetche et al., 2012; N'goran et al., 2011). The consequences of this dilemma are the reducing yields of food crops due to the proliferation of weeds and a downward trend in soil fertility. In this context, it appears that the increase in food production in the forest zone of Ivory Coast and especially in the Central Western part of the country forest clearly requires the adoption of farming techniques which are capable of increasing the productivity of the land. At the weed control level, effective control strategies should be put in place. In order to achieve this, we must first have a better knowledge of the biology of weeds encountered there, and especially the dominant weeds because they cause the majority of losses of crop yields (Basu et al., 2004). However, in Ivory Coast the majority of work in weed science is still focused on inventories of the weed flora of different cultures and/or some regions. Among the biological characteristics of weeds, (the knowledge of which could help fight effectively against those weeds) is included the dynamics of the soil seed bank.

[1] Graduate Student, Doctorate in Botany, Speciality: Weed Science, Université Félix Houphouët Boigny, Laboratory of Botany, UFR Biosciences, 22 BP 582 Abidjan 22, Ivory Coast. Telephone: (225) 06493978, Email: garsene21@yahoo.fr

[2] Assistant lecturer, Université Félix Houphouët Boigny, Laboratory of Botany, UFR Biosciences, 22 BP 582 Abidjan 22, Ivory Coast. Telephone: (225) 04821669, Email: estouri@yahoo.fr

[3] Lecturer, Université Félix Houphouët Boigny, Laboratory of Botany, UFR Biosciences, 22 BP 582 Abidjan 22, Ivory Coast.
Telephone: (225) 07546039, Email: ipoujoseph@yahoo.fr

Indeed, the dynamics of the weed seed bank in the soil would strongly influence the density of the surface flora (Gardarin, 2008) which could aid our knowledge of better predicting outbreaks and evaluating sustainable management strategies (Bhomik, 1997). This is related to the combined action of environmental factors and cultural practices that can result in quantitative and qualitative changes in weed flora (Dessaint et al., 1990; Makhlouf et al., 2011). In this respect, weed species the soil seed bank can vary in different burial environments (Schutte et al., 2008). Studies on the dynamics of seed stock of weeds in the major food crops in the forest zone of Ivory Coast are, therefore, necessary to fight effectively against weeds and to contribute to increased food production. In this context, we examined the annual evolution of soil seed banks of Croton hirtus L'Hérit (Euphorbiaceae), a weed species that is native to tropical America (Pauwells and Breyne, 1978) and which is a dominant weed in cultivated fields with short-period fallow rotation in forests of Central Western Ivory Coast (Kouadio, 2003; Cuero, 2006). We assumed that the seed bank of this weed is not only identical within different soil textures, but remains static during the year on both tilled and untilled land. The objective of this study was to evaluate the annual development of the seed bank of Croton hirtus in conditions of tilling and hoeing in four different soil types (i.e., sandy, clay, sandy clay, and gravelly).

2- Materials and Methods

2.1- Study Area

The research was undertaken on a farm in year 2012 in plots of maize with short-period fallow rotation of three years in the Department of Issia (latitude 60°29'00"N and longitude 60°35'00"W) in the Haut-Sassandra region of Central Western Ivory Coast. This part of the country, although characterised by high rural density (Ministry D'Etat, Ministry of Planning and Development, 2010), remains a major food production area (Douka, 2011).

2.2- Treatments and Experimental Design

Croton hirtus was the species under study. The observations were undertaken, primarily, on its seeds. Trials were set up in the beginning of the rainy season in order to assess the evolution of the seed bank. Among other equipment, an auger was used for collecting soil samples. The evaluation method used is based on that of Ipou Ipou (2005). Taking into account the soil texture (i.e., sandy, clay, sandy clay, and gravelly), four plots of 100 m^2 each and homogeneously grassed with C. hirtus were selected. All were rated at level 5 of the scale of abundance-dominance by Le Bourgeois (1993) before planting operations. The tasks undertaken on elementary plots were: soil sampling, determination of the density of seedling samples and the extent of their seed production. Each plot was divided into one hundred (100) basic plots of $1m^2$ each, numbered from 1 to 100, of which 20 were chosen for different operations. The 20 selected elementary plots were divided into two groups of 10, one of which received a tilling at the end of the cycle of the first generation of weed and the other remained without maintenance after ploughing. Hence, it was the tilling activity undertaken which differentiated the two groups of elementary plots.

2.2.1- Abundance of Croton Hirtus Seeds in the Soil

Twenty (20) soil samples were collected with respect to soil type before ploughing at the rate of one sample per subplot. The samples are taken at the point of intersection of the two diagonals of the basic plot to a depth of 30 cm, which is greater than the usual seed sampling depth in soil of 10 cm (Forcella et al., 2005), because we wanted to collect as many seeds as possible. The samples taken from the Croton hirtus infested fields were dried, sieved and sorted in order to collect their seeds. A 3 mm screen was used to isolate the coarse matter (stones, plant debris, etc.). Another 0.5 mm screen was used to separate the portions of fine particles whose diameter component varied between 0.5 cm and 3 mm, and which may have contained seeds of Croton hirtus. At the end of the trials, the seeds of Croton hirtus were counted. The abundance of Croton hirtus seeds in the soil was calculated for each of the four soil textures, and was expressed as the number of seeds per square metre (seeds/m^2). The formula used is the following: $RS = \sum P_n / 2\pi R^2$ (where P is the number of seeds per auger core, (n= 20) is the number of elementary plots and R = 2 cm was the radius of the auger).

2.2.2- Density of Seedling Emergence

After ploughing, the densities of seedling samples were determined for both the non-tilled and tilled elementary plots. Two sets of counts were performed. On the elementary plots that were not tilled, the first seedling emergence density determinations took place three weeks after ploughing. After this period, it was assumed that all seedlings in the first generation had been lifted.

A second count was conducted after the release of the previous dissemination. On the tilled plots, the first count was undertaken in the same conditions already described. The second count was undertaken after the tilling of the post-ploughing generation. The density of seedling emergence is expressed as the number of seedlings per square metre (seedlings/m^2). The calculation formula is as follows: D = N/S (where D is density and N is the number of emergent seedlings on surface S).

2.2.3- Production and Evolution of Seed Bank per Plot

The plot productions of the first and second generations of Croton hirtus were harvested and the seeds were counted. On the tilled plots, the first generation was the one that was set up after ploughing and the second generation was the one that grows after tilling. On non-tilled plots, the first generation is as previously described; formed of the population established after ploughing, the second generation was the one that occurred after seed dispersal of the first generation, at the end of its growth cycle. Seeds were collected three times daily (9 am, 1 pm and 5 pm) from the date of the first fruit ripening. The annual production per parcel is expressed as number of seeds per square metre and was studied for four soil types. The variation of soil seed bank is the result of losses (germinated seeds, destroyed by fire, attacked by diseases, etc.) and seeds were mainly generated through production and also by the potential new influxes. In our case, on a plot the losses consisted only of the seeds that germinated during the season and the total number of harvested seeds were considered to be gains. This accounting is established for each of the four soil textures, for those subunits that were tilled for those that were not, in the form:

$$\mathbf{Pt_f = G_b + Pt_d - P}$$

where $\mathbf{Pt_f}$ = theoretical potential at the end of the observations; $\mathbf{Pt_d}$ = potential determined at the beginning of the experiment = seed rate in the soil + Number of seeds raised before ploughing (determined from the density of plants before ploughing); $\mathbf{G_b}$ = annual gain represented by the production obtained; **P** = All losses consisting of germinated seeds during the year (before and after ploughing). We had to distinguish the gross gain from the net gain. The net gain is the amount of additional seeds in the ground compared to the initial bank.

2.2.4- Statistical Analysis

All statistical analyses were performed with SPSS Statistical software version 20. The data on the abundance of seeds of Croton hirtus, as well as data on the final theoretical potential net gain with respect to the different soil types examined, underwent variance analysis and comparison of means was performed by the Duncan's test at a threshold of 5%. As for the final data and theoretical potential net gain with respect to the mode of maintenance, they were analysed using the Student's t-test. The data of the other parameters considered in this study, because they were considered non-normal, were submitted to the Kruskal-Wallis test in SPSS when there was a need to compare the different soil textures and the Mann-Whitney U test, where appropriate, in order to compare the conditions of tilling and non-tilling and the emergence of seedlings before and after ploughing.

3- Results

3.1- Soil agronomic Capability of Croton Hirtus Seeds at start of Experiment

The average agronomic capability of soils with sandy texture and Croton hirtus seeds is 8,143±1,406 seeds/m^2. For soils of sandy clay texture, it is 6,733 ± 1,135 seeds/m^2. An average potential of 8,841±1,054 seeds/m^2 was obtained on clay soils. With gravelly soil, the average agronomic capability of Croton hirtus seed is 6,470 ± 951 N / m2 (Figure 1). Significant differences were observed between the four soil types for this parameter ($p < 0.001$). Thus, the agronomic capability of sandy and clay soils in Croton hirtus seeds is significantly higher than that of sandy clay and gravelly soils (Figure 1).

3.2- Densities of Emergent Seedlings

The average density of seedlings Croton hirtus before ploughing is 903±225 seedlings/m^2 against 441±171 seedlings/m^2 after ploughing. A significant difference was observed between the average densities of emergent seedlings of Croton hirtus before and after ploughing ($p < 0.001$). Thus, the average density of emergent seedlings of Croton hirtus before ploughing was significantly higher than after ploughing (Figure 2). During the second generation of Croton hirtus, emergent seedlings densities were 263±139 and 159±124 seedlings/m^2, respectively, for the non-tilled and tilled plots. A significant difference was observed between the tilled plots and non-tilled plots for medium densities of second generation emergent seedlings of Croton hirtus ($p < 0.01$). Thus, the average density of second generation emergent seedlings of Croton hirtus was significantly higher in tilled plots (Figure 3).

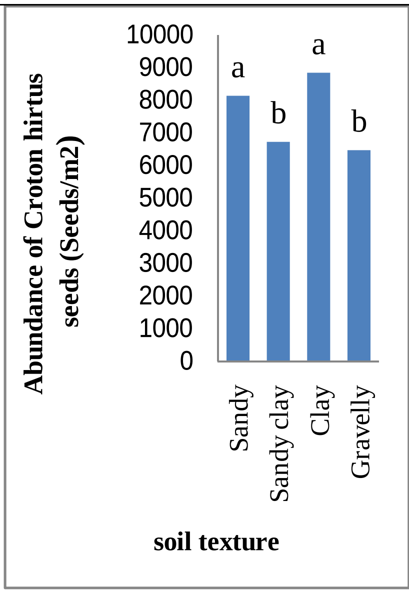

Figure 1. Soil Agronomic Capability of Croton Hirtus Seeds According to Soil Texture

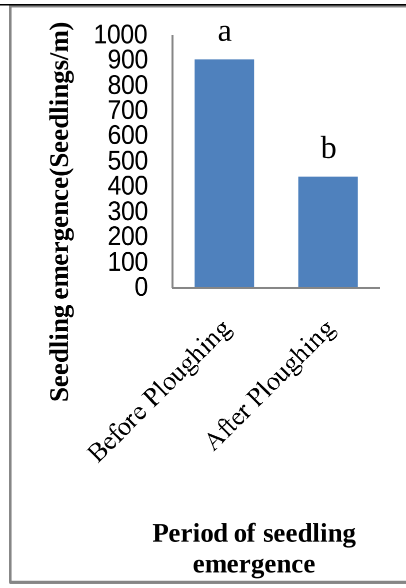

Figure 2. Seedling Emergence of Croton Hirtus Before and After Ploughing

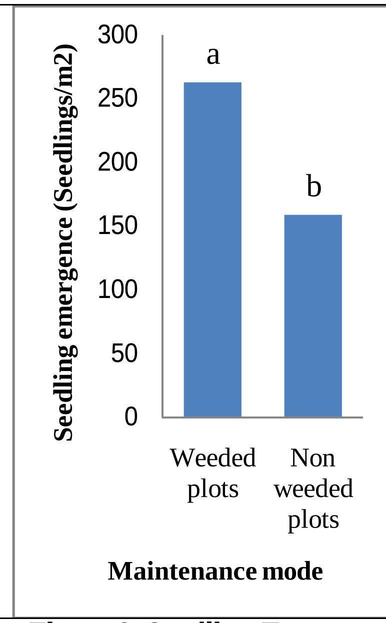

Figure 3. Seedling Emergence According to Maintenance Mode of 2nd Generation of Croton Hirtus

In each figure, the factors with the same letters are statistically identical. Average total densities of emergent seedlings of Croton hirtus are 1625±432 and 1474±388 seedlings/m² in tilled and non-tilled plots, respectively. The difference between the two densities of emergent Croton hirtus was not significant (p> 0.05). However, a greater number of emergent seedlings was noted on the ploughed plots (see Table I).

Table I: Total Average Density of Emergent Seedlings with Respect to Soil Texture and Maintenance Mode of Plots

Soil textures and Plot maintenance	Total density average of emergent seedlings (seedlings/m²)
Soil texture	
Sandy	1,565 ± 276[b]
Sandy clay	1,478 ± 236[b]
Clay	2,043 ± 278[a]
Gravelly	1,111 ± 204[c]
Maintenance of plots	
Tilled plots	1,625 ± 432[a]
Non-tilled plots	1,474 ± 388[a]

At the level of each independent variable, factors with the same letters are statistically identical. In terms of soil texture, average total densities of emergent seedlings in sandy, sandy clay, clay and gravelly soils are, respectively, 1,565±276, 1,478±236, 2, 043±278 and 1,111±204 seedlings/m². Significant differences were obtained (p< 0.01). Thus, the total density of emergent seedlings in clay soil was significantly higher than in sandy soils and sandy clay, themselves being significantly higher than the densities of emergent seedlings in gravelly soils (see Table I).

3.3- Seed Production

The average total production of seeds of Croton hirtus calculated on tilled and non-tilled plots were, respectively, 9,355±3906 and 6,857±2907 seeds/m². A significant difference was observed between the tilled and non-tilled plots for this parameter (p< 0.01), and the highest seed productions are noted on ploughed plots (see Table II).

Table II: Total Average Production of Seeds with Respect to soil Texture and Maintenance Mode of Plots

Soil texture and Maintenance of plots	Average seed production (seeds/m²)
Soil texture	
Sandy	8252 ± 2140[b]
Sandy clay	7936 ± 2126[b]
Clay	12381 ± 2618[a]
Gravelly	856 ± 995[c]
Maintenance of plots	
Tilled plots	9355 ± 3906[a]
Non-tilled plots	6857 ± 2907[b]

At the level of each independent variable, factors with the same letters are statistically identical. Total production of Croton hirtus seeds was calculated in sandy, sandy clay, clay, and gravelly soils as, respectively, 8,252±2140, 7,936±2126, 12, 381±2618 and 3,856±995 seeds/m². Significant differences were also observed between the different soil types examined for the total production of Croton hirtus seeds ($p < 0.001$). Thus, the total seed production in clay soils is significantly higher than the respective total production in sandy soils and sandy clay soils, themselves, being significantly higher than the gravelly soils (Table II).

3.4- Seed Bank Evolution

The theoretical potential of seeds evaluated at the end of the observations on both tilled and non-tilled soils was much higher than the earlier experiences of initial seed potential. However, tilled plots with clay soils were recorded with the final theoretical potential and the highest net gains (see Tables III and IV).

Table III: Final Theoretic Potential of soils with Seeds de Croton hirtus with Respect to Soil Texture and Maintenance Mode of Plots

Soil textures and plot maintenance	Final theoretic potential of soils with seeds (Seeds/m²)
Soil texture	
Sandy	15,033 ± 3027[b]
Sandy clay	15,002 ± 3236[b]
Clay	18,761 ± 3438[a]
Gravelly	11,202 ± 2012[c]
Plot maintenance	
Tilled plots	17,139 ± 3769[a]
Non-tilled plots	12,861 ± 2908[b]

At the level of each independent variable, factors with the same letters are statistically identical.

Table IV: Net Gain of soils with Seeds of Croton Hirtus with Respect to Soil Texture and Maintenance mode of Plots

Soil textures and plot maintenance	Net gain of soils with seeds (Seeds/m²)
Texture du sol	
Sandy	7604 ± 2064[b]
Sandy clay	7312 ± 2097[b]
Clay	11316 ± 2577[a]
Gravelly	3582 ± 983[c]
Plot maintenance	
Tilled plots	8647 ± 3633[a]
Non-tilled plots	6260 ± 2676[b]

At the level of each independent variable, factors with the same letters are statistically identical.

4- Discussion

Seeds of Croton hirtus are abundant in the experimental plots of land used in this study, which could certainly explain the abundance of Croton hirtus in arable plots in Central Western Ivory Coast (Kouadio, 2003; Cuero, 2006). Similarly, the abundance of seed bank in the experimental plots express an inefficient shifting of cultivation within the short duration fallow system practiced in the study area to promote weed control (N'goran et al., 2011; Cuero, 2006). With the exception of weeds with large seeds, for some researchers, the seed bank rather than the vegetation is a better indicator of long-term influences of agronomic practices with respect to weeds (Forcella et al., 2005). Significant differences were also observed between soil textures for their potential abundance of hirtus Croton seed. The highest seed densities are noted in clay and sandy soils, due to the abundance of the studied weed in these two types of soil. Indeed, Croton hirtus produces many seeds (Pauwells and Breyne, 1978). It is noteworthy that the high density of this species in sandy and clay soils has favoured the production of a large quantity of seeds in previous years. During this study, more emergent Croton hirtus seedlings were observed before ploughing, compared to the first generation of seedlings emerging after ploughing. This result is explained by the fact that on the study sites, the practice of ploughing barely existed in previous years. The weed seeds were, therefore, concentrated in the surface layers. The ploughing has deeply buried these seeds. As the lifted soil is less rich in recovered Croton hirtus seed, there was therefore less emergent seedlings after ploughing. For the second generation of Croton hirtus, more emergent seedlings were also observed on tilled plots compared to non-tilled plots. This result is consistent with the research results of Ipou Ipou (2005) who noted that in the cultivation of cotton in Northern Ivory Coast, emergent seedlings of Euphorbia heterophylla L. (Euphorbiaceae) were more abundant greatest on tilled plots than non-tilled plots. This result confirms the principle that any form of disturbance confined to the top 10 cm of soil can increase density of emergent seedlings (Egley, 1989).

Significant differences were noted for the densities of emergent Croton hirtus seedlings according to the different soil textures between the examined plots. The strongest emergent seedlings were reported on clay soils, which could be explained by the fact that this type of soil is, along with sandy soil, the richest in Croton hirtus seeds. The density of individuals of this species on the soil surface is indicative of the importance of the seed potential (Gardarin, 2008). However, fewer emergent seedlings were recorded on plots with sandy soils rather than with clay soils. This could be due to the fact that some seeds of Croton hirtus would be dormant in sandy soil. Indeed, the research work in the Democratic Republic of Congo (DR Congo) has shown that the seeds of this weed species may express dormancy under certain conditions (Pauwells and Breyne, 1978). In general, a strong production of Croton hirtus seeds was recorded during this study. The increase in the number of seeds in the soil under cultivation was approximately 7453 seeds/m^2. This increase is based on certain parameters, such as the texture and maintenance mode of the soil. The evolution dynamics of the seed bank was stronger on tilled plots. Although there was no significant difference between the non-tilled and tilled plots for the total number of emergent seedlings, it is on those that were tilled records over emergent seedlings. The number of seeds produced by the difference between plants raised on tilled plots and plants raised on non-tilled plots, could then explain the fact that there were more seeds produced on plots that received tilling.

5- Conclusion

In this study, we examined the annual development of the seed bank of Croton hirtus, a dominant weed in cultivated fields in short-term fallow rotation in forest areas of Ivory Coast. The experimental approach used allowed to note, generally, a strong increase of seed stock by an average of 7453 seeds/m^2. This development, however, depends on the texture and maintenance mode of the soil. Indeed, the strongest evolutionary dynamics of Croton hirtus seeds were recorded in those stored in tilled plots and in clay soils. We can infer from these results that the fight against Croton hirtus must, firstly, employ a preventive strategy in order to obviate contamination of the plots. In the highlighted soils that were planted with Croton hirtus, the fight will focus on the establishment of technical programmes of weeding that favour methods which reduce the seed bank and prevent re-infestation. Thus, the cultivation technique consisting of creating a false seed bed would be very effective in reducing the seed bank, which would be favoured by the requirement of the practice of deep tillage. Similarly, it will be necessary to achieve the tilling before fructification of the weed.

6- References

Basu, C., Halfhill, D. M., Mueller, C. T., & Stewart Jr N. C. (2004). Weed genomics: new tools to understand weed biology. TRENDS in Plant Science, Vol 9 Nº 8, 391-398.

Bhomik, P. C. (1997). Weed biology: importance to weed management. Weed Science, 45, 349-356.

Cuero, M.J., (2006). Maintaining the yield of Upland Rice under Intensified Land Use in Slash and Burn Systems of West Africa: Master of Agronomy of Agricultural Science and Resource Management in the Tropics and Subtropics (ARTS) in Universitat zu Bonn, Germany, (Chapter 4).

De Foresta H., (1995). Systèmes de culture, adventices envahissantes et fertilité du milieu : le cas de Chromoleana odorata. In J. Pichot, N. Sibelet & J. J. Lacoeuilhe (Eds.), Fertilité du milieu et stratégies paysannes sous les tropiques humides (pp. 236-244). Montpellier, France : CIRAD.

Dessaint F., Chadoeuf R., & Barralis G. (1990). Etude de la dynamique d'une communauté adventice. II- Influence à long terme des techniques culturales sur le potentiel semencier. Weed Research, 30, 319-330.

Douka A.M., (2011). La contribution des coopératives dans la régulation des marchés de vivriers à Abidjan : l'exemple de la Comagoa Roxy. pp 93-108 In C. Y. KOFFIE-BIKPO & A. D. D. NASSA (Eds.), Production vivrière et sécurité alimentaire en Côte d'Ivoire (pp. 93-108). L'Harmattan- Côte d'Ivoire.

EGLEY G. H. (1989). Stimulation of weed seed germination in soil. Weed Science, 2, 67–89.

Forcella, F., Webster, T., & Cardina J. (2005). Protocoles pour la détermination de banque de semences de mauvaises herbes dans l'agro-écosystème. In R. Labrada (Eds.), Gestion des mauvaises herbes pour les pays en développement (pp. 3-20). Rome : Étude FAO, Production Végétale et Protection des Plantes.

Gardarin, A. (2008). Modélisation des effets des systèmes de culture sur la levée des adventices à partir de relations fonctionnelles utilisant les traits des espèces. Thèse de Doc. , Inst. Nati. Agro., Université de Bourgogne, France, (Chapter 1).

Gbakatchetche, H., Sanogo, S., Camara M.; Bouet A., Kéli J., & Tahouo O., (2012). Le paillage par le pois d'angole pour améliorer le rendement du riz pluvial en Côte d'Ivoire, p. 12 in Le CNRA en 2011, Côte d'Ivoire, CNRA, (Chapter 4).

Kouadio, Y. P., (2003). Dynamique des adventices dans la culture de maïs de second cycle, dans la région de Gagnoa : Master thesis of Université de Cocody, Abidjan, Côte d'Ivoire, (Chapter 3).

Ipou Ipou, J., (2005). Biologie et écologie de Euphorbia heterophylla L. (Euphorbiaceae) en culture cotonnière, au Nord de la Côte d'Ivoire : doctorate thesis of Université de Cocody-Abidjan, (Chapter 8).

Le Bourgeois, T. (1993). Les mauvaises herbes dans la rotation cotonnière au Nord-Cameroun (Afrique) : Amplitude d'habitat – Degré d'infestation – Phénologie : doctorate thesis, université de Montpellier II Sciences et techniques du Languédoc, France, (Chapter 2).

Makhlouf, M., Benkherbache, N., Rahali A., (2011). Influence de l'itinéraire technique sur le stock semencier de mauvaises herbes de la zone semi-aride de Sétif. In H. Bouzerzour, H. Irekti & B. Vadon (eds.), 4 Rencontres Méditerranéennes du Semis Direct (pp. 153-162). Zaragoza : Options Méditerranéennes, Séminaires Méditerranéens.

Ministère d'Etat Ministère du Plan et du Développement (2010). Les conditions du développement durable de la Côte d'Ivoire, Côte d'Ivoire, Ministère d'Etat Ministère du Plan et du Développement, (Chapter 5).

N'Cho A. S., (2001). Analyse des systèmes de production en zone forestière ivoirienne : cas de Gagnoa. Master Thesis of École Supérieure d'Agronomie, Yamoussoukro, Côte d'Ivoire (chapter 3).

N'goran, K. E., Kassin, K. E., Zohouri, G. P., N'gbesso, M. F. D. P., & YORO G. R. (2011). Performances agronomiques des associations culturales igname-légumineuses alimentaires dans le Centre-ouest de la Côte d'Ivoire. Journal of Applied Biosciences, 43, 2915-2923.

Pauwells, L., & Breyne L. (1978). Deux espèces rudérales nouvelles pour la Flore du Zaïre: Croton hirtus L'Hérit. (Euphorbiaceae) et Eupatorium odoratum L. (Compositae). Bull. Jard. Bot. Nat. Belg., 48, 433-435.

Schutte, J. B., Davis, S. A., Renner, A. K., & Cardina J. (2008). Marternal and burial environment effects on seed mortality of Velvetleaf (Abutilon theophrasti) and Giant Foxtail (Setaria faberi). Weed Science, 56,834-840.