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Constraining weeds in okra cultivation and farmer management of weeds in South-East of Côte d'Ivoire

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Abstract

This study was carried out among okra growers in the La Mé region, with the aim of identifying farmers' weed management practices and the main weeds present in the fields. Using a questionnaire coupled with a floristic inventory in each field, the agrotechnical characteristics of the farms and the main weed species were determined. The results show that 94.67% of the farmers surveyed use herbicides and 67.33% use insecticides. Almost all the herbicides used were total herbicides, applied before sowing. 68.67% of growers carry out three weed control operations per production cycle, and the weed control method most frequently used is chemical weed control combined with manual weed control. The inventory of major weeds reveals that 16 species are a constraint for the crop and 7 of them are cited with a high frequency. These were *Panicum maximum*, *Chromolaena odorata*, *Ageratum conyzoides*, *Mimosa pudica*, *Panicum laxum*, *Croton hirtus* and *Centrosema pubescens*. The floristic surveys showed that the constraining weeds come from four major botanical families: Asteraceae (37.5%), Poaceae (25%), Euphorbiaceae (18.75%) and Fabaceae (18.75%). Hemicryptophytes (41.84%) and Nanophanerophytes (34.05%) are the two biological types that contain the most constraining weeds. This study is a fundamental step towards initiating an effective weed management strategy for okra. The results of this study will make it possible to propose effective ways of controlling these weeds. These include reducing weeds to a tolerable nuisance threshold for the crop, setting up a trial to determine the critical weed period, and establishing crop rotations and combinations.

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Introduction

Food crops and market gardening have long played an important role in Côte d'Ivoire's food supply. They are a source of foreign currency and employment. According to Schilter (1991), they are one of the responses to the increasingly chronic food deficit in urban areas. One of these crops is okra. This vegetable originated in Africa. It is grown in tropical, subtropical and Mediterranean regions for its high market value, its rich nutrient content and its importance in the diets of urban and rural populations (Kahlon *et al.,* 2007; Khomsug *et al.,* 2010). Okra thus contributes to household nutritional security thanks to the diversity of uses in meal preparation (Tshomba *et al.,* 2015). Given its importance and its place in the global agricultural development strategy, okra cultivation is currently being given a new lease of life, both in terms of increasing farmers' resources and combating malnutrition.

In Côte d'Ivoire, all people eat and grow okra. However, pest management and okra production techniques have evolved very little. Unfortunately, in farming systems, several constraints linked to biotic and abiotic factors, socio-economic conditions (low labour and falling product costs) and constraints due to weeds lead to huge losses in agricultural production (Siemonsma and Kouamé, 2004 ; Yapi, 2017 ; Tano *et al.,* 2019). What's more, okra is not produced intensively. It is generally produced during the main rainy season on plots of land close to large areas of cereal crops (rice, maize) and yams, or scattered throughout these fields (Fondio *et al.,* 2003). Today, farm labour is scarce and weed control is virtually ineffective. This situation has led farmers to use synthetic chemicals to maintain their plots. However, the excessive and abusive use of these synthetic herbicides is causing considerable environmental damage, resulting in the degradation of farmland (Pell *et al.,* 1998) and often in the presence of chemical residues in the environment and in harvested products, leading to a deterioration in human health (Vyvyan, 2002).

The aim of our study is to take stock of okra production techniques by identifying farmers' weed management practices and determining the main weeds in the fields.

Materials and methods

Materials

The biological material consisted of okra plants and the major weeds found in the fields visited. The technical material consisted of phyto-ecological survey and weed rating sheets to record the names of the species, survey sheets for the various interviews and newsprint used to collect the species that could not be identified in the field.

Study area

The study took place in the department of Akoupe. This locality is located in the Me region, more than a hundred kilometres from Abidjan, on the international Abidjan-Abengourou road (Axis A1). Geographically, its coordinates are : 6° 28‘ 49“north latitude and 3° 51’ 28“ west longitude. Three localities were used as sampling zones in this study. These were the okra growers in Becouefin, the capital of the sub-prefecture, and those in the villages of Soribadougou and Bonahouin. In these three villages, one hundred and fifty (150) producers were surveyed, at a rate of fifty (50) producers per village. The interviews were conducted in French or in the local language.

Data collection

Agro-technical survey

To find out about the cultivation and weed management techniques used by growers in the study area, a number of questions were asked. These questions concerned the area cultivated, the previous crop, the sowing method, the type of clearing, the weeding method, the number and period of weeding, the types of herbicide and insecticide used, and the major weeds encountered.

Weed inventory

During the field visits, this phase consisted of listing, identifying and classifying the major weeds indicated or mentioned by the growers. On the plots, the growers

gave the vernacular names of the weeds they considered to be troublesome and/or recurrent. These weeds were recorded, photographed and/or harvested and then brought back to the village for identification. In addition, a tour of the field was carried out to determine the abundance-dominance of these species. For the major species, the biological type was defined.

Data processing

Information concerning the various agro-technical data such as: herbicide use, number of weedings, type and period of weeding, etc. is ordered.

Percentage or frequency calculations were made for each characteristic. With regard to the data on major weeds, the list of weeds that are a constraint in these localities was drawn up on the basis of the survey forms.

Weed citation frequency

The citation frequency (CF) is the number of citations of an entity of an agro-technical variable out of the total number of citations of all the entities of this variable (Doh, 2015). Relative to weed species, it is determined by the following formula (Fah *et al.*, 2013):

CF={(Number of citations)/(Total number of citations)}×100

Average abundance-dominance of major weeds

For each species inventoried, an abundance-dominance score (ADmoy) is assigned. This expression reflects the extent of the weed problems posed by the different weed species. The scale used (Table 1) is that proposed by Le Bourgeois (1993). It is the sum of the abundance-dominance scores over the total number of records (N) in which the species is present.

Table 1. Scale adopted for quantifying weediness (Le Bourgeois, 1993)

Index	Meaning
1	Individuals that are rare, not very abundant or abundant, but with low coverage
2	Very abundant individuals or individuals covering 1/20 of the area sampled
3	Individuals covering ¼ to ½ of the surface, any abundance
4	Individuals covering ½ to ¾ of the surface, any abundance
5	Individuals covering more than ¾ of the surface, any abundance

Biological spectrum of major weeds

Each major weed identified is classified according to botanical criteria (family, genus and species) and assigned the biological type (B.T.) to which it belongs. The biological type classification model adopted is that of Aké Assi (1984 ; 2001 and 2002), itself adapted from the model of Raunkiaer (1905). The percentages representing each biological type were calculated. These were used to construct the biological spectrum. The following formula is used to calculate the percentages:

$$p.c.B.T. = \frac{\sum \text{AD moy of the same biological type}}{\sum \text{AD for all species}} \times 100$$

Statistical analysis of the data

Two statistical tests were carried out. The first is the Chi-square test, used to compare the proportion of agricultural inputs (herbicide and insecticide) according to locality. The second is the ANOVA test. The significance level chosen for these analyses is 5%.

Results

Agronomic characteristics of practices

Area, previous crop and sowing method

In the study area, the areas of okra visited ranged from 1,000 m² to one hectare or more. Over 58% of okra growers farm an area of one hectare or more. Those whose fields are larger than a quarter hectare and smaller than half a hectare represent (36%) and (6%) respectively. In terms of previous cultivation, all the producers surveyed grow okra in fallow land and do not sow it in rows.

Weeding methods

There are two main methods of weeding okra fields in the study area. These were manual weeding (5.3% of the population surveyed) and a combination of manual weeding and the use of herbicides (94.7%) (Fig. 1). Manual weeding is carried out either with a machete alone or with a machete and a daba. The use of herbicides in field maintenance is always associated with machete weeding. Moreover, most of

the herbicides used are total herbicides applied before or just after sowing okra.

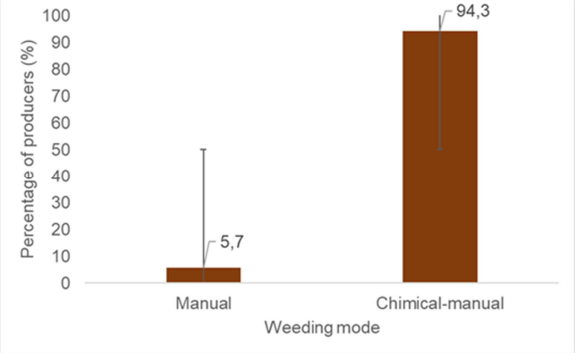

Fig. 1. Distribution of okra growers according to type of weed control

Number and timing of weed control operations

During the crop cycle, two to three weeding operations are generally carried out. All growers carry out at least two weeding operations (Table 2). Statistical analysis shows that there is a significant difference between growers in the three localities in terms of the third weeding operation (F=17.406 ; P-value=0.003). The weeding periods extended from the second week to the tenth week after sowing. The first weeding generally took place between the 2nd and 4th week after sowing. Fig. 2 shows the distribution of growers according to weeding periods. The second weeding is generally carried out between the 6th and 8th week after sowing (Fig. 3).

Table 2. Proportion of growers according to weeding frequency

	Number of weedings in (%)			Results
Localities	1	2	3	
Becouéfin	100	100	82	
Bonahouin	100	100	56	F = 17,406
Soribadougou	100	100	68	P-value = 0,003

Statistical analysis shows that the timing of the second weeding differs from one locality to another (F=1.072 ; P-value=0.399). Over 82% of okra growers carried out three weeding operations. The results showed that there was no significant difference between weeding frequency and producer origin (U=16.5 ; P-value=0.810).

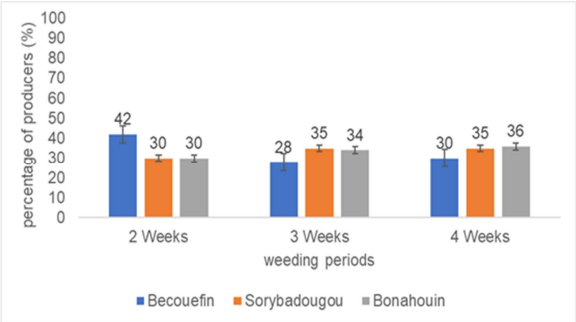

Fig. 2. Distribution of okra growers according to first weeding period

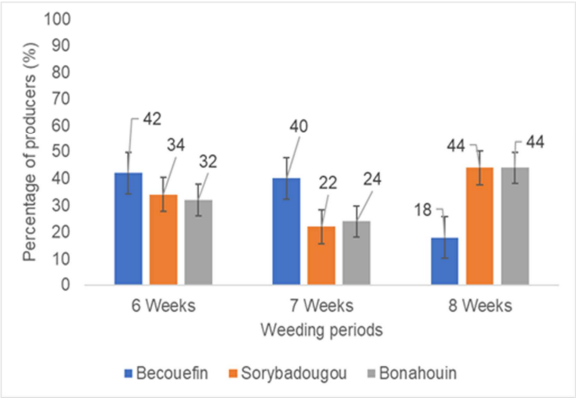

Fig. 3. Distribution of okra growers according to second weeding period

Table 3. Proportion of farmers using herbicides in the study area

	Herbicide use by farmers in (%)		Results
Localities	Yes	No	
Becouéfin	100	0	χ^2=20,065
Bonahouin	84	16	ddl=2
Soribadougou	100	0	p-value=0,00021
Study area	94,67	5,33	

Use of agricultural inputs

Farmers in the three localities surveyed used at least one type of chemical product, either a herbicide or an insecticide, or both, during the crop cycle. With regard to herbicide use, over 94.67% of farmers used a total herbicide, compared with 5.33% who did not. Almost all of these farmers said that they use total herbicide to clean their okra fields before sowing. The analysis shows that there is a significant difference between producers who use a herbicide and those who do not (x^2=20.065 ; P-value= 0.00021) (Table 3). Regarding the use of insecticides, more than 67% of farmers used an

insecticide against 32.7% who did not. The statistical test (x^2= 20.065 ; P-value= 0.00003) shows that there is a significant difference between insecticide use and farmers' origin (Table 4).

Table 4. Proportion of farmers using insecticides in the study area

	Use of insecticide by farmers in (%)		Results
Localities	Yes	No	
Becouéfin	88	12	χ^2=20,065
Bonahouin	68	32	ddl=2
Soribadougou	46	54	p-value=0,00003
Study area	67,33	32,67	

Floristic composition

The survey identified sixteen (16) species, seven (7) of which are more frequent. Among these frequent species, *Ageratum conyzoides* (Asteraceae), *Chromolaena odorata* (Asteraceae), *Croton hirtus* (Euphorbiaceae), *Centrosema pubescens* (Euphorbiaceae), *Imperata cylindrica* (Poaceae), *Panicum laxum* (Poaceae) and *Panicum maximum* (Poaceae) were cited by all growers as being recurrent and difficult to control. These weeds are grouped into six (6) genera and four (4) families. These families are distributed as follows: Asteraceae (37.5%), Poaceae (25%), Euphorbiaceae and Fabaceae with 18.75% each (Table 5).

Table 5. Distribution of weed families by study area and locality

#	Family	Localities			Study area (%)
		Becouéfin (%)	Bonahouin (%)	Soribadougou (%)	
1	Asteraceae	50	28,57	40	37,5
2	Euphorbiaceae	25	14,29	20	18,75
3	Fabaceae	0	28,57	20	18,75
4	Poaceae	25	28,57	20	25

Biological types

Five biological types were identified from the survey. These are Nanophanerophytes (np), Chamephytes (Ch), Hemicryptophytes (H), Microphanerophytes (mp) and Therophytes (Th). In descending order, we have Hemicryptophytes (41.84%), Nanophanerophytes (34.05%), Microphanerophytes (11.66%), Therophytes (8.83%) and Chamephytes (3.62%). Fig. 4 shows the biological spectrum of the major weeds.

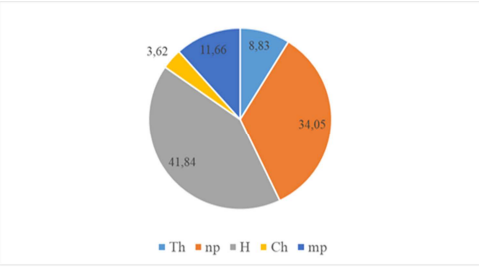

Fig. 4. Biological spectrum of weeds obtained in the study area

Discussion

Okra is grown by growers on small areas of between 1000 m² ha and 1.35 ha. Of these growers, 58 % farm an area of at least one hectare or more. This high proportion of farmers cultivating this type of area justifies the importance of this crop in the population's sources of income. In fact, in this region and practically in the major food-producing areas of Côte d'Ivoire, food crops are grown on fallow land and are one of the main income-generating activities for the population (Yapi, 2017).

In the study area, the technical itinerary for weed management is based on two methods of clearing and two methods of weeding. These are clearing or simple manual weeding and a combination of manual weeding and the use of herbicides. According to the farmers, manual weeding can be carried out with a machete alone or with a machete and a daba. These results corroborate those of Yapi (2017) in cassava and plantain crops. Moreover, the use of herbicides in field maintenance is always associated with machete weeding. The association of herbicide use with manual weeding with a machete could be explained not only by the fact that there is not a wide range of selective herbicides approved for this crop, but also by the fact that growers are unable to control the use of herbicides in weed management. This situation explains the heavy use of total herbicides before or just after sowing. Indeed, according to Ipou *et al.* (2016), the introduction of herbicide use in the

agricultural activities of producers in the central and southern part of Côte d'Ivoire began to gain momentum from 2010.

With regard to the composition of the weed flora, the study showed that four main botanical families contain the weeds that cause problems in okra cultivation. These are Poaceae, Fabaceae, Asteraceae and Euphorbiaceae. These four botanical families were cited by plantain and cassava growers as the main constraining weeds in south-eastern Côte d'Ivoire in the work of Yapi, (2017). The results of this study on the main weed families corroborate those of the work of Kouamé, (2014). Indeed, most species from these families proliferate rapidly by wind when they reach the fruiting stage. This explains their restrictive aspect. What's more, these species have a great aptitude for colonising cultivated environments. In addition, these four families are also on the list of major global weeds' cited by Akobundu (1987) and as major families in several crops in Côte d'Ivoire (Kouakou, 2016; Gue, 2017). Of these four families, Asteraceae and Poaceae are in the majority. The strong predominance of these two families could also be explained by the fact that okra is grown in open environments.

Species such as *Ageratum conyzoides, Chromolaena odorata, Croton hirtus, Centrosema pubescens, Imperata cylindrica, Panicum laxum* and *Panicum maximum* are the most frequently cited as being recurrent and difficult to control by all growers. The high frequency with which these species are cited could be explained by their early emergence, their ability to colonise the environment and their adaptation strategy. In addition, previous studies have shown that some of these species have a short reproductive cycle and are therefore insensitive to photoperiod. In terms of the spectrum of biological types, the study shows that Hemicryptophytes (41.84%) and Nanophanerophytes (34.05%) are the best represented.

These results partly corroborate the work of Touré (2009) on fallow land and cultivated plots in central-eastern Côte d'Ivoire. However, they are at odds with the work by Ipou (2005) in the cotton-growing zone in northern Côte d'Ivoire, and Kouamé (2014), in rice cultivation in central Côte d'Ivoire, where Hemicryptophytes are almost absent.

Conclusion

This study provided information on weed management techniques for okra cultivation in the Becouéfin sub-prefecture. This agronomic and weed science investigation made it possible to list sixteen (16) major weeds, including seven (7) of the most recurrent weed species. *Panicum maximum* (35.9%) and *Chromolaena odorata* (29.1%) are the most frequently cited constraining weeds. Asteraceae (37.5%) and Poaceae (25%) were among the four most frequently cited constraining weed families. The biological types most frequently encountered were Hemicryptophytes (42.03%) and Nanophanerophytes (33.33%). More than 68% of okra growers generally carry out three weeding operations, and 94.67% of them use chemical weeding combined with manual weeding during the crop cycle. The majority of herbicides used are total herbicides applied before or just after sowing okra. Insecticides are used by 67.33%.

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