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(RESEARCH ARTICLE)

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Influence of different post-emergence herbicides and crop varieties on weed flora diversity in maize (*Zea mays* L.) cultivation in Daloa (Central-Western Côte d'Ivoire)

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Abstract

Weeds are plants that are unwanted in a given situation and may be harmful, dangerous or economically detrimental. The objective of this study was to evaluate the impact of post-emergences herbicides and maize varieties associations on the diversity of weed flora in maize cultivation in Daloa with a view to improving weed management. The experimental design used to carry out this study was a Fisher block with three replicates. The dimensions of the unit plots were 5 m x 6 m. The treatments applied to the unit plots of the blocks were: T1 (Serenity 194 OD + Kabamanoj), T2 (Serenity 194 OD + Mastrop 143+), T3 (Monsoon Active 56.5 OD + DK818), T4 (Nicomaïs 40 OD + LG336), T5 (Monsoon Active 56.5 OD + DK7500) and T6 (Nicomaïs 40 OD + EV8728SR). The results showed that T5 plots were the least floristically diversified with the smallest numbers of aggressive and very aggressive weeds while the T6 plots were the most floristically diversified with the largest numbers of aggressive and very aggressive weeds. In addition, weed flora of plots T1 and T3 was similar to that of plots T5. Treatments T1, T3 and T5 therefore appear to be the most effective in controlling weed growth in maize cultivation in Daloa. They should therefore be prioritized in the establishment of maize cultivation in this locality in order to effectively control weed growth and increase maize production.

Keywords: Weeds; Post-Emergence Herbicide; Seed Varieties; Maize; Floristic Diversity; Côte d'Ivoire

1. Introduction

Maize, *Zea mays* L. (Poaceae), is one of the most widely cultivated cereals worldwide [1]. Native to Central America, it has become a staple food worldwide due to its versatility and high nutritional value [2]. It is the primary food source for billions of people and livestock feed [3].

In Côte d'Ivoire, maize is also one of the main food crops [4]. However, its production faces several constraints [5]. Small farmers, the largest producers of this cereal in this country, are sometimes faced with low productivity due to factors such as inadequate access to modern agricultural inputs, limited technical knowledge, biotic constraints and climate change [6].

In terms of biotic constraints, weeds severely reduce maize production by competing with it for vital resources such as light, water and nutrients [7], leading to a decrease in production and quality. They can also harbor diseases and other

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insects, which are also aggressive to the crop. Without an effective weed management method, maize yield losses can vary from 5% to 26% and even more than 80% [8].

In the Central West of Côte d'Ivoire, due to the lack of labor, producers are increasingly turning to herbicides, more specifically post-emergence herbicides [9]. In addition, they use traditional seeds for the establishment of this crop, while the plant material used in the establishment of the crop, as well as the weeding method, can influence the weeding [10].

This work aims to characterize the weed flora on an experimental site in Daloa and to evaluate the impact of various cultural practices on this flora.

2. Materials and Methods

2.1. Study Site

The study was carried out in 2024 on an experimental site at the Jean LOROUGNON GUÉDÉ University, in the department of Daloa (latitude 6° 53′ 00″ N and longitude 6° 27′ 00″W), capital of the Haut-Sassandra region, in the Central western Côte d'Ivoire (Figure 1). The soils of this department are ferralitic types [11]. Daloa is located in a region with a humid tropical climate and characterized by two seasons of unequal durations somewhat disrupted by current climate change [12]. These are, classically, a rainy season which runs from March to October and a dry season which begins in November and ends in February.

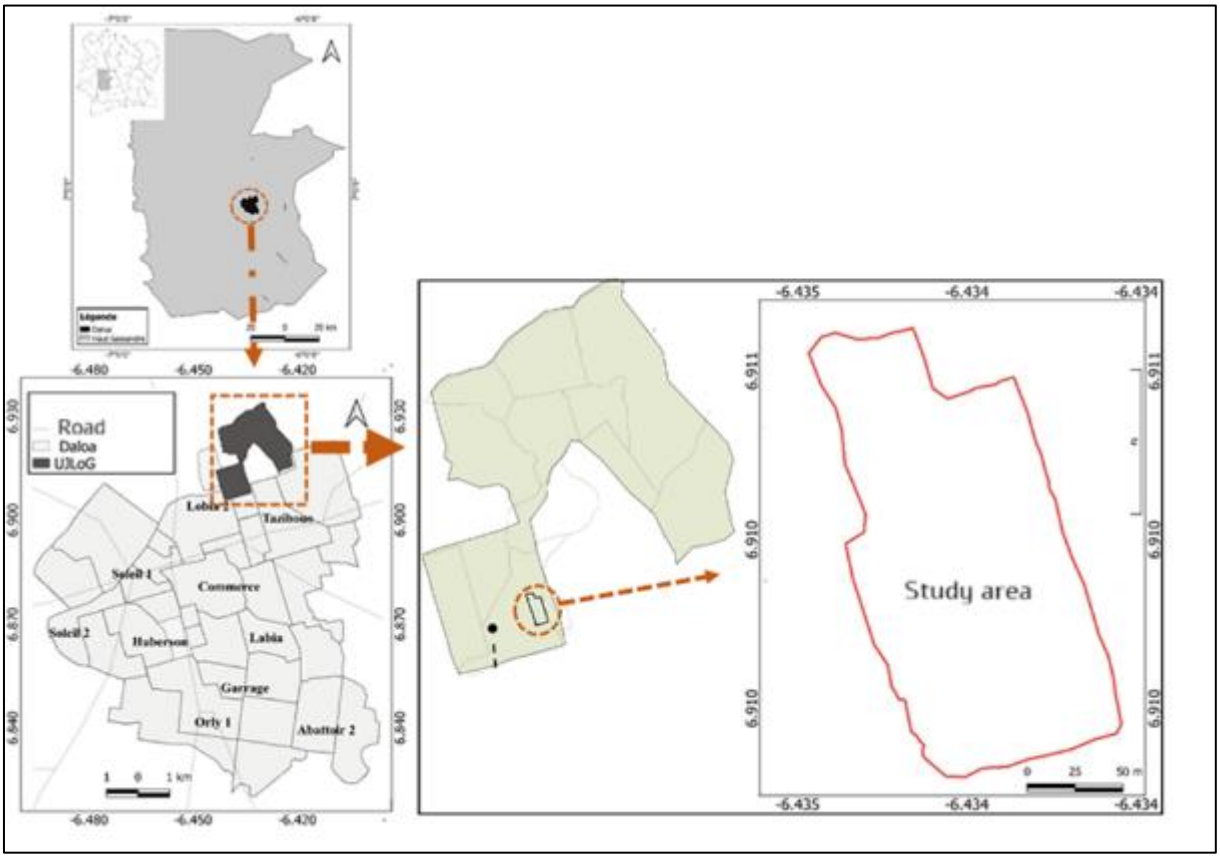

Figure 1 Study area

2.2. Treatments and experimental design

The effect of the combination of different maize varieties and post-emergence herbicides on weeds was evaluated in this study. The different treatments applied are shown in Table 1. The herbicides were applied two weeks after sowing the different maize varieties.

The experimental design used was a Fisher block design with three replicates. Within each block, the unit plots were 6 m x 5 m. Within the unit plots, the distance between two adjacent corn rows was 70 cm, and the distance between two adjacent corn plants in a row was 15 cm.

Table 1 Treatments applied to unit plots

Treatments	Post-emergence herbicides	Active ingredients	Applied doses	Maize varieties
T1	Serenity 194 OD	Nicosulfuron + Mesotrione + Amicarbazone	0.75 l/ha	Kabamanoj
T2	Serenity 194 OD	Nicosulfuron + Mesotrione + Amicarbazone	0.75 l/ha	Mastrop 143
T3	Monsoon Active 56.5 OD	Thiencarbazone-methyl + Foramsulfuron Sodium + Cyprosulfamide	1.5 l/ha	DK818
T4	Nicomaïs 40 OD	Nicosulfuron	1 l/ha	LG336
T5	Monsoon Active 56.5 OD	Thiencarbazone-methyl + Foramsulfuron Sodium + Cyprosulfamide	1.5 l/ha	DK7500
T6	Nicomaïs 40 OD	Nicosulfuron	1 l/ha	EV8728SR

2.3. Characterization of the weed flora

In order to characterize the weed flora of the experimental site, floristic surveys were carried out on the different elementary plots of the device at the end of the crop cycle. This work made it possible to establish the floristic list of weeds present on the experimental site and to determine the specific contribution of each weed inventoried.

The specific contribution (CIA) due to the frequency of a species is the translation of its contribution within a given plant formation. It is obtained by the ratio of the absolute frequency ($\boldsymbol{Fa_i}$) of the species, to the sum of the absolute frequencies ($\sum_1^n \boldsymbol{Fa_i}$) of all the species encountered, multiplied by 100:

$$\boldsymbol{Cs_i = Fa_i / \sum_1^n Fa_i . 100}$$

The Specific Contribution reflects the importance of species as follows [13]

- Cs less than 1%: less aggressive weeds;
- 1 ≤ Cs ≤ 4: aggressive weeds;
- Cs greater than 4: very aggressive.

2.4. Diversity of weed flora according to cultural practices

To assess the diversity of the weed flora in our experimental site according to the cultivation practices, the Shannon indices and Piélou equitability indices of the differently treated plots were calculated.

The formula for the Shannon index (H) is

$$H = -\sum_{i=1}^{S} \frac{n_i}{N} \log\left(\frac{n_i}{N}\right)$$

Were

- $\frac{n_i}{N} =$ proportional abundance or percentage importance of species i
- n_i = number of individuals of species i in the sample;
- N = total number of individuals of all species in the sample.

- S = number of species

Piélou equitability index (E) of [14] provides information on the distribution of individuals among the different species present in the environment. It measures the degree of diversity achieved by a population and corresponds to the ratio of observed diversity (H) to the maximum theoretical diversity (H*max*). Piélou's evenness or evenness index varies between 0 and 1. It tends towards 0 when almost all individuals correspond to a single species in the given environment (e.g., in the case of monoculture). It moves towards 1 when all species tend to be represented by the same number of individuals or the same overlap.

Piélou equitability index (E) is expressed in the following mathematical form

$$E = H/H_{max}$$

H_{max} = log(S) with S: the total number of species in the environment studied.

2.5. Floristic homogeneity of the treated plots

To assess the homogeneity of the plots taken two by two, we considered the Sorensen coefficient (Cs).

$$Cs = 2c/(a + b)$$

Cs represents the Sorensen similarity coefficient; c represents the total number of species that the two stations have in common; a represents the total number of species at station A and b the total number of species at station B.

The values of Cs vary between 0 and 100%. The more species the lists have in common, the more Cs tends towards 100%. The more different the two floristic lists are, the more the value of Cs tends towards 0. A plant formation is considered homogeneous if Cs is greater than or equal to 50% [15].

3. Results

3.1. Floral richness

Floristic surveys conducted at the experimental site identified 33 plant species. These were distributed among 27 genera and 13 botanical families, the most important of which were Fabaceae, Poaceae, Asteraceae, and Euphorbiaceae (Figure 2). Dicotyledons were the most abundant botanical class, representing 72.72% of the weeds at the experimental site, compared to 27.27% for monocotyledons (Figure 3).

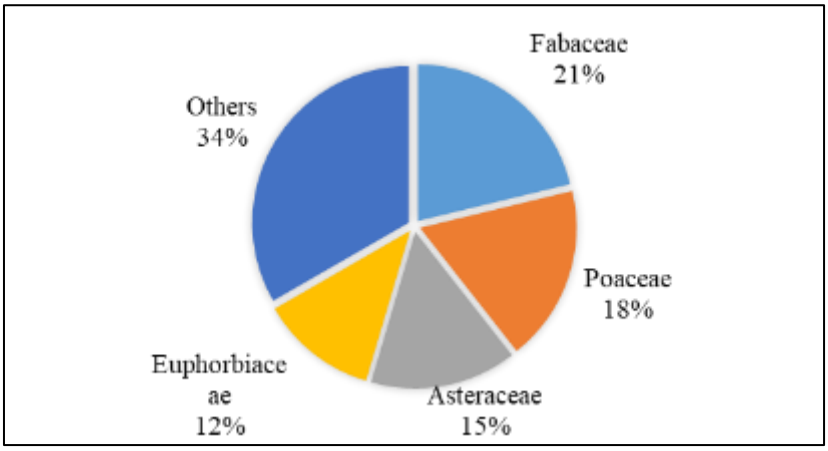

Figure 2 Botanical families of weeds in the experimental site

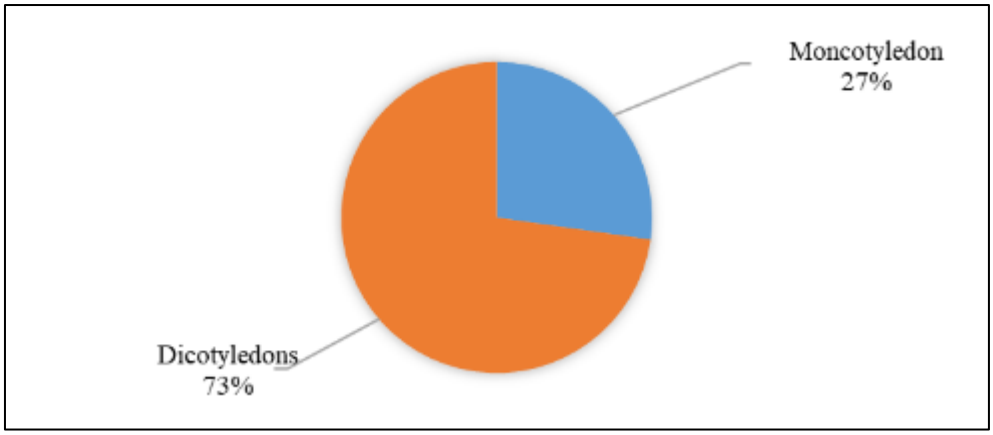

Figure 3 Botanical classes of weeds in the experimental site

3.2. Weed aggressiveness

Weed flora of the experimental site included 10 very aggressive species, 15 aggressive species, and eight less aggressive species at the end of the study (Table 2). The highest number of highly aggressive species in the experimental plot was observed on the unit plots receiving treatment T6 and the lowest on the unit plots T5 (Table 2; Figure 4).

Table 2 Aggressiveness of Weeds Encountered on the Experimental Site

N° Species	Families	Fa	Cs	Treatments					
				T1	T2	T3	T4	T5	T6
1 *Ageratum conizoides*	Asteraceae	2	1.32				*		*
2 *Antiaris toxicaria*	Moraceae	1	0.66						
3 *Bracharia lata*	Poaceae	7	4.64	*	*		*		*
4 *Caesalpinia mimosoides,*	Fabaceae	1	0.66	*					
5 *Centrosema pubescens*	Fabaceae	8	5.30		*	*	*	*	*
6 *Clerodendrum volubile*	Lamiaceae	2	1.32			*			
7 *Cnestis ferruginea*	Connaraceae	1	0.66			*			
8 *Commelina benghalensis*	Commelinaceae	2	1.32	*					
9 *Commelina diffusa*	Commelinaceae	1	0.66		*				*
10 *Croton hirtus*	Euphorbiaceae	18	11.92	*	*	*	*	*	*
11 *Desmodium ascendans*	Fabaceae	1	0.66		*				
12 *Desmodium tortuosum*	Fabaceae	8	5.30		*	*	*		*
13 *Desmodium velutinum*	Fabaceae	4	2.65	*				*	*
14 *Digitaria gayana*	Poaceae	6	3.97		*	*	*		
15 *Euphorbia heterophylla*	Euphorbiaceae	7	4.64	*	*	*		*	*
16 *Euphorbia hirta*	Euphorbiaceae	3	1.99			*			
17 *Ficus exasperata*	Moraceae	3	1.99	*	*	*			
18 *Flagellaria guineensis*	Flagellariaceae	1	0.66						*
19 *Mallotus oppositifolius*	Euphorbiaceae	5	3.31	*	*	*		*	
20 *Mezoneuron benthamianum*	Fabaceae	1	0.66			*			

21 *Mimosa pudica*	Fabaceae	8	5.30			*	*	*	*
22 *Mitracarpus scaber*	Rubiaceae	10	6.62	*	*	*	*		*
23 *Panicum maximum*	Poacae	5	3.31	*		*			*
24 *Paspalum scrobiculatum*	Poaceae	10	6.62	*	*	*	*	*	*
25 *Passiflora foetida*	Passifloraceae	6	3.97			*	*		*
26 *Pennisetum polystachion*	Poaceae	2	1.32	*	*				
27 *Porophyllum ruderale*	Asteraceae	1	0.66						*
28 *Rottboellia cochinchinensis*	Poaceae	5	3.31	*		*		*	*
29 *Sida acuta*	Malvaceae	2	1.32						*
30 *Spigelia anthelmia*	Loganiaceae	7	4.64	*	*		*	*	*
31 *Tridax procumbens*	Asteraceae	7	4.64	*	*		*		*
32 *Vernonia amygdalina*	Asteraceae	4	2.65				*		*
33 *Vernonia cinerea*	Asteraceae	2	1.32				*		*

Very aggressive weeds, Agressive weeds Less aggressive weeds * (Presence of a species)

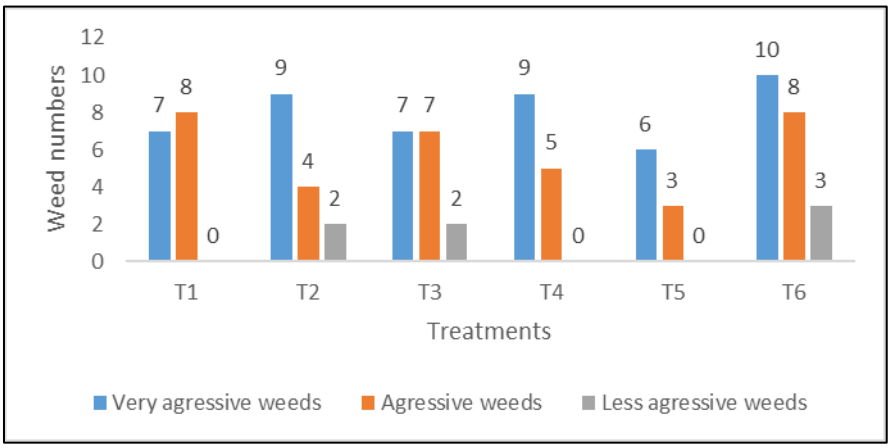

Figure 4 Number of weed categories according to the applied treatments

3.3. Floral diversity

In the present study, experimental plots that received the T6 treatment were characterized by the highest value of the Shannon index and those treated with T5 had the lowest value of this index (Figure 5), Regarding the Piélou equitability indices of the maize plots that received different treatments, they were very high and substantially equal overall, However, the highest values were observed for treatments T1, T3, T4 and T6 (approximately 0,97) against lower indices for treatments T2 and T5 (Figure 6),

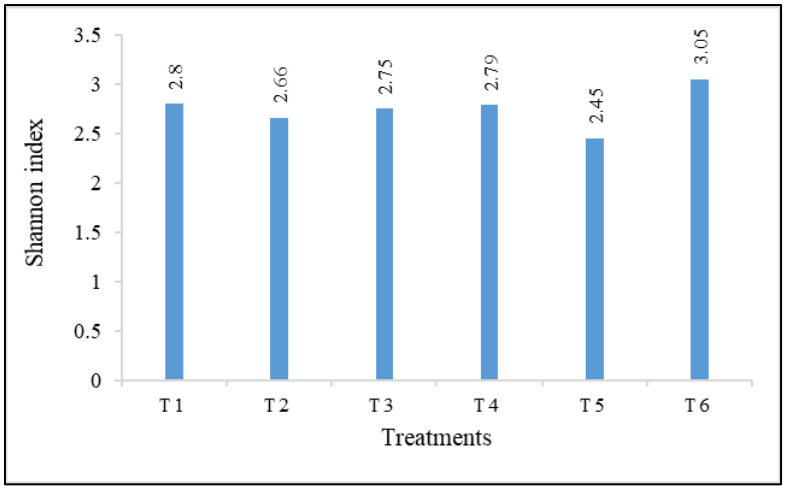

Figure 5 Shannon Indices of Plots Having Received Different Treatments

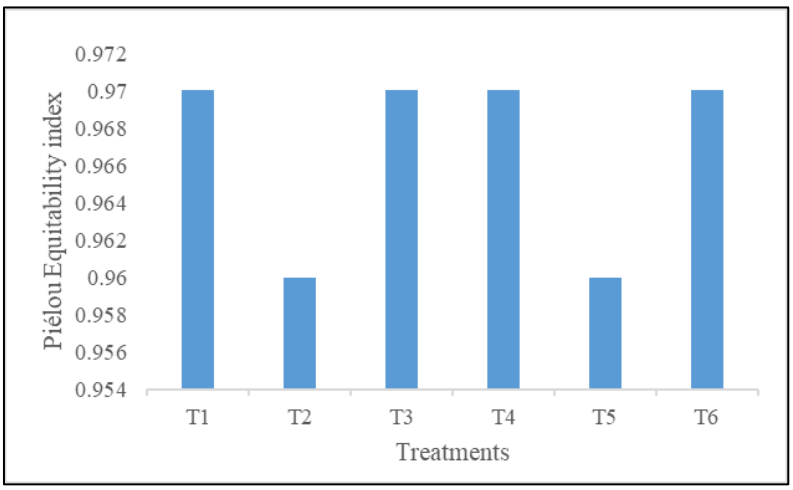

Figure 6 Piélou Equitability indices of the plots

3.4. Homogeneity of the weed flora of the treated plots

Sörensen similarity coefficient was used to evaluate the similarity of the weed communities of the experimental site (Table 3), When analyzing these weed communities in corn cultivation, modified by the different herbicides applied and corn crop varieties sown, it was observed that the greatest similarities were noted between the flora of the following pairs of plots (Table 3): T1 and T2, T1 and T5, T2 and T3, T3 and T5, T3 and T6 and T4 and T6,

Table 3 Homogeneity of the weed flora of the plots treated differently

	T1	T2	T3	T4	T5	T6
T1	-					
T2	78,78	-				
T3	42,42	70,58	-			
T4	46,66	25,8	45,16	-		
T5	57,14	48,26	62,02	38,46	-	
T6	47,36	41,01	56,4	61, 1	35,3	-

Two plots with a Sörensen similarity coefficient equal to or greater than 50% are floristically homogeneous,

4. Discussion

A little more than three dozen weeds were inventoried across the entire experimental site in the Daloa Department, This number is well below the number of weeds identified by [16] during an inventory of maize crops in the same locality, Indeed, they identified more than a hundred weeds, The difference between these two results is linked to the fact that the present work was carried out at the plot scale while that of [17] was carried out at the regional level,

At the level of the weed flora identified during this work, Fabaceae, Poaceae, Asteraceae and Euphorbiaceae are the most dominant botanical families, These botanical families are among the 10 most common weed families found in an agro-ecosystem across the world [18],

At the botanical class level, dicotyledons predominated in the list of weeds identified on the study site, [18] and [19] noted similar results in their respective works, Indeed, the majority of weeds in the intertropical region of Africa come from Dicotyledons, This dominance of Dicotyledons was also reported in the research of [20] Boraud (2000) on sugarcane crops, [21] for pineapple and [18] in corn crops,

During this study, the greatest number of highly aggressive and aggressive weeds and the most diverse weed flora were observed on the plots that received the T6 treatment, while the smallest number of highly aggressive and aggressive weeds and the least diverse weed flora were observed on the T5 plots, The T6 treatment is therefore the least effective in the study and T5, the most effective treatment, The effectiveness of the T5 treatment could be linked to the fact that it consists of a combination of three active ingredients of post-emergence herbicides and very effective plant material, Indeed, if one of the active ingredients of the T5 treatment is ineffective against a given weed on the experimental site, the other two remaining or one of them can eliminate it,

The ineffectiveness of the T6 treatment could be due to the fact that it consists of only one herbicide, Therefore, any weeds in the T6 plots that escape the control of this single herbicide remain present in that plot,

It was also observed that the weed flora in the T6 plots was more diverse than that in the T4 plots, even though both T6 and T4 treatments contained the same herbicide, nicosulfuron, In addition, the T6 plots had more aggressive and very aggressive weeds than the T4 plots, The difference between these two treatments can be explained by the fact that the plant material in the T6 treatment was less effective than that in the T4 treatment in competing with weeds for space, light, water, and soil nutrients,

5. Conclusion

The objective of this study was to evaluate the impact of post-emergence herbicide and maize variety associations on the diversity of weed flora in maize cultivation in the Department of Daloa (Central-West of Côte d'Ivoire) with a view to improving weed management in this crop and increasing maize grain production,

The experimental design used to carry out this work is a Fisher block with three replicates, The dimensions of the unit plots were 5 m x 6 m, The treatments applied to the unit plots of each block were: Serenity 194 OD + Kabamanoj, Serenity 194 OD + Mastrop 143+, Monsoon Active 56,5 OD + DK818), Nicomais 40 OD + LG33, Monsoon active 56,5 OD + DK7500 maize variety and Nicomaïs 40 OD + EV8728SR,

It appears from this work that the plots that received the herbicide Monsoon active 56,5 OD and the corn variety DK7500 are floristically the least diverse with the smallest numbers of aggressive and very aggressive weeds in the experimental site while the plots to which Nicomaïs 40 OD was applied and on which the corn variety EV8728SR was sown are the most floristically diverse with the largest numbers of aggressive and very aggressive weeds, In addition, the weed flora of the plots that received the associations Serenity 194 OD and Kabamanoj and Monsoon Active 56,5 OD and DK818 was similar to those treated with the association Monsoon active 56,5 OD and the corn variety DK7500, The associations “Serenity 194 OD + Kabamanoj”, “Monsoon Active 56,5 OD + DK818” and “Monsoon active 56,5 OD + DK7500” must therefore be prioritized in the establishment of corn plots in the Department of Daloa in order to effectively combat weeds and increase grain corn production,

Acknowledgments: Thanks to Bayer West-Central Africa S,A,, for supporting these experimental trials by providing maize seeds and herbicides for the implementation of this work,

Compliance with ethical standards

Disclosure of conflict of interest

Disclosure of conflict of interest No conflict of interest to be disclosed,

Statement of informed consent

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

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