Floristic Inventory and Evaluation of the Effectiveness of Three Herbicides in South Gabon Olive Farms

Samson Daudet Medza-Mve
Department of Phytotechnologie
Université des Sciences et Techniques de Masuku, Institute National Supérieur d'Agronomie et de Biotechnologie

Ayoni Ogunbayo
Department of Phytotechnologie
Country Project Manager Regional Hub, West and Central Africa, BP 320, Bamako-Mali

Julie Dumortier
Department of Phytotechnologie
Université des Sciences et Techniques de Masuku, Institut National Supérieur d'Agronomie et de Biotechnologie

André Toussaint
Department of Phytotechnologie
Université de Liège, Gembloux Agro-Bio Tech, 2 Passage des Déportés, 5030 Gembloux-Belgique

Maurice Ognalaga
Department of Phytotechnologie
Université des Sciences et Techniques de Masuku, Institut National Supérieur d'Agronomie et de Biotechnologie

Abstract

This study was carried out on the site of oil palm agro-industrial exploitation in South-East Gabon. The aim was to evaluate effectiveness of three herbicides: Roundup (glyphosate), Finish (c) and Ally (metsulfuron methyl) on the weed flora. An inventory weed flora was conducted to estimate abundance-dominance, post-treatment patch coverage, weed recurrence time, and the optimal herbicide application rate. The results obtained show that the weed flora is composed of 22 dominant species, divided into 20 genera and 15 families. The three predominance families are Rubiaceae, Poaceae and Cyperaceae. A mixture of two herbicides, specifically Finish Ally (glyphosate-metsulfuron methyl and metsulfuron methyl), is the most effective, with 85% of weeds eliminated by day 30 and 74 days of recurrence.

Keywords- Glyphosate, Methyl Metsulfuron, Oil Palm, Weeds

I. INTRODUCTION

The control of weeds is a major challenge to ensure the sustainability and profitability of agro-industrial plantations. It is therefore necessary to develop efficient and inexpensive control strategies [1]. The industrial plantations in Olam Gabon aren't exception. They are located in southern Gabon in Ngounié province. The site covers an area of 15,884 hectares of oil palm trees. Several control strategies are used to control unwanted flora in these oil palm plantations ranging from manual weeding, soil cover or mulching, and chemical control through the use of herbicides. Many authors [2]) note that weeds affect oil palm yields and crop quality. Chemical control has been recognized as an economically viable agriscultural practice in industrial oil palm plantations. Objective of this study is to carry out an exhaustive inventory the flora of Olam-Gabon and to evaluate the effect of three herbicides namely Roundup (glyphosate), Finish (glyphosate 360 g / l) and Ally (metsulfuron methyl) used by this company, when applied singly or in combination, to determine the best treatment that can reduce weed population.

II. MATERIALS AND METHODS

A. Study Area

The study was conducted in agro-industrial plantation of Olam-Gabon multinational in southern Gabon (geographical coordinates 1° 52'06 " South latitude and 11 ° 03'21 East longitude). The equatorial climate is marked by two seasons of heavy precipitation (March-May and September-December) and two seasons with less rainfall (June-August and January-February). The average annual rainfall is 1,700 mm. The average annual temperature is around 26ºC. Temperature peaks occur from February to April while minima are observed in July-August. The dominant soils are ferralitic facies with yellow facies, where all elements of the bedrock are hydrolysed and most of the bases exported. Generally, soils have low chemicalproperty, but their physical characteristics are in order and the clay contents are sufficient.

The [3] method was used for weed identification and counting. Linear transects oriented in different directions and intersecting different topographical situations have been defined at random. The area of the plots varied from 25 to 100 m^2. Eight

(8) transect surveys were conducted and the operation was repeated four (4) times at random. The collected specimens were determined from bibliographic support: Flora of Gabon [4] Practical determination of 14 rubiaceae, weeds from West and Central Africa [5]. The indices of abundance-dominance are based on the Braun Blanquet scale modified by [4] consisting of five levels. The assay was conducted according to a randomized Fisher Block, 4 replications and 4 treatments.

The treatments applied consist of different combinations of the three types of herbicides dissolved in 16 litres of water (Table 1).

Table 1: Composition of the treatments (diluted in 16 litres of water)

Treatments	*Roundup*	*Roundup + Ally*	*Finish*	*Finish +Ally*
Composition	*$T1_R$: 2.05 g/L*	*$T\ 5_{RA}$: 2.05 g/l +3.34 g/l*	*$T9_F$: 1.8 g/l*	*$T\ 13_{FA}$: 1.8 g/l + 3.34 g/l*
	$T\ 2_R$: 2.56 g/l	*$T6_{RA}$: 2.56g/l + 4.2 g/l*	*$T\ 10_F$: 2.25 g/l*	*$T\ 14_{FA}$: 2.25 g/l + 4.2 g/l*
	$T\ 3_R$: 3.08 g/l	*$T\ 7_{RA}$: 3.08 g/l + 5 g/l*	*$T\ 11_F$: 2.7 g/l*	*$T15_{FA}$: 2.7 g/l + 5 g/l*
	$T\ 4_R$: 3.84 g/L	*$T\ 8_{RA}$: 3.84 g/l + 6.25 g /l*	*$T\ 12_F$: 3.37 g/l*	*$T16_{FA}$: 3.4 g/l + 6.25 g/l*

R: Roundup; RA : Roundup+Ally ; F : Finish ; FA: Finish+Ally

The effect of different herbicidal treatments at different levels of concentration on weeds was estimated on abundance-dominance, treatment efficacy, weed re-establishment time, and recovery rate after treatment.

B. Visual Estimation of Abundance Dominance

Combined effect of three herbicides on weeds at different concentration levels was based on abundance-dominance, with enumeration and daily weed identification in 100-square-meter plots. The Braun Blanquet overlap, modified by [4] was used for the survey of weed populations. It contains 5 coefficients of abundance-dominance, the subjective frequency of which ranges from 4 (very abundant) to + very rare). The floristic diversity was then expressed by calculating the Shannon index (H ') which expressed the floristic diversity by taking into account the number of species and abundance of individuals within each of these species and the index of' [6] equality which measures the distribution of individuals within species, irrespective of species population.

$$H' = \Sigma\ (Ni / N)\ x \log\ (Ni / N)$$

With Ni the number of individuals of a given species and N the total number of individuals

$$E = H' / H'max \text{ with } H'max = \log 2\ N$$

N is the total number of species. Its value is between 0 and 1.

Weeds density per unit area (m^2) was determined by counting the dominant weeds in 128 $1m^2$/ plots ten days before treatment. Herbicide treatments were then carried out on 128 plots to evaluate the effectiveness of herbicide combinations. The control plots were adjacent to those receiving treatments in mid-September.

C. Observations

The effectiveness of the treatment was evaluated by counting every fortnight, on new plants that reappear. It is determined by the formula of [7].

$$\%\ efficacité = (1-(Ta\ .Cb)/(Ca\ .Tb))x\ 100$$

Ta: infestation of the treated plot on the day of observation;
Tb: infestation of the treated plot before application of the product;
Ca: infestation of the control plot before the start of the test;
Cb: infestation of the control plot on the day of observation.

The efficacy was evaluated according to the rating scale of European Weeds Research Council, based on percentage efficacy, noted from 1 to 9. The time for reappearance of weeds was determined by realizing a passage every fortnight in the field after treatments to check the appearance or not weeds. The recovery rate after treatment was determined as soon as the weeds first appear, by estimating percentage of the size of recovery in the plots. The passage interval is 15 days over a period of three months.

D. Data Analysis

Analysis on herbicide efficacy, weed reappearance, abundance-dominance, and recovery rate were performed using software R. The Newman-Keuls test at the 5% threshold was used to separate the mean. Results and discussion.

1) Results

The floristic analysis resulted in the identification of twenty-two species of dominant weeds, distributed in twenty genera and fifteen families, with variable frequencies (Table 2). According to these floristic surveys carried out, there are 22 species in the industrial estates of south-east Gabon.

Table 2: Species occurrence and their abundance-dominance in the Olam-Gabon palm plantation

Species	*Botanical Class*	*Family Botanical*	*Frequency(%)*	*IAD*	*Appreciation*
Borreria latifolia	*Dicotyledon*	*Rubiaceae*	*27,5*	*3*	*Very abundant*
Spermacoce genus	*Dicotyledon*	*Rubiaceae*	*7,49*	*2*	*Very abundant*
Marantochloa purpurea	*Dicotyledon*	*Marantaceae*	*1,66*	*1*	*Low density*

Calathea ornata	*Dicotyledon*	*Marantaceae*	*0,21*	*+*	*Very rare species*
Aframomum ou faux gingembre	*Dicotyledon*	*Zingiberaceae*	*0,53*	*+*	*Very rare species*
Macaranga sp	*Dicotyledon*	*Euphorbiaceae*	*0,49*	*+*	*Very rare species*
Dissotis rotundifolia	*Dicotyledon*	*Melastomataceae*	*0,22*	*+*	*Very rare species*
Mikania micrantha	*Dicotyledon*	*Asteraceae*	*3,22*	*1*	*Low density*
Costus afer ker	*Dicotyledon*	*Costaceae*	*0,24*	*+*	*Very rare species*
Euphorbia hyssopifolia	*Dicotyledon*	*Euphorbiaceae*	*3,68*	*1*	*Low density*
Panicum maximum	*Monocotyledon*	*Poaceae*	*0,14*	*+*	*Espèce très rare*
Paspalum conjugatum	*Monocotyledon*	*Poaceae*	*14,42*	*2*	*Very abundant*
Centotheca Iappacea	*Monocotyledon*	*Poaceae*	*3,71*	*1*	*Low density*
Hyparrhenia involucrata	*Monocotyledon*	*Poaceae*	*8,18*	*2*	*Very abundant*
Eleusine indica	*Monocotyledon*	*Poaceae*	*1,39*	*1*	*Low density*
Cyperus esculentus	*Monocotyledon*	*Cyperaceae*	*0,07*	*+*	*Very rare species*
Carex muskingumensis	*Monocotyledon*	*Cyperaceae*	*11,48*	*2*	*Very abundant*
Nephrolepis biserrata	*Ptéridophyte*	*Dryopteridaceae*	*0,55*	*+*	*Very rare species*
Pityrogramma calomelanos	*Ptéridophyte*	*Adianthaceae*	*1,95*	*1*	*Low density*
Lycopodium sp	*Ptéridophyte*	*Lycopodiaceae*	*10,98*	*2*	*Very abundant*
Diplazium sammatii	*Ptéridophyte*	*Athyriaceae*	*0,6*	*+*	*Very rare species*
Ctenitis protensa	*Ptéridophyte*	*Aspidiacieae*	*1,29*	*1*	*Low density*

ADI: abundance-dominance indice

Table 2 shows that species Borreria latifolia is the most abundant species and has a frequency of 27.5%, Cyperus esculentus is the least abundant species with almost 0.07% in our study area. The most common families are Rubiaceae, Poaceae, Cyperaceae and Lycopodiaceae with 34.99, 27.81, 11.55 and 10.98%, respectively.

Among the indices of abundance-dominance obtained, no species is present with a high density. Borreria latifolia has the highest index of 3. On the distribution of species according to the major taxonomic levels, Figure 1 shows the presence of dicotyledons, monocotyledons and pteridophytes in different proportions. Dicotyledons dominate the landscape with 45% frequency. These dicotyledons are divided into ten species, eight families and ten genera. Monocotyledons represent 40% of the taxa distributed in two families, six genera and seven species. Pteridophytes constitute 15% this flora with five species, five genera and five families.

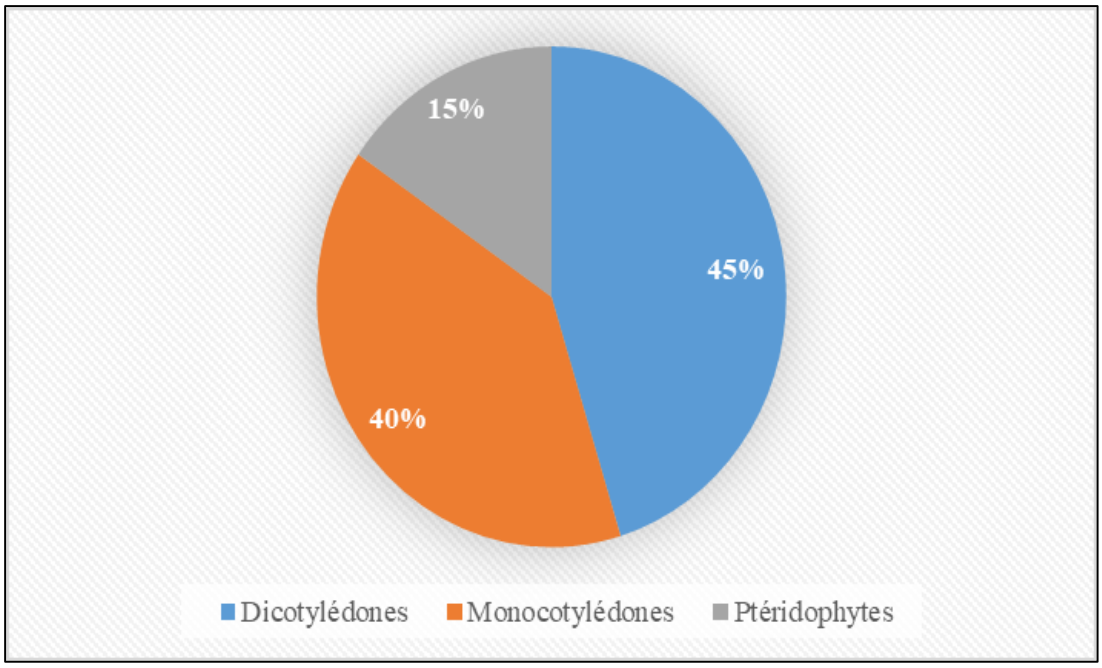

Fig. 1: Distribution Species

Shannon index is 1.04 indicating there is no particular dominance of a species or small group species on the entire weed community of plantation. This corroborates the fact that the species most encountered Borreria latifolia has a frequency of 27.5%. The equitability index is 0.58. This implies that there is a diversity of species, although some of these species are less representative.

The effectiveness of treatments consisting different combinations of herbicides on adventitious flora was determined on scale of European Weeds Research Council and illustrated in Table 3 which shows the effectiveness of the treatments up to the optimum of their effective on the thirtieth day.

Table 3: Treatment efficacy according to the European Weeds Research Council (EWR)

Number of days after treatments	*Herbicide mixture*	*Doses (ml)*	*Efficiency (%)*	*Note*	*Appreciation*
15 Days	*Roundup*	*T1*	*7,57*	*9*	*very low to zero*
		T2	*2,68*	*9*	*very low to zero*
		T3	*5,54*	*9*	*very low to zero*
		T4	*4,57*	*9*	*very low to zero*
	Roundup + Ally	*T5*	*4,55*	*9*	*very low to zero*
		T6	*3,63*	*9*	*very low to zero*
		T7	*4,96*	*9*	*very low to zero*
		T8	*3,18*	*9*	*very low to zero*
	Finish	*T9*	*2,79*	*9*	*very low to zero*
		T10	*5,50*	*9*	*very low to zero*
		T11	*4,37*	*9*	*very low to zero*
		T12	*5,52*	*9*	*very low to zero*
	Finish + Ally	*T13*	*2,95*	*9*	*very low to zero*
		T14	*3,82*	*9*	*very low to zero*
		T15	*7,56*	*9*	*very low to zero*
		T16	*4,91*	*9*	*very low to zero*
30 Days	*Roundup*	*$T1_R$*	*26,36*	*9*	*very low to zero*
		$T2_R$	*27*	*9*	*very low to zero*
		$T3_R$	*29,2*	*9*	*very low to zero*
		$T4_R$	*26,47*	*9*	*very low to zero*
	Roundup + Ally	*$T5_{RA}$*	*73,42*	*6*	*Moderate*
		$T6_{RA}$	*76,97*	*6*	*Moderate*
		$T7_{RA}$	*50,39*	*8*	*Very low*
		$T8_{RA}$	*75,88*	*6*	*Moderate*
	Finish	*$T9_F$*	*63,57*	*7*	*Low*
		$T10_F$	*66,43*	*7*	*Low*
		$T11_F$	*85,43*	*5*	*Acceptable*
		$T12_F$	*73,11*	*6*	*Moderate*
	Finish + Ally	*$T13_{FA}$*	*95,87*	*3*	*Good to very good*
		$T14_{FA}$	*88,13*	*5*	*Acceptable*
		$T15_{FA}$	*96,64*	*3*	*Good to very good*
		$T16_{FA}$	*90,54*	*4*	*Good*

T_R: treatment Roundup; T_{RA} : treatment (Roundup+Ally) ; T_F : treatment Finish ; T_{FA}: treatment (Finish+Ally)

Efficacy differs from one treatment to another, whether the herbicide is applied alone or in combination (table 3). The most effective treatments are, T6RA T11F and T16FA, their efficacy was above 70%. The Roudup used alone, treatment T3 R, reaches only 29.2% efficiency on the thirtieth day. Figure 2 illustrates the evolution of this average effectiveness of each treatment two months after application.

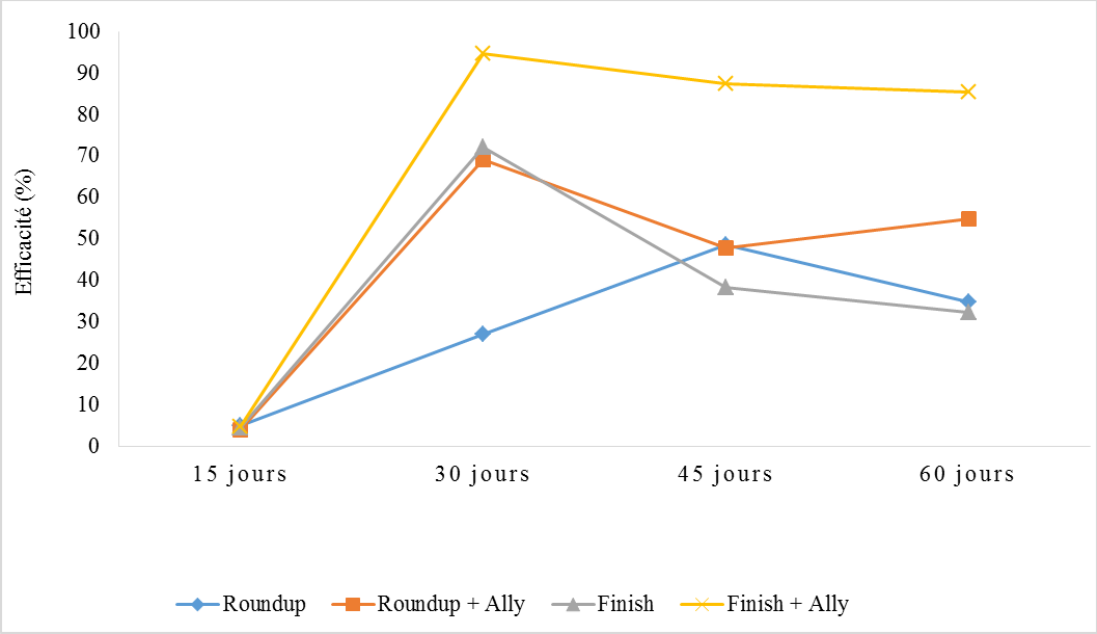

Fig. 2: Evolution of efficacy of best herbicide treatments alone or in combination with time

Four best proven treatments have the same efficacy first 15 days after application. Beyond the first fortnight, this effectiveness varies and all the treatments reach their optimal efficiency on the thirtieth day, with the exception of the Roundup whose optimal was at 60 days. The Finish-Ally combination has best efficiency compared to the others, it is of the order of 94%. As for the Finish and Roundup finish, their efficiency remains moderate at around 70%. The lowest efficiency is obtained with the use of Roundup, only 27%.

Table 4 shows the average time of weed reappearance on treated plots. It varies from 69 ± 16.75 (T11R) days on the Roundup treated plots to 74 ± 13.75 days (T16FA) for receiving a Finish-Ally solution.

Table 4: variance of weed reoccurrence time

Mixtures	*Averages with standard deviation*
T11 : Finish	*69^a ±17,25*
T16 : Finish + Ally	*74^a ±13,75*
T3 : Roundup	*69^a ±16,75*
T6 : Roundup + Ally	*69^a ±17,25*

The weed recovery was later on the plots treated with a mixture of Finish and Ally (glyphosate 3.40 g / l and methyl metsulferon 6.25 g / l). Weeds therefore reappear between two months and two and a half months for all treatments. After 90 days, the plots were treated with T3R, T6RA and T11F and reached a recovery rate of the other treatments with a recovery rate of 90% and 100% against (71%) for T16FA.

2) Discussion

The floristic inventory revealed that dicotyledons dominate agroindustrial plantations. These results corroborate the observations made by [8] on adventitious populations of lowland Ivory Coast and Gulf of Guinea dominated by dicotyledons. These authors have also shown that there was great floristic diversity in these agroecological zones, with a strong presence of Poaceae, Asteraceae, Cyperaceae, Euphorbiaceae, Rubiaceae, Fabaceae and Malvaceae. This was justified by Shannon 1.04 and Equitability 0.58 indices, which showed that there was a dominant group of individuals within total population. This dominance of three families could be explained by the fact that they are species of undergrowth and shade imposed palm crown does not favor the development of heliophilic plants. As observed by [9], quarterly flaking of oil palm interlining would deprive some taxa of a seed stock that would allow their spread.

The efficacy of all herbicide treatments tested remains low (5%) after two weeks. This may be justified by the fact that the molecules of herbicides used alone or in combination, especially glyphosate and metsulferon, have a systemic action. Therefore, their effect on weeds is slow. The active molecules take the phloemic path to reach all the organs. The same observations were made by [10] on the action of sulfonylureas, including glyphosate and methyle metsulferon. Their action on weeds was slow to develop with visible effects, including the onset of yellowing, two weeks after treatment, and total near weed control between 21 to 30 days.

Metsulfuron-methyl was absorbed by systemic action such as glyphosate, it inhibits acetolactate synthase, causing cell division to stop and thus to stop growth [11]. There was a process of dieback that can extend over several weeks, and some weeds species may even become nanogenous. Metsulfuron methyl helps destroy the roots that bring water and mineral salts to the plant. It penetrates the plant by the leaves as well the roots. Once absorbed by plant, the reduced ions of glyphosate bind to enzyme enolpyruvylshikimate-3-phosphate synthase (ESP) and blocks its activity. ESP is a precursor aromatic amino acids and, ultimately, hormones, vitamins and other essential plant metabolites. This inhibition enzyme of biosynthesis pathway of aromatic amino acids, thus affects the growth of plants. These two active ingredients of metsulfuron methyl and glyphosate, which inhibit the synthesis enzymes essential for plant growth, lead to their gradual disappearance and justify the efficacy of Finish treatment (glyphosate 360 mg / l and metsulferon methyl-600 g / l) -Ally (métsulferon métyl 600g / l).

The low effectiveness of Roundup and Finish treatments alone could be explained by the fact that these herbicides have been used frequently for nearly 5 years at these sites, which may have resulted in resistance or mutations in some weed species. [12] Also observed this phenomenon of resistance on Lolium rigidum in plots frequently treated with glyphosate. Significant reductions in efficiencies at 45th and 60th day after treatments for Finish, Roundup and Roundup-Ally mixtures could also be related to the release of new weed flora. Recovery of weeds and recolonization medium from the seed stock in the soil are often recorded after a 45-day glyphosate treatment [13].

The reappearance weeds are less than three months because of the degradation of polyoxyethylene amine (POEA), an anionic surfactant associated with glyphosate in its formulation to promote its penetration. Biodegradation of POEA is progressive [14]. Studies carried out by Monsanto have shown that half-life of POEA is less than one week, dissipation time of 50% of the residues is about 4 weeks and that more than 90% of the residues disappeared after 14 weeks under pH conditions varying from 4.6 to 7.8 [15] demonstrated that glyphosate residues reached their peak in the raspberry foliage after three weeks treatment and then declined rapidly within five weeks, with the product reaching the phloem going directly to the roots.

The variation over the recovery time observed between first three treatments and Finish-Ally could be explained initially by phloem system of sulfonylureas which moves the active substances towards the "well" zones. This system plays a distinct role depending on species and development stage in the expression herbicide ephytotoxicity [16]. In a second step, the Finish-Ally treatment contains a high amount of both metsulfuron methyl and glyphosate. These two sulfonylurea molecules have an acidic character and the anions resulting from their dissociation have a certain solubility in the lipids. This solubility allows them to cross the biological membranes that separate the phloem from the xylem. The acidity of the xylem and the

alkalinity of the phloem thus lead to an accumulation of herbicidal ions in the latter, where they are retained because of the impermeability of the biological membranes of its anion. As a result, the herbicide migrates mainly to phloem, where it accumulates in large quantities but is not completely retained [15]. The anions of the two sulfonylurea active ingredients will then be slowly diffused to inhibit amino acid synthesis in the weed propagation organs (roots, stolons, bulbs, rhizomes and seed stock) thus delaying regeneration vegetative weeds.

III. CONCLUSION

Weeds constitute a real scourge in palm oil plantations and their control would contribute to increase the yields of this essential plant for the company Olam Gabon qualitatively and quantitatively. The results show that the olive-growing agrosystems of South-East Gabon are composed mainly of twenty-two species of dominant weeds distributed in twenty genera and fifteen families. The dominant families are the Rubiaceae, Poaceae and Cyperaceae. Finish-Ally treatment achieved the best with acceptable efficacy, more than 85% at day 30, with weed re-emergence at day 74. However, the herbicides used (glyphosate) are not without consequence on the environment, hence the need to advocate a treatment integrating other weed control methods, also to avoid problems of resistance.

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