H

EGYPTIAN ACADEMIC JOURNAL OF
BIOLOGICAL SCIENCES
BOTANY

ISSN 2090-3812

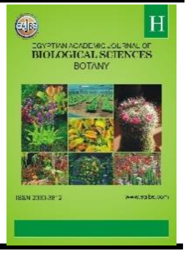
www.eajbs.com

Vol. 14 No.1 (2023)

Citation: Egypt. *Acad. J. Biolog. Sci.* (H. Botany) *Vol.14(1) pp81-90(2023)*
DOI: 10.21608/EAJBSH.2023.299254

Egypt. Acad. Journal Biology. Sci., 14(1):81-90(2023)

Egyptian Academic Journal of Biological Sciences
H. Botany
ISSN 2090-3812
www.eajbsh.journals.ekb.eg.



Vegetative Propagation of *Hallea stipulosa* (DC.) J.-F.Leroy (Rubiaceae) in The Bioclimatic Conditions of Gemena in South Ubangi, Democratic Republic of the Congo

Darly N. Mboka[1], Nathan F. N. U. Nyongombe[2], Nicodème K. Ndomba[2], Bienvenu S. Yange[1], Jean-Bernard Z. Bosanza[1], Monizi Mawunu[3], Colette Masengo Ashande[4], Narcisse B. Basosila[5] and Koto-Te-Nyiwa Ngbolua[5, *]

[1] High School of Agricultural studies of Bokonzi, P.O. Box 67 Gemena, Democratic Republic of the Congo.
[2] Faculty of Agricultural Sciences, National Pedagogical University, P.O. Box 8815 Kinshasa-Ngaliema, Democratic Republic of the Congo.
[3] Department of Agronomy & Botanical Garden, Kimpa Vita University, P.O. Box 77 Uíge, Republic of Angola.
[4] Department of Environment, Faculty of Science, University of Gbado-Lite, P.O. Box 111 Gbado-Lite, Democratic Republic of the Congo.
[5] Department of Biology, Faculty of Science, University of Kinshasa, P.O. Box 190 Kinshasa XI, Democratic Republic of the Congo.

***E-mail:** jpngbolua@unikin.ac.cd

ARTICLE INFO
Article History
Received:5/4/2023
Accepted:6/5/2023
Available:12/5/2023

***Keywords*:**
Wetlands, *Hallea stipulosa*, Vegetative propagation, Productive ecosystem, Ramsar Convention, Democratic Republic of the Congo.

ABSTRACT

The aim of this study was to evaluate the rate of regrowth of *Hallea stipulosa* cuttings on different substrates by vegetative means, a hydrophytic species of the Mombonga and Labo rivers in Gemena (South Ubangi) in the Democratic Republic of the Congo (DRC). To collect the data a randomized experimental design consisting of four treatments was used, namely: T_0 (hydromorphic soil); T_1 (dry land soil + potting soil), T_2 (hydromorphic soil + potting soil), T_3 (dry land soil + dirt) and T_4 (sawdust + hydromorphic soil). The study showed that the regrowth rate was 100% six weeks after the experiment while the survival rate was constant for all treatments applied. T_3 (dry land soil + dirt) had a survival rate of 100% followed by T_4 (sawdust + hydromorphic soil) with 88.9%. The substrates T_0, T_1 and T_2 yielded 77.8%. The survival rate of the seedlings from the 2nd to the 5th week after taking over the cuttings showed a statistically significant difference between the treatments applied ($p<0.05$). With a survival rate of 88.9%, the average of T_4 (sawdust + hydromorphic soil) straddles the gap between these two groups and does not show a significant difference with all treatments. The T_3 and T_4 substrates (sawdust + hydromorphic soil) thus shorten the duration of cuttings for this plant species. Thus, the domestication of this multifunctional plant can reduce human pressure on natural forests while improving the lives of local communities by creating a productive ecosystem.

Citation: Egypt. *Acad. J. Biolog. Sci.* (H. Botany) *Vol.14(1) pp81-90(2023)*
DOI: 10.21608/EAJBSH.2023.299254

INTRODUCTION

Vegetation is the set of plants that grow in a given place according to their nature. It plays a major role in the production and protection of soil and humus, in the production of oxygen, as a bio-indicator and in the carbon cycle (Trochain, 1980). In wetlands, the role of vegetation, in general, and trees in particular, is significant for water management, bank stabilisation, erosion control as well as fisheries maintenance and habitat for biodiversity (Bouldjedri et *al*., 2011). These wetlands can be preserved from degradation or restored through appropriate conservation and management measures (Diana, 1992). To this end, humans must use them wisely and sustainably so that they best meet the needs of present generations while maintaining their capacity to meet the needs of future generations. This implies the maintenance of a set of natural features of wetland ecosystem components such as water, nutrients, soils, plants and animals in all their diversity (Sinsi & Kampmann, 2010). Thus, wetlands are a public good to be protected as they harbour about 80% of biodiversity and play a key role in the regeneration of water resources and the preservation of biodiversity. Its implementation is governed by the Convention on Wetlands, also known as the Ramsar Convention (De Klemm, 1990).

Currently, the conservation and sustainable management of natural resources is required by the Aichi Biodiversity Targets, especially articles 11 and 16, which aim to ensure that at least 17% of forest areas, inland waters including coastal areas and some particularly important areas and 100% of marine areas are protected for ecological reasons, access to genetic resources, and fair and equitable sharing of benefits derived from their use (Santamaria & Bodin, 2017). However, the anthropic pressure and the shrinking of the Mombonga and Labo rivers in the town of Gemena, causing the progressive disappearance of the hydrophytic species that once surrounded them, is very worrying. This is why it is necessary to resort to vegetative propagation in order to multiply elite trees of certain species which, until now, were normally regenerated by natural seedlings (Meunier et *al*., 2008). The present work aims at the macro-propagation of *Hallea stipulosa*, a very useful plant in the Democratic Republic of Congo (Latham & Konda, 2006), with the aim of providing material for the restoration and/or protection of the above-mentioned rivers thanks to the different treatments allowing to shorten the duration of its biological cycle. In order to do so, it is necessary to answer the following main research questions:

- Is vegetative propagation by cuttings of *H. stipulosa* possible in the bioclimatic conditions of Gemena?
- What type of substrates would favour its propagation by cuttings?

The following assumptions should be checked:

- As with other wetland species, cuttings of *H. stipulosa* would be possible;
- Firm soil mixed with rice husk would be the best type of substrate to favour its cuttings.

The present study aims to evaluate the recovery of *H. stipulosa* cuttings on different substrates and to study the behaviour of the plants on substrates. The interest of this study is obvious because it will allow putting at the disposal of the riparian population plants for the protection of wetlands and deforested banks of the two watercourses Mombonga and Labo of the city of Gemena.

MATERIALS AND METHODS

Study Area:

The Gemena Territory (Fig. 1) is located between 2° and 4° North latitude and 18° and 20° East longitude with an average altitude of 400 metres above sea level. It covers a total area of 11,488 km², of which 50 km² is the city of Gemena. The seasons of the year are distributed as follows: from November to February, plus the month of July, while the rainy seasons are from March to June, followed by August to October. The territory of Gemena has sandy-clay soil. In some places the soil is calcareous or clayey; however, the soil along the Labo River is ferralitic with an acid pH. The relief of the Gemena area is characterised by hills and hill ranges. The vegetation is dominated by *Chromolaena odorata*, swamp forests and gallery forests. The territory is also partly made up of *Imperata cylindrica* savannah, particularly in the Nguya and Mbari sectors.

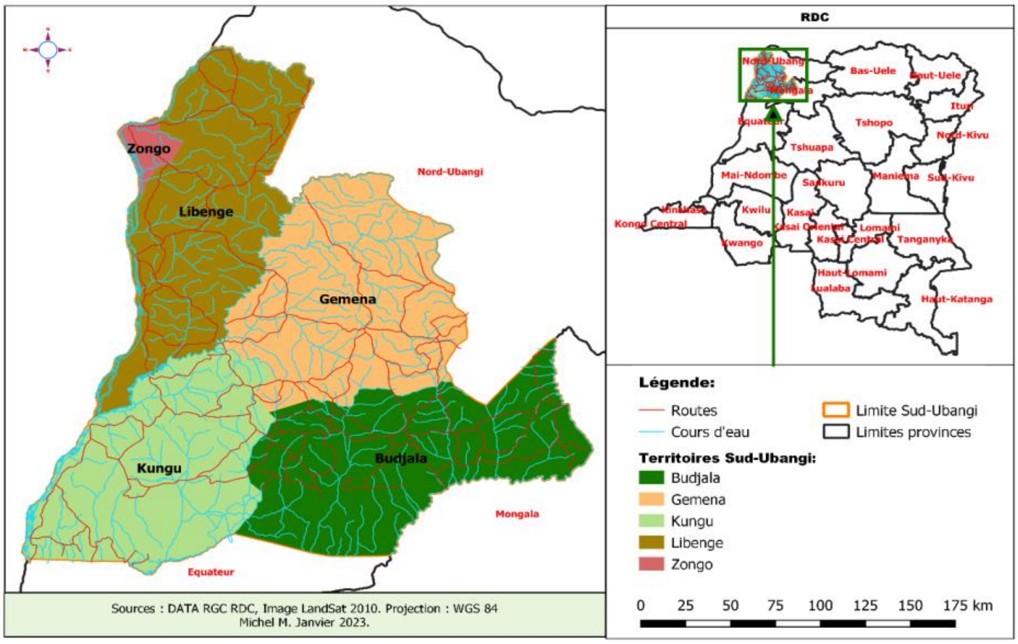


Fig. 1: Geographical location of Gemena Territory (South Ubangi Province).

Experimental Site:

The experimental site was installed on the banks of the Labo River (Quartier Ferme II, Commune de Labo) in Gemena. It is bounded to the north by the Jehovah's Witnesses Church concession; to the south by the Labo River; to the east by the Bokuda group and to the west by the Goza concession.

Experimental Design:

The experimental design in this study is completely randomised, consisting of five treatments from four different soil types and mixed with different culture substrates: T_0 (hydromorphic soil); T_1 (dry land soil + potting soil), T_2 (hydromorphic soil + potting soil), T_3 (dry land soil + dirt) and T_4 (sawdust + hydromorphic soil). A total of 45 cuttings were prepared with 9 cuttings per treatment and divided into three repetitions as shown in Figure 2.

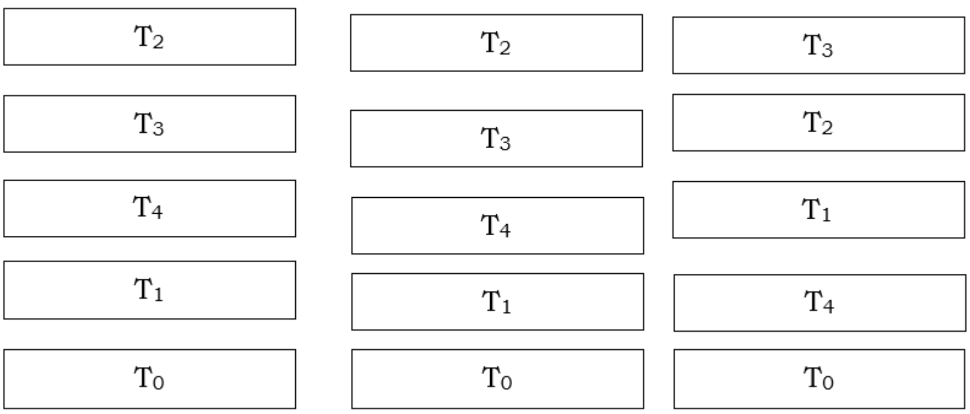


Fig. 2: Experimental design.

T_0 (hydromorphic soil); T_1 (dry land soil + potting soil), T_2 (hydromorphic soil + potting soil), T_3 (dry land soil + dirt) and T_4 (sawdust + hydromorphic soil).

The cuttings were planted directly on each substrate on 14 May 2021.

Observation Parameters:

For this study, observations were made on:

- The number of stems grown in each treatment
- The recovery of cuttings, which consisted in noting the number of days elapsed from the setting up to the beginning of the appearance of the leaf, then the calculation of the recovery rate (RR) from the 7th day using the formula:

$$RR\ (\%) = \frac{Number\ of\ recovered\ cuttings}{Total\ number\ of\ cuttings\ experimented} \text{x}100$$

- The survival of the plants at a certain time interval after the placement of cuttings, i.e. from the 2nd to the 6th week. The survival rate (SR) is calculated from the formula:

$$SR\ (\%) = \frac{Number\ of\ plants\ alive\ at\ the\ end\ of\ the\ period}{Total\ number\ of\ plants\ growing} \text{x}100$$

- The growth of the plants focused on the length of the first leaf, measured with tape at the 2nd, 3rd, 4th and 5th week after taking the cuttings. Thus, the growth rate of the first leaves was calculated using the formula:

$$VC\ (cm/d) = \frac{\text{Change in length (cm)}}{\text{Time interval (days)}}$$

Data Analysis:

All data collected was analysed using Statistix 8.0 software package.

RESULTS

Taking Cuttings:

The influence of each type of substrate on *Hallea stipulosa* cuttings is reflected in the recovery rate values recorded in Table 1.

Table 1: Indicators of recovery of Hallea stipulosa cuttings 7 days after placement

Treatment	Number of cuttings placed	Number of Recovered Cuttings	Recovery rates (%)
T_0	9	9	100
T_1	9	9	100
T_2	9	9	100
T_3	9	9	100
T_4	9	9	100
Average	9	9	100

From this table it can be seen that the cuttings recovery rate was 100%. This shows the homogeneity of the effects of these five treatments on the recovery of cuttings of *Hallea stipulosa*.

Survival of the Plants:

One week after the takeover until the end of the experiment, i.e., 5 weeks after the takeover of the cuttings (WATC) or 6 weeks after the placement of the cuttings, the mortality of the plants was observed, the number of which varied from one treatment to the other, as illustrated by the survival rate shown in Table 2.

Table 2: Indicator of survival rate of *Hellea stipulosa* plants 1 WATC

Repetition	Treatments				
	T_0	T_1	T_2	T_3	T_4
R1	100.0	100.0	100.0	100.0	100.0
R2	66.7	66.7	66.7	100.0	100.0
R3	66.7	66.7	66.7	100.0	66.7
Average	77.8±19.2[b]	77.8±19.2[b]	77.8±19.2[b]	100.0±0.0[a]	88.9±19.2[a]
Overall average	84.46				
CV	13.47				
Fisher Cal	2.29				
Probability	0.15				
$LSD_{0,05}$	21.42				

Legend: WATC: Week After Cutting (no significant difference between treatments whose means are followed by the same letter)

Statistically, the analyses of the survival rates of the seedlings from the 2nd to the 6th week after cutting showed that there are two groups of treatments (a and b) within which the means are not significantly different from each other. Thus, T_3 (dry soil + rice husk) showed a survival rate of 100% significantly higher than the other treatments, namely T_0 and T_1 and T_2, which were tied at 77.8%. With a survival rate of 88.9%, the average of T_4 (sawdust + hydromorphic soil) straddles these two groups and shows no significant difference with all treatments.

Table 3 shows the evolution of the survival of the plants from the beginning to the end of the experiment.

Table 3: Indicator of the evolution of the survival of *Hallea stipulosa* plants.

Treatment	Growing plants	1 WATC		5 WATC		
		Living plants	SR (%)	Living Plants	SR (%)	MR
T_0	9	7	77.8±19.2	7	77.8±19.2	
T_1	9	7	77.8±19.2	7	77.8±19.2	22.2
T_2	9	7	77.8±19.2	7	77.8±19.2	22.8
T_3	9	9	100.0±0.0	9	100.0±0.0	0.0
T_4	9	8	88.9±19.2	8	88.9±19.2	11.1
Average	9	7.75	86.1	7.75	86.1	39.0

(Legend: WATC = weeks after taking cuttings SR = survival rate; MR = mortality rate).

The results in Table 3 clearly indicate that from one week after recovery to the end of the experiment, the survival rate remained constant for all treatments applied, until the end of the experiment.

Growth Parameters:

For this study, only leaf length data were considered (Tables 4 and 5).

Table 4: Average indicators of growth in leaf length (cm) 2 WATC.

Repetition	Treatments				
	T0	T1	T2	T3	T4
R1	6	8	6	10	10
R2	7	5	6	8	8
R3	8	6	4	6	9
Average	7.0±1.0[a, b, c]	6.3±1.5[b, c]	5.3±1.2[c]	8.0±2.0[a, b]	9.0±1.0[a]
Overall average	7.13				
CV	18.28				
Fisher Cal	3.59				
Probability	0.59				
$LSD_{0, 05}$	2.46				

Legend: WATC: Week After Cutting (no significant difference between treatments whose means are followed by the same letter); CV: coefficient of variation

Statistically, two weeks after cutting, the growth in leaf length showed that there are three groups of treatments (a, b and c) within which the means are not significantly different from each other.

Table 5: Average indicators of growth in leaf length (cm) 4 WATC.

	Treatment				
Repetition	T_0	T_1	T_2	T_3	T_4
R1	11.5	11.0	8.5	14.0	15.0
R2	12.5	9.5	9.0	12.0	15.0
R3	12.0	18.0	7.0	12.5	14.0
Average	$12\pm0.5^{b, c}$	10.8 ± 1.3^{c}	8.2 ± 1.0^{d}	$12.8\pm1.2^{a, b}$	14.7 ± 0.6^{a}
Overall average	11.7				
CV	8.53				
Fisher Cal	17.63				
Probability	0.0005				
$LSD_{0, 05}$	1.88				

Statistically, four weeks after cutting the growth in leaf length showed that there are four groups of treatments (a, b, c and d) within which the means are not significantly different from each other.

The growth rate of the leaves is summarised in the following Table 6.

Table 6: Leaf growth rates.

Treatment	**In the Recovery**	**2 WATC**		**4 WATC**		
	L (cm)	ΔL (cm)	VC (cm/day)	L (cm)	ΔL (cm/day)	VC (cm/day)
T_0	0	7.0	0.5	12.0	5	0.36
T_1	0	6.3	0.45	10.8	4.5	0.32
T_2	0	5.3	0.38	8.2	2.9	0.20
T_3	0	8.0	0.57	12.8	4.8	0.35
T_4	0	9.0	0.64	14.7	5.7	0.40

Legend: WATC= Weeks After Cutting
L= Length (cm); ΔL = Variation in length (cm); VC = Growth Rate (cm/day).

It was observed that two weeks after taking the cuttings, the leaf growth rate of T4 was higher than the other treatments, followed in decreasing order by T_3, T_0, T_1 and T_2. In the 4th week after taking the cuttings, the same observation remains but T_0 is ahead of T_3.

Concerning the trend of this leaf growth rate for all the treatments applied, it goes in decreasing order, from the taking of cuttings as shown in Figure 3.

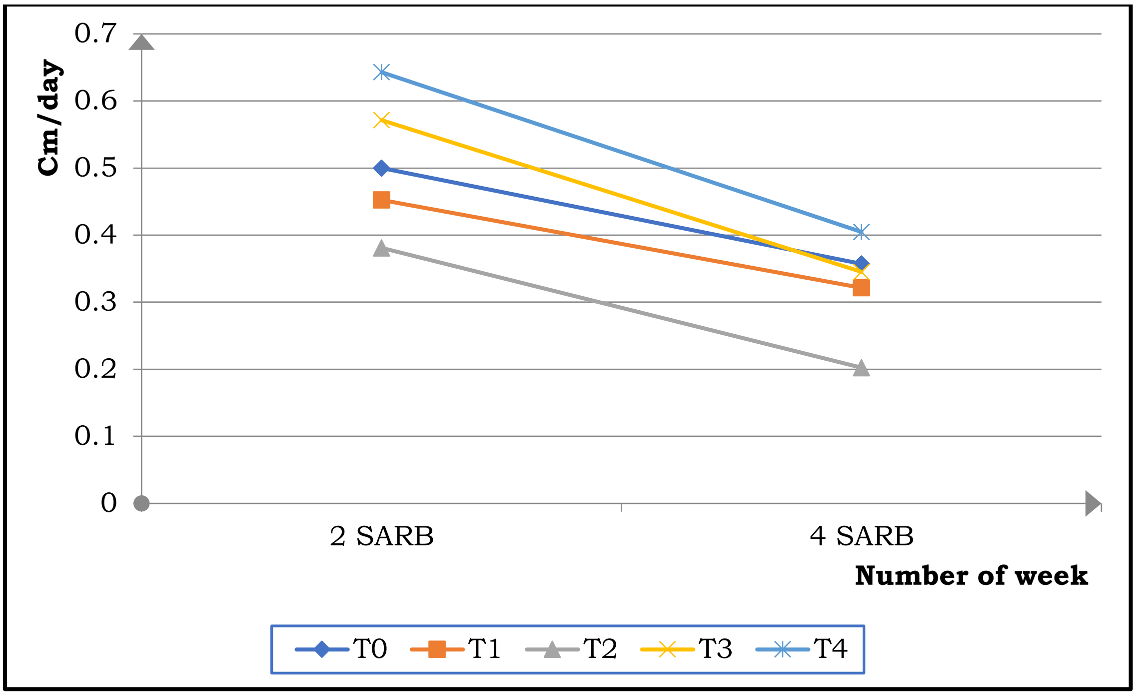


Fig. 3: Trend in the growth rate of first leaves.
Legend: SARB/WATC = Weeks After Cutting).

Figure 4 shows the plants in off-field cultivation.

Fig. 4: Experimental field (off-field)

DISCUSSION

The results obtained in this study show that one week after cutting, the recovery rate was the same for all treatments applied, i.e., 100% of the cuttings taken. This clearly shows the ease of reproduction of *Hallea stipulosa* by vegetative means.

Working on cuttings of the kolatier Cola acuminata (P. Beauv.) Schott & Endl. In South Ubangi, Bosanza *et al*. (2017) observed an average rate of recovery of cuttings of about 73% seventy days after cutting: semi-hardened cuttings with 86.7% compared to 60.0% for hardened cuttings; semi-hardened orthotropic shoots (93%) were followed by semi-hardened plageotropic ones (80%). The results obtained in this study clearly show the ease with which *Hallea stipulosa* can be reproduced by cuttings. Indeed, taking cuttings allows the mother plant to be reproduced identically, with all its qualities but also all its defects. For slow-growing plants, cuttings can shorten the biological cycle. The success rate varies according to the species, but generally, the average recovery rate of cuttings during the dry and hot period is 74.2%, which is high, and therefore it deserves to be generalised at the level of plant production nurseries (Abdessemed & Ledra, 2021). T_3 (dry soil + rice husk) showed a survival rate of 100% significantly higher than the other treatments, namely T_0 and T_1 and T_2, which are tied at 77.8%. With a survival rate of 88.9%, the average of T_4 (sawdust + hydro morphe soil) straddles these two groups and shows no significant difference with all treatments. These values corroborate those obtained by other researchers in Kolatier according to which, for the survival of the seedlings until the 90th day after cutting, the semi-hardened cuttings gave average values of 70% (i.e. 80% for the orthotropic cuttings and 60% for the plageotropic cuttings) (Bosanza *et al*., 2017).

The conservation of this phytogenetic resource is of great interest to the local population for its medicinal properties and in addition, *Hallea stipulosa* (DC.) J.-F.Leroy (Rubiaceae) constitutes an ecological niche for fish. Indeed, studies indicate that the decoction and maceration of barks and leaves are used in traditional medicine to treat fever (especially malaria), stomach ache, colic, diarrhoea, dysmenorrhoea, menorrhagia and liver ailments, as a purgative, emetic and oxytocic. The leaf powder treats skin diseases and the fruit extract is prescribed for asthma (Bolza & Keating, 1972). Phytochemically, several alkaloids with hypotensive and anaesthetic properties as well as intestinal and uterine contraction properties have been isolated from *Hallea stipulosa*. The leaves and barks of this plant are bioactive against *Staphylococcus aureus*, *Escherichia coli*, *Bacillus subtilis* and *Pseudomonas aeruginosa*, thus attesting to its possible use in traditional medicine as an antiseptic for wounds. Triterpene compounds such as quinovic acid, α-amyrin, quinovic acid--3-O-β-D-quinovopyranoside-27-O-β-D-glucopyranosyl; quinovic acid, ursolic acid, quinovine C glycoside, 3-O-acetyl-βursolic acid; quinovic acid-3-O-β-D-glucopyranoside; oleanolic acid; zygophyloside B, zygophyloside D, daucosterole as well as associated and derived heterosides have been isolated from the bark of this plant (Fatima et *al*., 2002). The quinovic acid glycoside isolated from this plant is an inhibitor of phosphodiesterase I of snake venom. And in Côte d'Ivoire, the bark is prescribed for the treatment of gonorrhoea (Bouquet *et al*., 1974). In Guinea, the decoction of the stem bark is used as a diuretic, antiseptic and anti-infective while the infusion is used in the treatment of female infertility and the leaves as a topical antiseptic for wounds (Magassouba et *al*., 2007). In Ghana, the decoction of dried stem bark, administered orally, is very effective against Guinea worm.

The decocted is used to treat malaria in adults while the bark is used for the treatment of genital, urinary and worm infections (Fatima et *al*., 2002). Monizi *et al*. (2018) in northern Angola showed that the stem of *Hallea stipulosa* is used for agricultural equipment (handle of hoe, axe, etc), House construction, cooking utensils, Mortar, Traditional extracting of sugar cane juice, domestics goods. In addition, the bark stem is used to give strength to fermented sugar cane juice. According to Mutombo (2014), fish species of the genus *Protopterus* (Nzombo), *Parachanna* (Mongusu), *Clarias* (Ngolo), *Clariallabes* (Ngbangele), *Xenomystus* (Lopelele), *Papyrocranus* (Lolembe) nesting under *Hallea stipulosa*. Thus, prior knowledge of the goods and services that *H. stipulosa* is capable of rendering argues in favour of its conservation for future generations in the context of sustainable development (SDG 15) in that this plant can provide goods of monetary value (phytomedicines, fish niche), it can render enormous services in climate regulation as a carbon sink. As traditional medicine in Africa occupies a key position in the management of diseases (Ngbolua *et al*., 2011a, b) domestication of this multifunctional plant can reduce human pressure on natural wetlands while improving the lives of communities through the creation of a productive ecosystem. To our knowledge, this is the first time this study has been carried out.

CONCLUSION AND SUGGESTIONS

The aim of the present study was to evaluate the recovery rate of *Hallea stipulosa* cuttings on different substrates by vegetative means, a hydrophytic species of the Mombonga and Labo streams in Gemena. The results of this work show that six weeks after experimentation, the rate of recovery of cuttings was 100%. This shows the homogeneity of the effects of these four treatments on the recovery of *H. stipulosa* cuttings. Regarding the survival of the plants, the results indicated that from the takeover to the end of the experiment, the survival rate was constant for all treatments applied. The T_3 substrate (firm earth soil + rice husk) showed the best survival rate. These results demonstrate that *H. stipulosa* cuttings are possible under the bioclimatic conditions of Gemena and that its growth rate can rapidly ensure the enrichment and restoration of deforested wetlands. The T_3 and T_4 substrates (sawdust + hydro morphic soil) thus make it possible to shorten the duration of cuttings of this plant species due to the content and contribution of organic matter in the treatments. In view of these preliminary results, some suggestions can be made as follows:

- Proceed with the installation and multiplication of a wood park in the degraded and experimental areas to facilitate the restoration of these wetlands;
- Raise awareness and provide guidance to the local population on the use and protection of wetlands;
- Apply laws and regulations on the practice of agriculture, urbanisation and housing, environmental protection and logging in wetlands.

REFERENCES

Abdessemed S., Ledra A. (2021). Methodes et techniques de bouturage : guide pratique. Mémoire de Master, Université des Frères Mentouri Constantine 1, République Algérienne démocratique et populaire.

Bolza E., Keating W.G. (1972). African Timbers: The properties, uses and characteristics of 700 species. Division of Building Research, CSIRO, Melbourne, Australia.

Bosanza Z. J. B., Mongeke M. M. Kalombo K. G., Bedi N. B., Djolu D. R., and Ngbolua K. N., 2017: Données préliminaires sur le bouturage de Cola acuminata (P. Beauv.) Schott & Endl. (Malvaceae) dans le Sud Ubangi (République Démocratique du Congo). *International Journal of Innovation and Scientific Research,* 31(2): 234-240.

Bouldjedri M., Gérard de Bélair, Boualem M., Muller S.D. (2011). Menaces et conservation des zones humides d'Afrique du Nord : le cas du site Ramsar de Beni-Belaid (NE algérien). *Comptes Rendus Biologies,* 334(10): 757-772. https://doi.org/10. 1016/ j.crvi.2011.06.009.

Bouquet A., Debray M. (1974). Plantes médicinales de la Côte d'Ivoire.Travaux et Documents de l'ORSTOM, Paris.

De Klemm C. (1990). La convention de Ramsar et la conservation des zones humides côtières, particulièrement en Méditérrannée. *Revue Juridique de l'Environnement,* 4 : 577-598.

Diana O. (1992). La protection et la gestion des zones humides. *Aménagement et Nature,* (105), 24-26.

Fatima N., Tapondjou L.A., Lontsi D., Sondengam B.L. (2002). Quinovic acid glycosides from *Mitragyna stipulosa*-first examples of natural inhibitors of snake venom Phosphodiesterase I. *Natural Product Letters,* 16(6): 389-393. doi: 10.1080/10575630290033169.

Latham P., Konda K.M. (2006). Quelques plantes utiles du Bas-Congo, province, République Démocratique du Congo. Deuxième édition : 330p.

Magassouba F.B., Diallo A., Kouyaté M., Mara F., (2007). Ethnobotanical survey and antibacterial activity of some plants used in Guinean traditional medicine. *Journal of Ethnopharmacology,* 114 :44-53. https://doi.org/10.1016/j.jep.2007.07.009

Meunier Q., Bellefontaine R., Monteuuis O. (2008). La multiplication végétative d'arbres et arbustes médicinaux au bénéfice des communautés rurales d'Ouganda. *Revue des Sciences Forestières,* 295(2) : 65-76. https://doi.org/10.19182/bft2008. 296.a20387

Monizi M., Fernando J., Luyindula N., Ngbolua K.N., Christoph N., Thea L., Félicien Lukoki L., Heitor M. T. 2018. Traditional Knowledge and Skills in Rural Bakongo Communities: A Case Study in the Uíge Province, Angola. *American Journal of Environment and Sustainable Development,* 3(3) :33-45.

Mutombo A. (2014). Etat de lieux de la biodiversité en République démocratique du Congo. Centre d'Echange d'Information de la RD Congo.

Ngbolua K.N., Rafatro H., Rakotoarimanana H., Urverg R.S., Mudogo V., Mpiana P.T., Tshibangu D.S.T. (2011b). Pharmacological screening of some traditionally-used antimalarial plants from the Democratic Republic of Congo compared to its ecological taxonomic equivalence in Madagascar. *International Journal of Biological and Chemical Sciences,* 5(5): 1797-1804. doi: 10.4314/ijbcs. v5i5.3

Ngbolua K.N., Rakotoarimanana H., Rafatro H., Urverg R.S., Mudogo V., Mpiana P.T., Tshibangu D.S.T. (2011a). Comparative antimalarial and cytotoxic activities of two Vernonia species: V. amygdalina from the Democratic Republic of Congo and V. cinerea subsp vialis endemic to Madagascar. *International Journal of Biological and Chemical Sciences,* 5(1): 345-353. doi: 10.4314/ijbcs. v5i1.68111

Santamaria C., Bodin B. (2017). Mise en œuvre du plan stratégique pour la biodiversité 2011-2020 et objectifs d'Aichi liés à la forêt. *Forêt Méditerranéenne,* 38(3): 417-418.

Sinsi B., Kampmann D. (eds) (2010). Atlas de la biodiversité de l'Afrique de l'Ouest. Tome I: Benin. Cotonou & Frankfurt/Main.

Trochain J.L. (1980). Écologie végétale de la zone intertropicale non désertique. Volume I, 148p, Université Paul Sabatier éd., Toulouse, France.