MORTALITY OF EXOTIC SPECIES (*Eucalyptus deglupta* B., 1863, *Pinus caribeae* M., 1851, and *Gmelina arborea* R., 1814) IN CELLUCAM PLANTATIONS NEAR EDEA (LITTORAL, CAMEROON) AND AT THE INSTITUT SUPERIEUR AND THE MBAIKI INSTITUTE OF RURAL DEVELOPMENT (CENTRAL AFRICAN REPUBLIC)

Abstract:

The study was carried out at the CELLUCAM artificial plantation located some 15 km north-east of the town of Edéa, capital of the Sanaga Maritime in the Cameroon coastal zone, and at the Higher Institute of Rural Development Mbaïki in the Central African Republic. In the plantations at both sites, three species form homogeneous blocks : *Eucalyptus deglupta*, *Pinus caribeae* and *Gmelina arborea*. These plantations were installed by the pulp and paper production company CELLUCAM (Cellulose du Cameroun) from 1979 to 1982, and as plantations at ISDR Mbaîki in the Central African Republic. The aim of the study was to assess the level of evolution of the exotic species planted in the plantations at the two sites. The following results were obtained: Exotic species densities, mean diameters, mean basal area, mortality rates and survival rates vary between plantations and sites. Mortality is very high in the CELLUCAM plantations, while the survival rate is high in the ISDR plantations.This mortality may be due to the lack of maintenance of the plantations since CELLUCAM ceased its activities, and to the presence of herbivores in the surrounding forest, which in the absence of monitoring can destroy the young seedlings at the start of the plantation. Mortality can also be caused by microscopic fungi and soil bacteria. In the well-maintained plantation of the Mbaïki Higher Institute of Rural Development (Central African Republic), mortality of planted exotic species is much lower than in the CELLUCAM plantations. To ensure the harmonious development of exotic species, and above all to achieve reforestation objectives in a given environment, an artificial plantation requires constant maintenance.

Keywords: Artificial planting, Exotic species, Cameroon, Central African Republic

Introduction

UNDER PEER REVIEW IN IJAR

Growing human demand for forests and the economic development of certain countries, based essentially on the exploitation of natural resources, have given rise to various forms of exploitation that raise the issue of forest management and the capacity of forests to regenerate. Population pressures are causing tropical forests to shrink by 100,000 ha to 200,000 ha per year, i.e. an annual rate of 0.3% to 1%3 (FAO, 2022). Forest ecosystems in Cameroon cover 21 million ha with over 8,000 plant species, including 300 species of exploitable wood (Bikié Ndoyé B. et al., 2000). This forest is subject to various forms of destruction: industrial logging by forestry companies, the installation of industrial plantations (coffee, cocoa, oil palm, banana plantations, etc.), bush cultivation and bush fires (Nkongmeneck B. et al, 1999, Bikié Ndoyé B., et al., 2000). From 1979 to 1982, CELLUCAM (Cellulose du Cameroun) was a pulp production company based in the village of Magombé, 15 km from Edea, capital of the Sanaga Maritime region (Littoral). Work began in 1976. Pulp production lasted just 4 years (1979-1982 (J.R. Ngueguim et al., 2011). For pulp production, the company signed an agreement with the Cameroon government to exploit 100,000 ha of forest in the Edéa region. The company's forestry department adopted a method of cutting all woody species for pulp production, then a bulldozer would pass through afterwards to expose the soil (Ngueguim et al., 2011). As the block is harvested, reforestation is carried out using exotic species adapted to pulp production. The species planted are Pinus caribeae, Eucalyptus deglupta and Gmelina arborea (Ngueguim et al., 2011). Around 100 ha of forest were cleared, but only around 30 ha of plantations were established, i.e. 30% of the cleared area (Ngueguim et al., 2011). Since work stopped in 1982, the plantations have not been maintained and have been abandoned in dense forest. An artificial plantation that has been installed needs to be maintained and must undergo the conditions necessary for its proper development.

In many cases, exotic plants have been widely used because of their ecological plasticity, their rapid growth, which is often a real advantage (for the supply of wood energy in particular), and for many other interests (ecological: dune stabilization, soil rehabilitation, soil fertilization, phytoremediation, microclimate restoration, drying out flooded environments), socio-economic (provision of fruit, fiber, fodder, gum, tannins, medicines, service wood) (Boutefeu Benoit, 2005). Environmental impact studies linked to the use of these exotic species have later given negative ecological effects that often modify the properties of the host ecosystem to promote their own establishment and adaptation (J.M. Ayem, J. Koyode., 2013, Lidwine Le Mire Pecheux, Tanguy Jaffre , 1996). In addition to their effect on the composition and functioning of the host ecosystem, exotic species can become threats to biodiversity, which is essential to the sustainability of ecosystems and the provision of vital

UNDER PEER REVIEW IN IJAR

ecosystem services (Boyce J. S., 2005,). The threats posed by planted exotic species are linked to various allelopathic effects defined in 1937 by the Austrian Hans Molish. The origin of the word comes from the Greek, allélo (“the one/the other”) and pathos (‘suffering’ “effect”). Thus, the etymology of this word implies that these interactions are negative: competition for resources, defense mechanisms (Inderjit, 2005). Current acceptance of allelopathy also includes positive interactions such as cooperation and stimulation between microorganisms. These interactions take place via so-called allelopathic compounds, released by the plant into its environment (Inderjit, 2005). Most often these compounds are secondary metabolites and belong to a wide variety of biochemical families (Inderjit, 2005, Romagni J. G., Allen S. N. & Dayan F. E., 2000). They can be released by roots (exudation), by aerial parts (leaching, volatilization) or by the decomposition of dead plant residues. Allelopathy also refers to the emission or release by an organ of a plant species, whether living or dead, of toxic organic substances that inhibit the growth of plants growing in the vicinity of this species or succeeding it on the same land (J.M. Ayem, J. Koyode. 2013, Romagni J. G., Allen S. N. & Dayan F. E., 2000). The study of this phenomenon has developed rapidly and extensively in agronomy. Today, the ecology of the emission of inhibitory substances involved in chemical interactions between plants is being developed in the field of forestry, especially for the reforestation of arid and desert environments (J.M. Ayem, J. Koyode. 2013).

The general objective of the study is to carry out a comparative study of plantation dynamics at the two sites. Specifically, it aims to: Identify the exotic species in CELLUCAM's artificial plantations, Evaluate the average density, average diameters and average basal area per plantation in the two sites, Determine the mortality and survival rate of exotic species planted per plantation in the two sites.

Materials and methods

Experimental site:

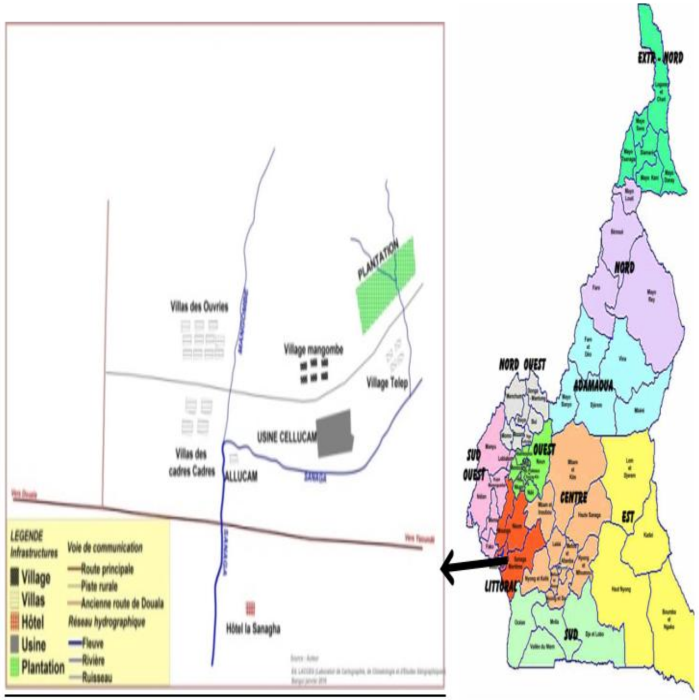
The CELLUCAM plantation (30° 50 N and 10° 10 E) is located around 15 km northeast of the town of Edéa in Cameroon's coastal zone. The original vegetation is a rainforest. The most common species are *Lophira alata*, *Saccroglotis gabonenecis*, *Cynometra hankei harms* and *Coula edulis*. The forest is rich in paper species, with a potential of over 300 m3/ha 17. The plantation is located at an altitude of around 30 m. Run-off

UNDER PEER REVIEW IN IJAR

water has eroded the site, which has a gentle slope towards the rivers that cross the plantations. The exotic species planted are Pinus caribeae, Eucalyptus deglupta and Gmelina arborea (J.R.Ngueguim et al., 2011). (figure 1).

The plantations of the Higher Institute of Rural Development (ISDR) are located in Mbaîki, 107 km south of Bangui, capital of the Central African Republic. Plantations of *Pinus caribeae, Eucalyptus deglupta* and *Gmelina arborea* were established in 1990. These plantations are located around the institute and are maintained by the institute during practical work carried out by Water and Forestry students.

UNDER PEER REVIEW IN IJAR



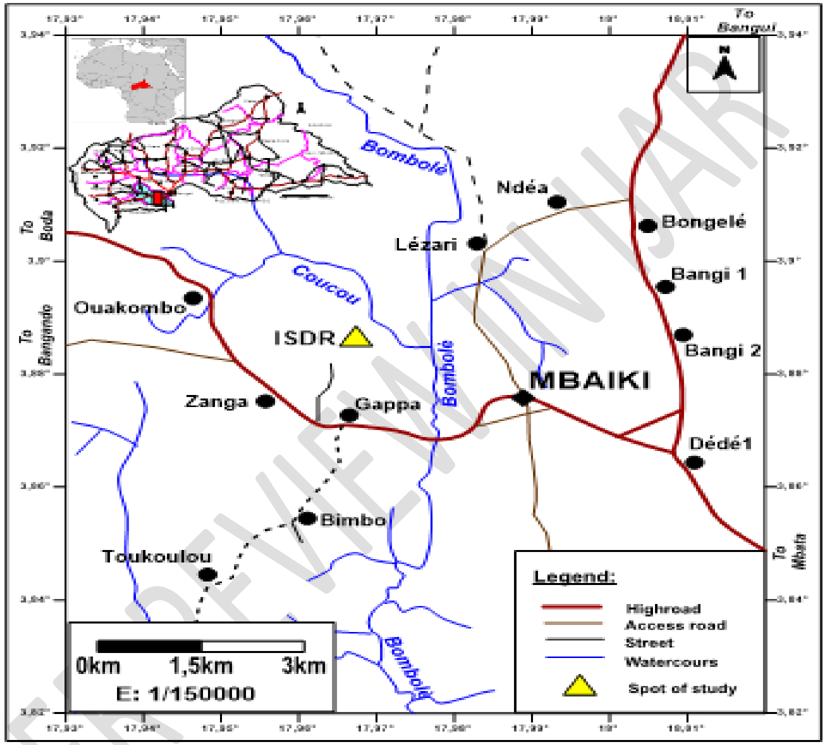


Figure 1: Administrative Division of Cameroon Plan of study site(NACHOUI MOUSTAPHA 2021)

Figure2: Map of the Central African Republic study area of Higher Institute of Rural Development (ISDR)/Mbaïki

Matériel biologique :

Le matériel biologique se compose de :

Pinus caribeae (A. Graves. Oxford, U.K. 1980). *Pinus* trees belong to the Pinaceae family and the Pinus genus. The Pinus genus is generally divided into two subgroups: Hardwood pines (Diploxylon) and softwood pines (Haploxylon). Diploxylon pines have their needles fasciculated by 2, 3 or 5, while Haploxylon pines always have their needles fasciculated by 5.

UNDER PEER REVIEW IN IJAR

In general, pines are large trees with monopodial growth, like most other conifers. Only a few species lack apical dominance, such as *Pinus sabiniana* in California. Others can also be found as bushes when they live in difficult conditions. Many pine species are very long-lived. A dozen species can reach 1,000 years. *Pinus balfouriana* and *Pinus longaeva* can reach 5000 years.

Eucalyptus (Delphine BASSOU., 2003). *Eucalyptus* belongs to the Myrtaceae family. The Eucalyptus genus comprises some 600 species,) native to Australia, southern Papua, New Guinea and the southern Philippines. Eucalyptus grows in all climates. It can withstand drought because its roots gorge themselves with water. It grows best in well-drained, fairly dry, deep soil. It also thrives in dry, rocky soils, even growing rapidly in poor, degraded soil. Eucalyptus is not pruned, so its habit remains balanced throughout its growth. Fertilizer is not necessary, as this tree can do without it even in very poor soil.

Gmelina arborea (A. Graves. Oxford, U.K. 1980) is native to India. Its adaptation to a variety of environments has given it a wide geographical distribution. A fast-growing tree, it thrives in a variety of locations, preferring fertile valleys with 750-4500 millimeters of rainfall. It does not thrive on diseased drained soil, and poor arenaceous soils. Drought also reduces it to a shrubby form. The tree grows to a moderate height of 30 m, and the trunk can reach 9 to 15 m in diameter. *Gmelina arborea* is generally found in gardens and avenues, and is also planted in villages and along agricultural land. It is drought-tolerant, and regenerates easily after bushfire.

Experimental set-up:

The transect method (Lejoly J & Sonké B. 1996) was used for the floristic inventory. Four 50 m x 100 m layons were established in each plantation. The layons were divided into 50 m x 50 m survey units. In each layout, the exotic species planted were identified and counted, and their diameters measured. A total of 2 ha was surveyed per plantation. The number of plants of the exotic species originally planted per ha is determined, using the distance between lines and the distance between plants in a homogeneous survey unit of a layon. From the number of plants counted, the survival and mortality rate of a species per ha is determined. This data collection methodology enabled us to identify the species planted, determine average density and average diameters, and assess the mortality rate of exogenous species planted in homogeneous

UNDER PEER REVIEW IN IJAR

plantations. This experimental set-up is used in the study of the artificial plantation at CELLUCAM (Cameroon) and at the Higher Institute of Rural Development (SDR) in Mbaïki (Central African Republic).

Data processing :

Excel software was used for data entry. For statistical analysis, certain parameters were evaluated:

species density, i.e. the number of stems per unit area.

D = Nt/s D= density, Nt = number of stems, S = unit of surface area which can be, hectare, square metre... It is used to determine the density of planted species.

Mortality rate. Expresses the percentage of exotic species that have died.

T (%) = Nb p - Nb c / Nbp. 100 T = mortality rate, Nb p = number of stems planted, Nb c : number of stems counted.

basal area (G) or basal cover.

G=$\pi D^2/4$, D = Diameter at base or dbh, π = 3.14.

Arithmetic mean

$\overline{X} = \frac{1}{N}\sum_{i\_1}^{n} xi$ N= Total number of stems, xi = diameter of a stem.

ANOVA software version R and TUKEY test.

RESULTS

The results of the data collected are presented according to the specific objectives set:

- **Stem density of *Eucalyptus deglupta, Pinus caribeae* and *Gmelina arborea***

UNDER PEER REVIEW IN IJAR

Figure 2 shows the density values for each plantation. These values were compared by a two-factor ANOVA (* = P<0.05; ** = P<0.005 and *** = P<.0005, highly significant difference).

The values show that exotic plant densities vary according to plantation type at each site. There is also a variation in density for each exotic species at the CELLUCAM and ISDR sites. The variation in densities is significant between the two sites.

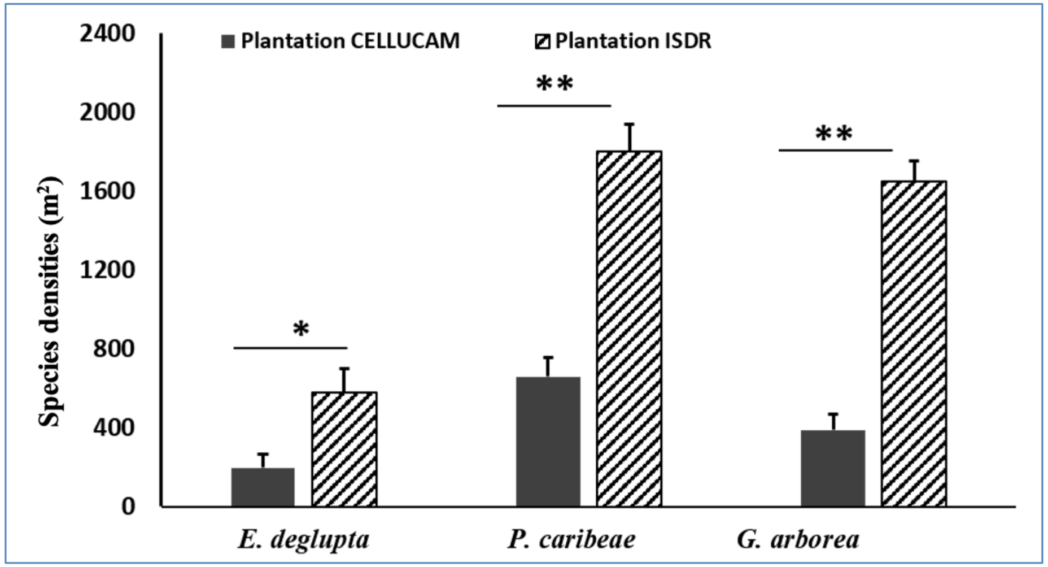


Figure 2: Stem densities of exotic plants at both sites.

- **Stem diameter**

Figure 3 shows the average stem diameters of exotic species in plantations at both sites. There are no significant differences between the diameters of stems of the same species at the two sites. If we consider the diameter values at one site, we see that the mean diameter value of the Pinus caribeae species is low compared with the mean diameters of the *Gmelina arborea* and *Eucaleptus deglupta* species.

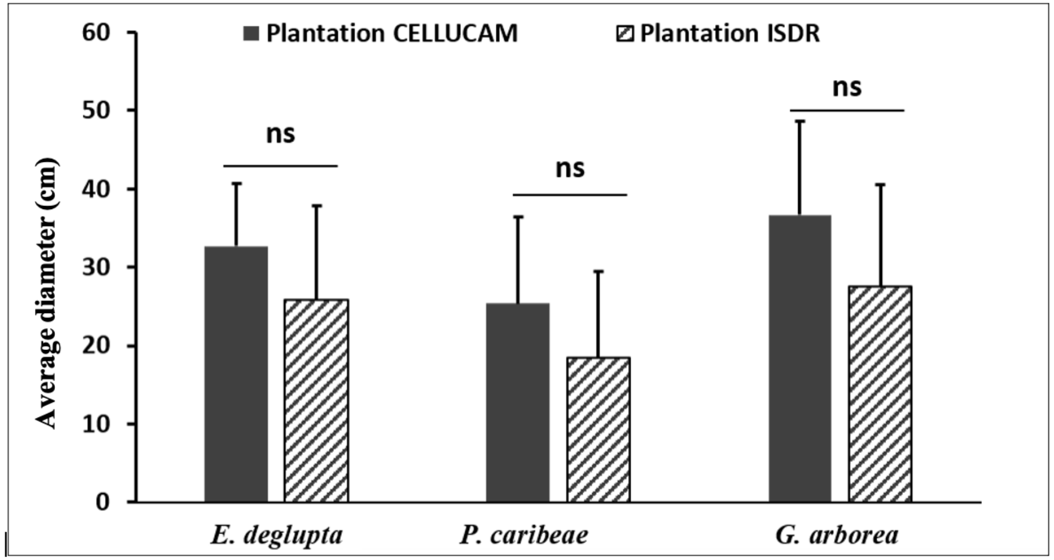


Figure 3: Average stem diameters of exotic plants at both sites.

- Basal area of exotic plant stems

The basal area expresses the surface area of the stems of the species at the base of the plants. Figure 4 shows the average stem area of exotic plants at the two sites, with little variation in mean basal area between species at the CELLUCAM site and those at ISDR. But on the same site, the difference between the mean basal area of *Pinus caribeae* and those of the other species (*Gmelina arborea* and *Eucalyptus deglupta*) was significant.

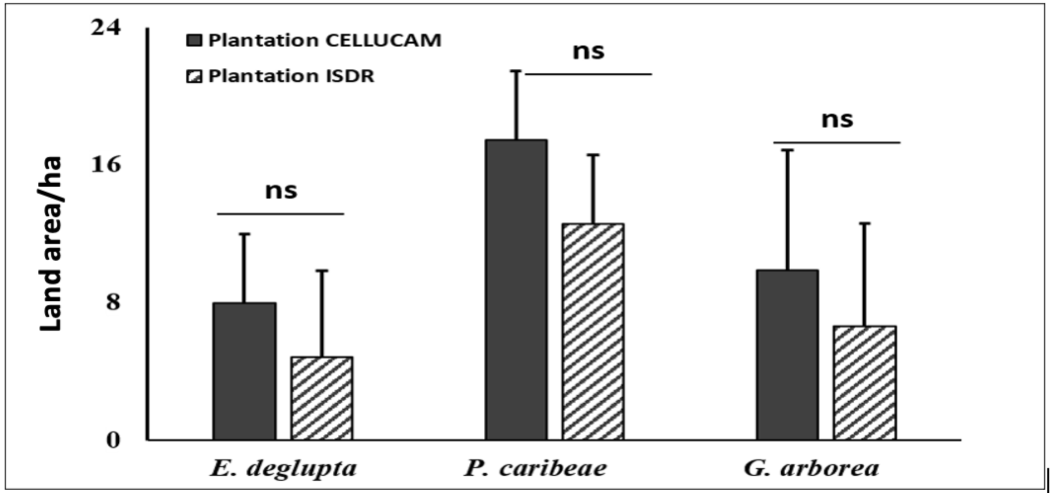


Figure 4 : Basal area of exotic plant stems for both sites.

- Mortality rate of exotic plants in plantations at both sites

Figure 5 shows the values of mortality rates for exotic species in each plantation at both sites. Differences in mortality rates for the same species at both sites are highly significant (*** = P < 0.0005). When we consider the mortality rates of species within a site, the differences in rates are not significant. This is the case between the mortality rates of exotic species in the CELLUCAM plantation and the mortality rates of species in the ISDR plantation.

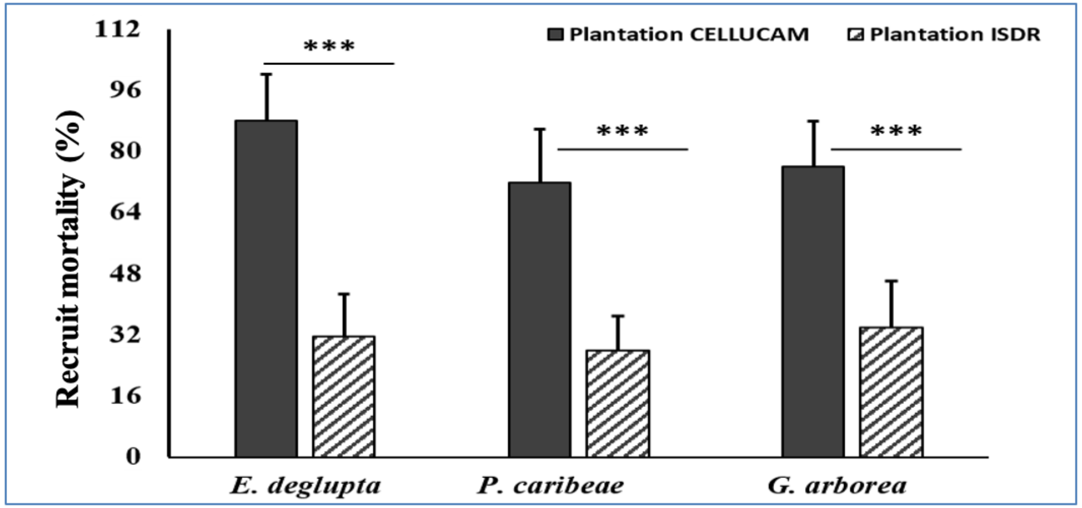


Figure 5 : Exotic plant mortality rates for both sites.

- **Survival rate of exotic plants in plantations at both sites**

Figure 6 shows the survival rates of exotic plants from each plantation at both sites. These values were compared using a two-factor ANOVA. The survival rate expresses the percentage of exotic species planted that are still alive in the plantations. The results show a significant difference between the survival rates of seedlings of the same species on the two sites (*** = $P < 0.0005$); the difference between the survival rates of exotic species on the same site is small, but the differences between the survival rates of species on the CELLUCAM plantations and the survival rate of species on the ISDR plantation is highly significant. As the area where the CELLUCA plantation is located is protected, the two plantations studied were not subject to exploitation or anthropogenic activities. The results presented reflect the actual state of the two plantations.

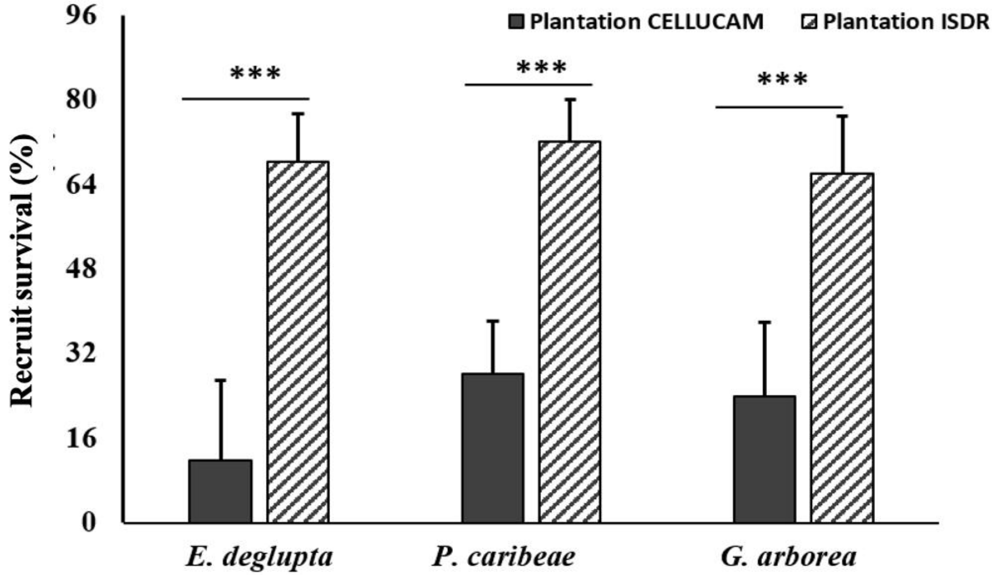


Figure 6 : Taux de survie des plantes exotiques pour les deux sites.

Discussion :

The parameters used in this study are: stem density, mean stem diameters, mean stem surface area, mortality rate and stem survival rate of planted exotic species. The parameters used in the study at the two sites were compared using a two-factor ANOVA (* = P<0.05; ** = P<0.005 and *** = P<.0005). The results show that exotic plant densities vary according to the type of plantation at each site. There was also a variation in density for each exotic species at the CELLUCAM and ISDR sites. Densities vary significantly between the two sites. The ISDR plantation has a higher density than the CELLUCAM plantation. This variation in density explains the high mortality in the CELLUCAM plantation compared with the ISDR plantation, and at the same time results in high survival rates in the ISDR plantations compared with the CELLUCAM plantations.

These variations in parameters may be due to plantation maintenance conditions at the two sites. The CELLUCAM plantations were established in 1982, whereas the ISDR plantations were established in 1990. Despite this small difference in age, the variations between average diameters and land area are small. This shows that the two plantations show similar dynamics for these two parameters.

Exotic plant mortality is very high (over 70%) in CELLUCAM plantations, resulting in a low survival rate. This result confirms that CELLUCAM stopped work on the plantations at a very early stage. To achieve satisfactory results in Eucalyptus, Pinus and Gmelina plantations, certain conditions must be met. These include the soil (chemical nature), the selection of seeds or cuttings, and above all the maintenance of the plantation from the very beginning of the seedlings' development (Mensbruge G.. Martin Paegelow2010). CELLUCAM plantations are carried out without taking into account the regional biodiversity and ecological conditions in which they are introduced. Comparable results were obtained in a study carried out on Teak plantations in Malaysia (Delphine Bassou, 2003). Individuals of the *Tectona, Eucalyptus, Pinus* and *Gmelina* genera need a lot of light throughout their life cycle. The lowest trees are quickly removed if the stand density is too high. Plantations must therefore be thinned at regular intervals (Mensbruge G., Martin Paegelow, 2010). The spacing and number of trees, as well as the timing and intensity of thinning, have a strong influence on the rate of growth and yield of the plantation (Gravas. et al, 1980, Delphine Bassou, 2003,). If thinning is carried out too late, plant growth diminishes or stops; on the other hand, if it is too extensive or too early, the trees tend to produce more lateral branches and adventitious shoots. This reduces the plantation's potential yield, as growth is diverted from the main stem (Boutefeu, 2005).

In the case of this study, the CELLUCAM plantations, which are not subject to these silvicultural standards, showed a very high mortality rate, whereas the ISDR plantation, which complies with silvicultural standards, showed a very high survival rate. *Pinus*, *Eucayptus* and *Gmelina* are also genera that are highly susceptible to disease, which can be caused by various microorganisms (fungi, bacteria), animal pests such as insects, herbivores (duikers, rodents) can destroy young shoots, leading to high mortality in a plantation if not monitored (J. Le Guen, 2010).

UNDER PEER REVIEW IN IJAR

CELLUCAM's plantations are unattended and overgrown with grasses and regenerating local woody species, providing an opportunity for herbivores and other animals to destroy the young exotic species developing in the plantations.

The low variation in the mortality rate of Pinus caribeae compared to other species can be explained by the resistance of *Pinus* needles to herbivores (Herder, 2009). *Pinus* needles are highly resistant to grazing by herbivores (Michael F; et al, 2005). Thus, herbivores can only consume the leaves of *Gmelina* and *Eucalyptus,* which can lead to high mortality of young *Gmelina* and *Eucalyptus* shoots compared with Pinus (Michael den Herder, et al, 2009).

The inventory of planted exotic species shows three species. *Pinus caribeae*, *Eucalyptus deglupta* and *Gmelina arborea.* These three species were chosen for their adaptability to the environment and their pulp yield. However, today's society is no longer functioning, and these species have become huge industrial monocultures, occupying huge areas of land where natural forests with their biological diversity once grew. Plantations are not forests, although they are wrongly called artificial forests (Delphine BASSOU 2003). They provide a large quantity of cheap, formatted wood, and while their paper value is very high, these plantations do not meet any social or ecological criteria outside their native environment (Mensbruge G. and Martin Paegelow, 2010). In monocultures, the trees are all the same age, often genetically identical because the species are cloned. The trees are lined up in immense rows, offering virtually no vital space for other plant and animal species. They are biologically dead, earning them the nickname “green desert” (Mensbruge G.. Martin Paegelow, 2010). In the specific case of the CELLUCAM plantations, the high mortality of planted species will provide an opportunity for the natural regeneration of local species, thus diversifying biodiversity (Delphine BASSOU, 2003). The lack of monitoring, the frequent absence of man from the plantation and, above all, the absence of anthropic pressure on the plantations will encourage the establishment of animal biodiversity.

The ISDR plantation is located in the heart of the equatorial forest. Artificial plantations with fast-growing species such as *Eucalyptus, Tectona*, *Cassia, Pinus* and *Gmelina* are often established when the need is of great importance, such as flooding in an environment, mountain slopes, blocking sand dunes (Delphine BASSOU, 2003), as in the case of the Senegal-Djibouti green belt in the Sahel (A. Sanon et al, 2012). Wetlands are not suitable for artificial plantations based on exotic species. In the Central African Republic, the northern part of the country bordering Chad

UNDER PEER REVIEW IN IJAR

is threatened by desertification, and artificial plantations based on fast-growing exotic plants need to be established to halt the advance of the desert towards the center of the country.

Conclusion

The study of CELLUCAM plantations continues to pose problems, due to a lack of documentation and information on the establishment of plots and the choice of exotic species planted. Recent data are based on studies carried out by Ngueguim in 2008. Stem densities of exotic species vary from plantation to plantation and from site to site.Mortality of planted exogenous species is very high, over 70% in the CELLUCAM plantations (Cameroon) compared with the ISDR plantation in Central Africa. Artificial plantations are an alternative way of restoring vegetation after desertification and deforestation, or the destruction of plant cover. They can also rapidly restore a microclimate in an environment, dry out the soil thanks to their high water absorption capacity, and protect the soil against erosion. The wood of certain species is used as poles for telephone and electrical wires in many countries. But numerous studies have shown that these plants have a negative impact on the environment and natural regeneration. Artificial plantations of *Eucalyptus, Pinus, Gmelina* and *Tectona* should be established when the need is of great importance to the country or region. The public, environmental specialists and political leaders of the countries concerned need to be aware of this problem, so that they can make the right decisions about ecological rehabilitation projects and plantations of economic importance.

Références

UNDER PEER REVIEW IN IJAR

Ayem, J. M., & Koyode, J. (2013). The allelopathic effects of tree crop residues on the germination and radicle length of Sphenostylis. Ayem, J. M., & Koyode, J. (2013). The allelopathic effects of tree crop residues on the germination and radicle length of Sphenostylis ; Mémoire de master, Université de Bangui.

Bassou, D. (2003). Impact des plantations d'Eucalyptus sur la diversité floristique (rapport de stage). Afocel, Lauragais, France itto.int.

Bikié, H., Ndoye, O., & Sunderlin, W. D. (2000). L'impact de la crise économique sur les systèmes agricoles et le changement du couvert forestier dans la zone forestière humide du Cameroun (Occasional Paper No. 27). Center for International Forestry Research, Bogor, Indonésie / Yaoundé, Cameroun CIFOR-ICRAFGoogle Books.

Delphine, B. (2003). Impact des plantations d'Eucalyptus sur la diversité floristique (rapport de stage). Afocel, Lauragais, France Wikipédia.

FAO. (2010). Évaluation des ressources forestières mondiales (pp. 145–161). Rome: Organisation des Nations Unies pour l'alimentation et l'agriculture.

FAO. (2011). Les cycles nutritifs des plantations d'eucalyptus du Brésil et du Congo. Rome: Organisation des Nations Unies pour l'alimentation et l'agriculture.

FAO. (2022). The State of the World's Forests 2022: Forest pathways for green recovery and building inclusive, resilient and sustainable economies. Rome: Food and Agriculture Organization of the United Nations. https://doi.org/10.4060/cb9360en

Greaves, A. (1980). *Gmelina arborea*. Oxford, UK: Commonwealth Forestry Institute, University of Oxford.

Inderjit. (2005). Soil microorganisms: An important determinant of allelopathic activity. Plant and Soil, 274(1–2), 227–236. https://doi.org/10.1007/s11104-004-0159-x

Jamin, J.-Y., Gounel, C., & Bois, C. (2003). *Agriculture et développement rural des savanes d'Afrique centrale (Cameroun – République centrafricaine – Tchad)*. (Préface de S. Namkossérena ; Avant-propos de L. Seiny Boukar). Montpellier, France : CIRAD.

Jordan, N. R., Larson, D. L., & Huerd, S. C. (2008). Soil modification by invasive plants: Effects on native and invasive species of mixed-grass prairies. Biological Invasions, 10, 177–190. https://doi.org/10.1007/s10530-007-9121-1

Le Guen, J. (2010). Protection des forêts tropicales et de leur diversité contre la dégradation et la déforestation. Forest Monitor, 1–10.

UNDER PEER REVIEW IN IJAR

Lejoly, J., & Sonké, B. (1996). Utilisation de la méthode de transect en vue de l'étude de la biodiversité dans la réserve de faune de Dja (Cameroun) (thèse, Université Libre de Bruxelles, pp. 10–30).

Le Mire Pécheux, L. (1995). Impact écologique de l'introduction d'une espèce végétale sur la diversité floristique endémique des maquis mineurs de la Nouvelle-Calédonie : cas des plantations de Pinus caribaea var. hondurensis (Wild) de la province du Sud Mémoire de DEA, Université de la Nouvelle-Calédonie ;

Mensbruge, G., & Paegelow, M. (2010). Protection des sols et restauration forestière dans la région de savane du nord de la Côte d'Ivoire. CTFT, Nogent-sur-Marne, France, 31 p.

Allen, M. F., Allen, E. B., & Gómez-Pompa, A. (2005). Effects of mycorrhizae and nontarget organisms on restoration of a seasonal tropical forest in Quintana Roo, Mexico: Factors limiting tree establishment. Restoration Ecology, 13(2), 234–241. https://doi.org/10.1111/j.1526-100X.2005.00030.x

den Herder, M., Kouki, J., & Ruusila, V. (2009). The effects of timber harvest, forest fire, and herbivores on regeneration of deciduous trees in boreal pine-dominated forests. Canadian Journal of Forest Research, 39(4), 712–722.

Nachoui, M. (2021). Présentation du Cameroun : Potentialités à rentabiliser, défis à surmonter et des ambitions à réaliser. Université Hassan II, Casablanca.

Ngueguim, J. R., Zapfack, L., Youmbi, E., Riera, B., Onana, J., Foahom, B., & Makombu, J. G. (2010). Diversité floristique sous canopée en plantation forestière de Mangombe-Edéa (Cameroun). Biotechnologie, Agronomie, Société et Environnement, 14, 167–176.

Nkongmeneck, F. B., & Laminsi, S. (1991). Les problèmes de l'environnement au Cameroun. CREAP, Yaoundé, Cameroun, 52 p. (pp. 8–20).

Sanon, A., Beguiristain, T., Cebron, A., Berthelin, J., Ndoye, I., Leyval, C., Sylla, S., & Duponnois, R. (2009). Changes in soil diversity and global activities following invasions of the exotic Amaranthus viridis L. decrease the growth of native Sahelian Acacia species. FEMS Microbiology Ecology, 70, 118–131. https://doi.org/10.1111/j.1574-6941.2009.00743.x

UNDER PEER REVIEW IN IJAR

Sanon, A., Martin, P., Thioulouse, J., Plenchette, C., Spichiger, R., Lepage, M., & Duponnois, R. (2006). Displacement of an herbaceous plant species community by mycorrhizal and non-mycorrhizal Gmelina arborea, an exotic tree, grown in a microcosm experiment. Mycorrhiza, 16, 125–132.

Sanon, A., Ndoye, F., & Duponnois, R. (2012). Reboisements à base d'essences exotiques, allélopathie et mycorhization contrôlée : améliorer la mise en œuvre de la Grande Muraille Verte. In A. India & R. Duponnois (Éds.), *La Grande Muraille Verte : systèmes agricoles et changement du couvert forestier dans la zone forestière* (pp. 85–96). Paris, France : Éditions de l'IRD

Sonké, B. (1998). Étude floristique et structurale des forêts de la réserve de Dja (Cameroun) (Thèse de doctorat, Université de Yaoundé I, pp. 12–20).

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