Performance of *Dacryodes edulis* mycorrhized layers under different cropping conditions in Makenene, Cameroon

Martin MBEUYO¹, Nehemie DONFAGSITELI TČHINDA²*, Emmanuel YOUMBI¹, Hubert Jean Claude MBITA MESSI¹, Akoa AMOUGOU³

¹Laboratory of Biotechnology and Environment, Faculty of Science, University of Yaounde I, 812 Yaounde, Cameroon
²Medicinal Plants and Traditional Medicine Research Centre, Institute of Medical Research and Medicinal Plants Studies, 6163 Yaounde, Cameroon
³Laboratory of Ecology, Faculty of Science, University of Yaounde I, 812 Yaounde, Cameroon

*Correspondence: donfagsiteli@yahoo.fr

Abstract: *Dacryodes edulis*, with its potential dietary and medicinal uses, is an aging member of the agroforestry system and is classified among the priority species for domestication in Central Africa. Reliable techniques for producing quality planting materials other than seeds are urgently needed. The aims of this study were to produce *D. edulis* layers and integrate them into the cropping system. To promote rooting and the survival rates of layers, 4 treatments were used. The layers produced were inoculated with mycorrhiza and introduced into cropping systems for the evaluation of morphobiochemical parameters. The results show that 67.91% of *D. edulis* trees are planted in cocoa plantations and 32.09% in other cropping systems in Makenene. In addition, 12% of the plants are produced from technical improvement, and 88% from seeds. The use of honey significantly increased layer survival and rooting rates after 2 months. The mycorrhized layers grow better in fallow fields than among food crops or in cocoa-based agroforests. High levels of chlorophylls a and b, total proteins, total amino acids, and peroxidase activity supported higher growth rates of mycorrhized layers. The results show the potential of producing plant materials through layering.

Key words: Agroforestry systems, *Dacryodes edulis*, domestication, layering, mycorrhizal inoculation

1. Introduction

In developing countries, food security is still a challenge and is one of the most pressing needs among rural communities. Initiatives for the adaptation and dissemination of farm product innovations and participatory management of natural resources and integration of trees into farming systems can enhance food provision, income generation, and services, ensuring both the short- and long-term sustainability of agriculture production (Sasson 2012). One solution is to identify new sources of phytomedicines and food in unexploited or underexploited equatorial forests.

*Safou* [*Dacryodes edulis* (G.Don.) H.J.Lam], a Burseraceae tree, is featured prominently among nonconventional oilseeds that are underutilized for medicinal, food, or cultural needs (Ajibesin 2011). It is a woody species found in the forest region of Central Africa and the Gulf of Guinea. This plant has been classified as a priority species for domestication by the International Centre for Research in Agroforestry (Tchoundjeu et al. 2002).

In Cameroon, safou covers a geographical area of about two-thirds of the national territory (Isseri and Temple 2002). The pulp of its fruit (safou) is consumed and appreciated by people in its area of production (Obasi and Okorie 1993). Analysis of nutritional value indicates high levels of fatty acids and amino acids. The oil content of its fresh pulp varies between 33% and 65% depending on the origin and degree of ripeness of the fruit (Silou et al. 1991; Ajayi and Adesanwo 2009). In terms of economic value, safou is ranked third in Cameroon among important fruits, after banana and cola. An evaluation undertaken in 1998 by Isseri and Temple (2002) placed the domestic production of safou at 11,000 t. During this same period, Cameroon exported approximately 651 t to Nigeria, Gabon, and Congo Brazzaville (Ndoye and Ruiz-Perez 1999). In addition to their importance in local and...
national markets, safou fruits are sold to the countries of the European Union (Ndoye and Ruiz-Perez 1999; Awono et al. 2002). Therefore, in ecological and economic terms, it is important to provide opportunities for farmers to diversify and increase their income sources by growing safou in a sustainable cropping system.

The safou sector is underexploited, yet the very few orchards and trees found in the agroforestry system are aging and scattered among food crop fields, coffee or cocoa plantations, and home gardens without any special maintenance. In addition, there is a lack of quality planting materials, reliable propagation techniques, and effective management methods. In general, D. edulis is planted from seeds, resulting in great architectural variability and diversity among the fruits, which differ in yield and physicochemical composition (Kengue et al. 2002; Anegbeh et al. 2005).

To increase the supply of good plant materials, a simple and efficient vegetative propagation technique is essential. Although producing safou plant materials through cutting and grafting is difficult, layering tests carried out by several researchers have shown that it is possible to multiply this plant vegetatively (Okorie et al. 2000; Kengue et al. 2002). Layering has the advantage of producing individuals that conform to the mother plant, and layering shortens production time. Association with beneficial microorganisms, such as vesicular mycorrhizae, will facilitate mineral absorption and, consequently, the growth of layers (marcots) transplanted in the field. The objectives of this study were to produce D. edulis plant materials through layering techniques and integrate them into the cropping system in Makenene, Cameroon.

2. Materials and methods

2.1. Study site

The study was conducted from March to October 2010 in Makenene, Cameroon, which covers an area of 885 km². Makenene is a city located at an average altitude of 580 m and an average temperature of 26°C. The climate of Makenene is humid equatorial with bimodal rainfall, which is characterized by a long dry and rainy season and a short dry and rainy season. The average annual rainfall is 721 mm. Lateritic soils are predominantly sandy clay in the plains and valleys. These soils are deep, fertile, and composed of biodegradable laterite in several places (Letouzey 1985).

The plant cover of Makenene is made up of approximately 60% savannah or shrub and 40% secondary forest, dominated by useful species such as Ricinodendron heudelotii, Irvingia gabonensis, and Albizia sp. (Letouzey 1985).

2.2. Utilization of Dacryodes edulis in cropping systems

An assessment was done by survey form to collect information on farming systems and safou utilization. A total of 150 farmers were interviewed. The questionnaires focused on techniques for soil improvement, cultivation techniques, methods of selection and breeding of plant material, and the marketing system.

2.3. Dacryodes edulis plants

The layering was performed in a peasant field at Kolon village. Approximately 16-year-old trees 8–12 m in height were used in this study. The safou were very productive and free from symptoms of disease, and they were grown from seed. In general, safou trees bloom in December and the first fruits ripen in late May. In cocoa-based agroforests, safou receives no maintenance and no modern cultivation techniques (pruning, fertilizing, phytosanitary treatment).

2.4. Preparation of layers

The layers were prepared at the beginning of the rainy season (March) on orthotropic branches 3–5 cm in diameter. These branches were characterized by an ascending stream of sap and developed in the normal sequence of branching (Kengue 2002). The sheath containing the substrate was then put under the skinned part of the branch. The substrate used consisted of decomposed male inflorescences of oil palm.

2.5. Effect of hormones and honey on the layering

There were 4 treatments used to promote rooting ability: indole-3-butryric acid (IBA), pure honey, a mixture of IBA and pure honey (IBA + honey), and a control without IBA or pure honey. Previous results showed that IBA is more reactive for rooting than indole–acetic acid (IAA) and naphthalene acetic acid (NAA) (Mialoundama et al. 2002). Honey facilitates the healing of the abraded part of shoot, thanks to its antibiotic properties (Kwakman et al. 2010). The cutaway portion of the shoot was coated with pure honey harvested in the savannah at 30 mL layering⁻¹, while IBA was applied to the substrate in dissolved form by syringe at a concentration of 5 mL L⁻¹. The experiment consisted of 80 layers (10 trees × 4 treatments per tree × 2 replications). The layering substrate was kept moist by injecting 50 mL of distilled water every 15 days by syringe. At the end of 2 months, the layers were weaned, and the following parameters were evaluated: survival rate, rate of rooted layers, root number per layering, and root length per layer.

2.6. Mycorrhizal strains and inoculation of layers

Mycorrhizae used for inoculation of layers were provided by the Regional Laboratory for Biological Control and Applied Microbiology, Institute of Agricultural Research for Development (IRAD) of Cameroon. Glomus
intraradices and Gigaspora margarita were used in this study. Onguene (2000) reported these vesicular arbuscular mycorrhizae in association with Burseraceae.

For inoculation, the layers were produced in a new experiment using the earlier treatment that gave the greatest number of roots (IBA + honey). These layers were sown in pots on sterile substrate mixture consisting of black soil and sand in equal volumes. There were 2 treatments in this experiment, control and layers inoculated with 150 g spores 100 g⁻¹ substrate of Glomus intraradices and Gigaspora margarita. The experiment consisted of 100 layers (25 layers × 2 treatments × 2 replicates). A month later, the analysis of root colonization was performed. The roots were cut in small pieces and cleaned with tap water; then they were colored with a mixture of methyl blue (0.01%) + lactic acid–glycerol–water (5:3:2) according to the method described by Phillips and Hayman (1970).

2.7. Performance of layers in cropping systems
The layers were planted in 3 different cropping systems (1 ha for each): cocoa-based agroforests, fallow fields, and food crop farms. Several tree species, such as Ricinodendron heudelotii, Mangifera indica, Persea americana, and Canarium schweinfurthii, were planted together with cocoa under the cocoa-based farming system. Food crop fields consisted of crops such as banana, cassava, and beans; fallow land consisted of unproductive upstream areas of shrub land that had been abandoned for 2 to 3 years for soil conditioning. The experiment consisted of 90 layers [only 90 layers were planted because the other layers were destroyed during handling (15 layers × 3 treatments × 2 replicates)]. Morphological and biochemical parameters were evaluated 4 months after the transfer of layers.

2.8. Assessment of morphological parameters
After 4 months the following parameters were determined: survival rate (SR) of layers, number of branches (NB) per plant, number of leaves per branch (NL), total leaf area per plant (LA), plant height (H), and basal diameter (D). LA was assessed by recording the surface of each leaf on graph paper using a pencil and converting the number of tiles per unit area. Using a measuring tape and callipers, H (height of plant, including the cutting) and D were measured (D was not measured when the planting was done; it was measured at the end). The plants were uprooted and root number (RN) was counted. The length of roots (LR) and diameter at the base of the root (DR) were measured. The roots and leaves were then dried in an oven and their weights (WR and WL) were evaluated using a Sartorius balance with 0.001 precision. These data were processed using SPSS 10.1 for Windows.

3. Results

3.1. Integration of Dacryodes edulis in cropping systems
The agroforestry system in Makenene is multifaceted. According to surveys conducted, farmers aim to diversify and optimize agricultural production through the ecological and socioeconomic development of effective and sustainable farming systems. Several species and crop types are integrated: food crops (such as maize, cassava, and plantain), export crops (cocoa), fruit trees, and medicinal plants. Among the fruit trees, D. edulis is grown for its pulp, which is rich in oil. Its culture requires the involvement of several stakeholders (farmers, exporters of fruits, small retailers, and agricultural extension services). Throughout the area, 88% of farmers confirm that they plant safou. The majority of safou plants (88%) are planted from seeds derived from adult individuals, while 12% are...
from conventional breeding techniques (aerial layering). The seeds used are selected from trees bearing large, nonacid fruits that are rich in oils.

Air layering is a recent technique that was introduced by researchers from IRAD in Cameroon, following the training of farmers interested in growing this plant. Currently, there are safou populations from layering in the different cropping systems (Figure 1). The cultivation of safou is promoted by introducing its edible fruits into the daily diet of households. In addition, the leaves and bark are used in traditional medicine.

The safou orchards are located in the following cropping systems: gardens among food crops, cocoa-based agroforests, and fallow fields. At Kolon village, Makenene, 67.91% of 589 safou plants were found in the cocoa farms; 23.44% and 8.65% were in gardens among food crops and falls, respectively. The plants do not benefit from phytosanitary treatment or amendment, as the farmers believe that fallen leaves are a potential source of natural fertilizer. The commercialization of the best quality fruits (Figure 1) is ensured by small retailers, 62% of whom are also producers, while wholesalers (6% also produce) ensure the supply in the cities of Cameroon (such as Yaounde, Douala, and Kribi), Gabon, and Equatorial Guinea.

3.2. Air layering

The layers were made on orthotropic twigs, with a substrate of male inflorescences of oil palm (Figure 2). The roots of the layers began to form and were visible through the transparent sheath a month later. At this time the maximum survival of layers (95%) was obtained with the honey treatment (Table 1). After 2 months the roots were well developed, with a significant maximum rate of 95% for the honey treatment compared to 45% for control (Table 1). The maximum number of roots per layer (19) was obtained with IBA + honey. All treated layers had a significantly higher number of roots per layer than the control (Table 1). However, control gave significantly longer root length (26.3 cm) than the other treatments (Table 1).

3.3. Growth of layers under different cropping systems

The layers that produced the maximum number of roots (IBA + honey treatment) were inoculated with mycorrhizae and tested in different cropping systems. Mycorrhizae had beneficial effects on growth and development of the

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**Figure 1.** *D. edulis* in the agroforestry system in Makenene: a) layered plant in a cocoa field, b) layered plant in a crop field, c) fruits from layered plants on sale in the local market, and d) fruit from layered plants ready for export.
layers (number of leaves formed, their surface, and color) 4 months after transplantation (Figure 2). The highest significant (P < 0.05) survival rates were recorded in food crops fields as compared to cocoa-based agroforests and fallow fields. However, the highest values of NL, LA, H, D, and WR were found in mycorrhized layers planted in the fallow fields. These results are confirmed by the higher MI for nonmycorrhizal and mycorrhizal layers in the fallow areas: 29.72 and 28.55, respectively (Table 2). However, the highest VI of layers was recorded in the cocoa-based agroforests. There was a positive and significant (P < 0.05) correlation between NL and NR (r = 0.695), NL and LA (r = 0.724), WL and NL (r = 0.691), LR and NL (r = 0.715), and VI and H (r = 0.756).

3.4. Biochemical parameters
The highest levels of chlorophyll a and b, proteins and amino acids, and peroxidase activity were found in mycorrhized layers established in fallow fields 4 months after the transplantation of layers (Table 3). However, in the fallow areas, the content of chlorophyll a and b was

![Figure 2. Different stages of air layering in a cocoa plantation: a) placing a layer, b) rooted layers after 3 months of treatment, c) 2-month mycorrhizal layers, and d) 2 month nonmycorrhizal layers.](image)

### Table 1. Growth parameters of *D. edulis* layers (2 months after layering).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Survival rates (%)</th>
<th>Rooting rates (%)</th>
<th>Number of roots per layer</th>
<th>Average length of a root per layer (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>85 ± 05&lt;sup&gt;a&lt;/sup&gt;</td>
<td>45 ± 15&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8.1 ± 1.3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>26.3 ± 3.5&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>IBA</td>
<td>85 ± 05&lt;sup&gt;a&lt;/sup&gt;</td>
<td>80 ± 00&lt;sup&gt;b&lt;/sup&gt;</td>
<td>16 ± 2.4&lt;sup&gt;b&lt;/sup&gt;</td>
<td>20.2 ± 3.1&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Honey</td>
<td>95 ± 05&lt;sup&gt;c&lt;/sup&gt;</td>
<td>95 ± 05&lt;sup&gt;d&lt;/sup&gt;</td>
<td>13 ± 1.9&lt;sup&gt;b&lt;/sup&gt;</td>
<td>22.9 ± 2.4&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>IBA + honey</td>
<td>90 ± 00&lt;sup&gt;b&lt;/sup&gt;</td>
<td>90 ± 00&lt;sup&gt;c&lt;/sup&gt;</td>
<td>19 ± 2.9&lt;sup&gt;d&lt;/sup&gt;</td>
<td>17.2 ± 3.5&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Values having same letters in the same column are not significantly different according to Duncan's multiple range test (P < 0.05).
not significantly different between mycorrhized and nonmycorrhized layers (Table 3). Moreover, the opposite phenomenon was observed with proteins and amino acids in food crop fields and cocoa farms where the mycorrhizal effect was significantly different. There was a significant positive correlation between levels of amino acids and protein (r = 0.92).

4. Discussion
Agroforestry is the practice of combining woody perennial and herbaceous plants in the same cropping system, both in time and in space. In the agroforestry system, there is ecological interaction of plants. The system aims to address the problems of soil infertility and land degradation while diversifying and improving agricultural production (Okafor 2002). The integration of D. edulis into the agroforestry system in Makenene fulfils these environmental and production objectives. This explains why safou is among the priority plants that have been adopted by most African populations for cultivation in different distribution areas (Molet et al. 1994). In Nigeria, for example, safou trees, hazel (Plukenetia conophora), and oil bean (Pentaclethra macrophylla) are the 3 most dominant woody perennial plants in the cropping system (Okafor 2002). In the south of Cameroon farmers introduced the following plant species into the agroforestry system in addition to D. edulis: Irvingia gabonensis and Elaeis guineensis; timber trees of high value such as Terminalia superba and Chlorophora excelsa; exotic fruit trees such as Persea americana, Mangifera indica, and Citrus spp.; and medicinal plants such as Alstonia boonei (Sonwa et al. 2002).

At Makenene, although plant selection was low and random, farmers were still able to obtain individuals that produced safou fruits of exceptional quality based on size and taste, which is associated with oil content (Youmbi et al. 2010). This success is also linked to the layering technique of multiplication used by some farmers on selected individuals that then retain their characteristics. Only 8.65% and 23.44% of safou were found in fallow and food crops fields, respectively, for the simple reason that cocoa-based agroforest is the dominant cropping system in Makenene. Cocoa plantations are able to provide moisture for the development of safou trees. Another reason given by farmers is that high-moisture environments can reduce the spread of fire, thus promoting the resistance of safou to this hazard.

The marketing of Makenene safous in local, national, regional, and international markets generates income. Although precise figures are not available, Tchatat (1999) emphasized that the balance of trade in the border markets of Central Africa (such as Amban-Minko and Kyossi) weighs in favor of Cameroon, which sells huge amounts of D. edulis from production areas such as Makenene.

The development of a proper vegetative propagation technique is essential for the production of high quality

### Table 2. Morphological parameters of layers 4 months after transplantation in the field.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Food crops field</th>
<th>Cocoa-based agroforest</th>
<th>Fallow field</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control</td>
<td>Mycorrhizal layer</td>
<td>Control</td>
</tr>
<tr>
<td>SR (%)</td>
<td>80.0 ± 6.66b</td>
<td>83.3 ± 3.33b</td>
<td>40.0 ± 6.6a</td>
</tr>
<tr>
<td>NB</td>
<td>2.5 ± 0.2a</td>
<td>2.6 ± 0.9a</td>
<td>3.0 ± 0.5b</td>
</tr>
<tr>
<td>NL</td>
<td>41.5 ± 3.2b</td>
<td>84.7 ± 5.3d</td>
<td>36.0 ± 3a</td>
</tr>
<tr>
<td>LA (cm²)</td>
<td>581.0 ± 13b</td>
<td>1185.0 ± 23d</td>
<td>504.0 ± 9a</td>
</tr>
<tr>
<td>H (cm)</td>
<td>31.0 ± 2a</td>
<td>44.8 ± 4.4c</td>
<td>35.0 ± 2.4b</td>
</tr>
<tr>
<td>D (cm)</td>
<td>5.2 ± 0.8a</td>
<td>6.1 ± 1.1a</td>
<td>4.6 ± 0.9b</td>
</tr>
<tr>
<td>NR</td>
<td>13.5 ± 2.1a</td>
<td>18.5 ± 1.8b</td>
<td>20.0 ± 2.3b</td>
</tr>
<tr>
<td>LR (cm)</td>
<td>19.0 ± 1.3a</td>
<td>28.0 ± 3.1b</td>
<td>15.0 ± 2.1a</td>
</tr>
<tr>
<td>DR (cm)</td>
<td>0.5 ± 0.1a</td>
<td>0.5 ± 0.02a</td>
<td>0.6 ± 0.1b</td>
</tr>
<tr>
<td>WR (g)</td>
<td>3.2 ± 0.9a</td>
<td>4.4 ± 0.5b</td>
<td>1.3 ± 0.3b</td>
</tr>
<tr>
<td>WL (g)</td>
<td>6.3 ± 1.2a</td>
<td>13.7 ± 1.3b</td>
<td>5.0 ± 1.0a</td>
</tr>
<tr>
<td>VI</td>
<td>17.8 ± 2.3a</td>
<td>25.5 ± 3.7c</td>
<td>21.0 ± 2.2b</td>
</tr>
<tr>
<td>MI</td>
<td>8.9 ± 1.8b</td>
<td>8.3 ± 1.6b</td>
<td>5.4 ± 1.3a</td>
</tr>
</tbody>
</table>

Values having same letters in the same line are not significantly different according to Duncan's multiple range test (P < 0.05). SR: survival rate, NB: number of branches, NL: number of leaves per branch, LA: leaf area, H: plant height, D: diameter of stem, NR: number of roots, LR and WR: length and weight of the root, DR: diameter of root, WL: weight of leaves, VI: vigor index, MI: morphological index.
material. Cuttings and graftings of mature safou trees have failed so far (Damesse et al. 2002). However, previous studies have shown that it is possible to multiply this plant by layering (Okorie et al. 2000; Kengue 2002). Our work was to optimize conditions for regeneration. Emphasis was placed on the IBA and honey treatments. In 2 months, high rates of survival (95%) and rooting (95%) of layers were obtained (in honey treatments). These results are superior to those of Okorie et al. (2000), who obtained 88% rooting in layers 4 months after cropping. In most studies the waiting times for layer rooting varies between 4 and 6 months, with percentages lower (52%–90%) than those obtained in our study (Damesse et al. 2002; Kengue 2002; Mialoundama et al. 2002). Honey may be a very positive external factor for the rooting of layers. It plays both physical and biochemical roles. The viscosity of honey protects the cells of the wood from water stress or dehydration after skinning by maintaining favorable osmotic potential. It also facilitates healing of the abraded part of the shoot, thanks to its antibiotic properties (Viuda et al. 2008). Honey is an organic material rich in sugars, vitamins, minerals, and amino acids. These substances are likely to be assimilated directly in the process of root initiation without the need to wait for synthesis to be initiated by the leaves and buds of the branches. The honey + IBA treatment did not further improve the rooting of layers when compared to honey. However, their combined action resulted in a significantly higher number of roots per layer. IBA, which is a synthetic auxin, acts in synergy with the honey for induction and proliferation of roots on the layers.

When the rooted and mycorrhized layers were transferred to the fields, it was found that mycorrhizae generally have a beneficial effect on the growth and development of plants when compared to the control. Because of their abundance in different soils and their influence on nutrition and crop protection, mycorrhizae represent a significant potential for sustainable agriculture that uses fertilizers and pesticides judiciously (Garg and Chandel 2011; Ong et al. 2012). Several studies have shown a mutually beneficial relationship between the roots of most plants and some types of fungi-forming mycorrhizae (Moora et al. 2004; Tüfenkçi et al. 2012). These mycorrhizal associations are involved in facilitating mineral absorption, especially in the poor soils that dominate tropical rain forests (Bothe and Hildebrandt 2002; Parniske 2008; Garg and Chandel 2011). In our study, this mineral absorption resulted in the ability of mycorrhizal layers to develop a number of leaves and roots and a significantly higher leaf area than in nonmycorrhized layers.

Dacryodes edulis, like most Burseraceae, is associated with arbuscular vesicular mycorrhizae. Better nourished, the mycorrhizal plants grow more vigorously, fructify abundantly, and ensure productivity in plantations (Vega-Frutis et al. 2011). In the current study, fallow areas were more favorable for the growth and development of this species. Higher organic matter accumulation in the fallow areas than in other cropping systems may promote the growth of safou.

Levels of chlorophylls a and b, total protein, total amino acids, and peroxidase activity were higher in mycorrhized layers planted in fallow fields than in mycorrhized layers grown in cocoa-based agroforests or food crop fields. Plants in fallow areas receive more sunlight compared to those in cocoa fields. This exposure to sunlight and the richness of the soil influence the accumulation of chlorophyll, which is indirectly used in the synthesis of organic matter.

### Table 3. Biochemical parameters of layers 4 months after transplantation in the fields.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Food crops field</th>
<th>Cocoa-based agroforest</th>
<th>Fallow field</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control</td>
<td>Mycorrhizal layer</td>
<td>Control</td>
</tr>
<tr>
<td>Chlorophyll b (mg FW mL⁻¹)</td>
<td>0.21 ± 0.02ᵇ</td>
<td>0.10 ± 0.01ᵃ</td>
<td>0.08 ± 0.001ᵇ</td>
</tr>
<tr>
<td>Chlorophyll a (mg FW mL⁻¹)</td>
<td>0.45 ± 0.1ᵃ</td>
<td>0.54 ± 0.1ᵇ</td>
<td>0.56 ± 0.02ᵇ</td>
</tr>
<tr>
<td>Proteins (µg mg⁻¹ FW⁻¹)</td>
<td>0.50 ± 0.03ᵃ</td>
<td>0.90 ± 0.1ᵇ</td>
<td>0.80 ± 0.09ᵇ</td>
</tr>
<tr>
<td>Amino acids (µg mg⁻¹ FW⁻¹)</td>
<td>13.20 ± 1.6ᵇ</td>
<td>16.10 ± 1.8ᵇ</td>
<td>17.80 ± 2.5ᶜ</td>
</tr>
<tr>
<td>Pox (OD g⁻¹FW⁻¹ 5 mn⁻¹)</td>
<td>20.20 ± 3.5ᶜ</td>
<td>18.60 ± 2.7ᵇ</td>
<td>15.20 ± 1.9ᵃ</td>
</tr>
</tbody>
</table>

Values having same letters in the same line are not significantly different according to Duncan’s multiple range test (P < 0.05). FW: fresh weight, Pox: peroxidase.
notably proteins and amino acids. Peroxides as a group are the most abundant proteins in the plant, and they are very active during growth phenomena such as root, leaf, and bud development. In addition, fallows are generally very rich in organic and mineral matter (Djoumessi et al. 1997). Nitrogen is an essential element for growth and development of the plant. It can be found in the form of amino acid and protein (notably peroxides, the most abundant category in plants) in plant roots, leaves, buds, and grains (Maurot-Gaudy 1997). Amino acids and proteins serve to elaborate their enzymatic structures, in particular for the construction of the photosynthetic system. Conditions in the fallow milieu, in the presence of favorable sunlight, led to the synthesis of more chlorophyll by the layers, which also had larger leaf surface areas. On the basis of morphobiochemical parameter assessment, the fallow system is the most suitable for growing layers of *D. edulis*.

Integrating safou in fallow areas using mycorrhized layers could significantly improve production time and the quantity and quality of fruit in the agroforestry system in Makenene.

References


