DOMESTICATION OF *Vitex madiensis* IN THE ADAMAWA HIGHLANDS OF CAMEROON: PHENOLOGY AND PROPAGATION

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Abstract

Vitex madiensis Oliv. is an agroforestry shrub valorized for food and medicinal purposes. This study was carried out to investigate its phenology and determine the effects of the stock plant height, branch size and position on rooting potential of *V. madiensis* native to the Adamawa highlands of Cameroon. The phenology of the species was monitored from 1997 to 2002 in the Sudano-Guinean Savannah. The leafy juvenile cuttings with single nod were collected from new branches of stock plants at 0, 25, 50, 100, 150, 200 and 250 cm heights at the beginning and propagated in polypropagators. In aerial layering, marcots were organized on three types of woods (mature, semi-mature and soft wood) on the branches and two branch diameters (higher and lower than 6.67 cm) were considered. In the region, fruiting period in *V. madiensis* varies from March to August and the seeds are dormant. The rooting potential of cutting was significantly influenced by the stock plant height and this effect was consistent at 0 cm height with 45.83 % of the rooted cuttings. This stock plant height also significantly enhanced the number of roots per cutting (8.72) and improved their length (12.73 cm). Type of wood and branch diameter significantly affected rooting in aerial layering and the highest rooting percentage (100%) were recorded for the marcots made on medium wood parts of branches which had larger diameter than 6.67 cm. With respect to wood types, the mean rooting percentage of the marcots varied from 40% (hard wood) to 80% (middle wood). For the branch diameter, mean marcot rooting percentage increased from 20% to 46.7% with increasing branch diameters. These results indicate that *V. madiensis* is suitable to vegetative propagation by cutting and aerial layering.

Key words: *Vitex madiensis*, domestication, phenology, vegetative propagation, rooting ability

Kamerun'un Adamawa Dağlık Bölgesinde *Vitex madiensis*'in Kültüre Alınması: Fenoloji ve Çoğaltma

Özet

Vitex madiensis Oliv. tıbbi ve beslenme amaçlı kullanılan önemli bir çalı türüdür. Bu çalışmada, Kamerun'un Adamawa Dağlık Bölgesinde doğal olarak yetişen bu türün fenolojisi incelenmiş ve köklenme yeteneği üzerine ana bitki boyu, dal çapı ve pozisyonunun etkileri araştırılmıştır. Bitkilerin fenolojik özellikleri 1997 ve 2002 yılları arasında Sudano-Guinean Savannah'da incelenmiştir. Genç, yapraklı ve tek boğumlu çelikler, başlangıçtaki boyları toprak seviyesinden 0, 25, 50, 100, 150, 200 ve 250 cm yükseklikte olan ana bitkilerin yeni sürgünlerinden alınmış ve çoklu çoğaltma kaplarında köklendirilmişlerdir. Daldırma ile çoğaltmada, çapları 6,67 cm'den küçük ve büyük dalların odunsu, yarı odunsu ve odunlaşmamış bölümlerinde hava daldırması yapılmıştır. Bölgede *V. madiensis*'in meyve vermesi mart ve ağustos ayları arasında gerçekleşmekte ve tohumlar dormant durumda olmaktadır. Başlangıçtaki ana bitki boyu çeliklerin köklenme potansiyelini önemli düzeyde etkilemiş ve en yüksek köklenme oranı (%45.83) başlangıçta boyu 0 cm olan ana bitkilerden elde edilen çeliklerde saptanmıştır. Bu başlangıç ana bitki boyu, ayrıca çelik başına düşen kök sayısını (8.72) ve kök uzunluğunu (12.73 cm) da olumlu yönde etkilemiştir. Hava daldırmasında, dalların çapı ile daldırmanın yapıldığı noktalarda odun dokusunun olgunluk durumu köklenme oranlarını önemli düzeyde etkilemiştir. En yüksek köklenme oranı %100 ile çapı 6,67 cm'den büyük dalların yarı odunsu bölümlerinde yapılan hava daldırmasından elde edilmiştir. En düşük ortalama köklenme oranı yumuşak odunsu dokularda yapılan hava daldırmalarında ortaya çıkmış, bu oran odunsu noktalarda %40 ve yarı odunsu noktalarda ise ortalama %80 olarak saptanmıştır. Dal çapı açısından en yüksek hava daldırması köklenme oranı ortalama %46,7 ile çapı 6,67 cm'den büyük dallarda belirlenmiş, bu oran çapı 6.67cm'den küçük dallarda %20,0'ye düşmüştür. Araştırma sonucunda *V. madiensis*'in çelikle ve hava daldırması ile vegetatif olarak çoğaltmaya uygun olduğu saptanmıştır.

Anahtar Kelimeler: *Vitex madiensis*, Kültüre Alma, Fenoloji, Eşeysiz Çoğaltma, Köklenme Yeteneği

1. Introduction

Vitex madiensis Oliv., (syn. *Vitex camporum* Büttn, *Vitex barbata* Planch. ex Bak, *Vitex pobeguini* Aubrév.), belongs to the Verbenaceae family. It is a shrub tree ranging in height from 3 to 5 m. The species grows in the savannah. In the highlands of

the Adamawa, it is known as "boumehi" in fufulde, "billiti" in gbaya. The species is among the top agroforestry tree species widely used in the Central and West Africa for many purposes (food, medicinal, etc.) (Hutchinson and Dalziel, 1963; Baumer, 1995; Mapongmetsem, 1995; Ngassoum *et al*., 2004).

The fruits from the plant are edible, in the sudano–guinean savannah. They are mainly harvested by women, consumed and commercialized in the local and regional market (Mapongmetsem *et al*., 1997; Tchiégang–Megueni *et al*., 2001; Mapongmetsem, 2005a). In addition, the roots and aerial parts of the species are used for medicinal purposes against headaches, indigestion, stomach pain (Hutchison and Dalziel, 1963; Kerharo and Adam, 1974). The flowers are good forage for bees (Tchuenguem *et al*., 1998).

The essential oils from *Vitex madiensis* can be used for cosmetic and food properties due to their good aroma (Kubo *et al*., 1984; Mapongmetsem *et al*., 2004).

Despite the socio–economic importance of the species, it is still in the wild state where it is subjected to various biotic and abiotic pressures (Mapongmetsem *et al*., 1998). Domestication and introduction of agroforestry species in farmer's lands could improve the life stand of the rural populations (Tchoundjeu *et al*., 1998). Unfortunately, the propagation techniques of the species are unknown. This constraint justifies and motivates the present investigation. Vegetative propagation is the most important domestication techniques used for agroforestry tree species (Tchoundjeu *et al*.,1997; Tchoundjeu *et al*., 1998).

The overall objective of this study is to elaborate domestication strategies of the species for stimulating farmers to intensively cultivate it in agroforests of the area. The specific aims are to: determine the fruiting period; identify the best germinative pretreatment; identify the stock plant height which can improve the rooting ability of the species; identify the type of wood and the branch diameter which significantly improve the rooting potential of the marcots. The goal of these management techniques is to produce a large number of easily rooted cuttings or marcots on a regular basis over a long period of time and to provide farmers with sound vegetative materials.

We hope that this information will help in elaborating appropriate domestication strategies for the species.

2. Materials and methods

2.1. Study site

The Adamawa highlands spread between the latitude 7°2 36'N and the longitude13°34'72E. The climate type is sudano-guinean with one active dry season (October-March) and a rainy season covering the remaining of the year. The yearly average total precipitation is 1315.6mm with a yearly total mean evaporation of 1902.95 mm. The distribution of the rainfall is monomodal (Fig.1). Two main winds blow in the region notably the monsoon during the rainy season from the South and the harmattan from the North responsible for the drought (Mapongmetsm *et al*., 2002 and 2005). The soil of the area is rich in ferruginous compounds derived from granites, granodiorites and of gneiss after rejuvenation and is composed of red ferralitic developed on old basalts (Yonkeu, 1993). The vegetation is mainly composed of prairies and shrubby and/or woody savannah with consistent predominance of *Daniellia oliveri* and *Lophira lanceolata* (Letouzey, 1968). Nowadays, the density of these species is strongly decreased under the influence of human activities (Mapongmetsem *et al*., 2000).

2.2. Phenology

Phenological observations were undertaken at Borongo, Bini, Dang and Tyson stations. In each of these stations, 10 trees were labelled and followed from 1997 to 2002. The experimental design was a randomized complete bloc with four replications corresponding to the aforementioned locations. The treatments were represented by the different years. The frequency of observations was twice a

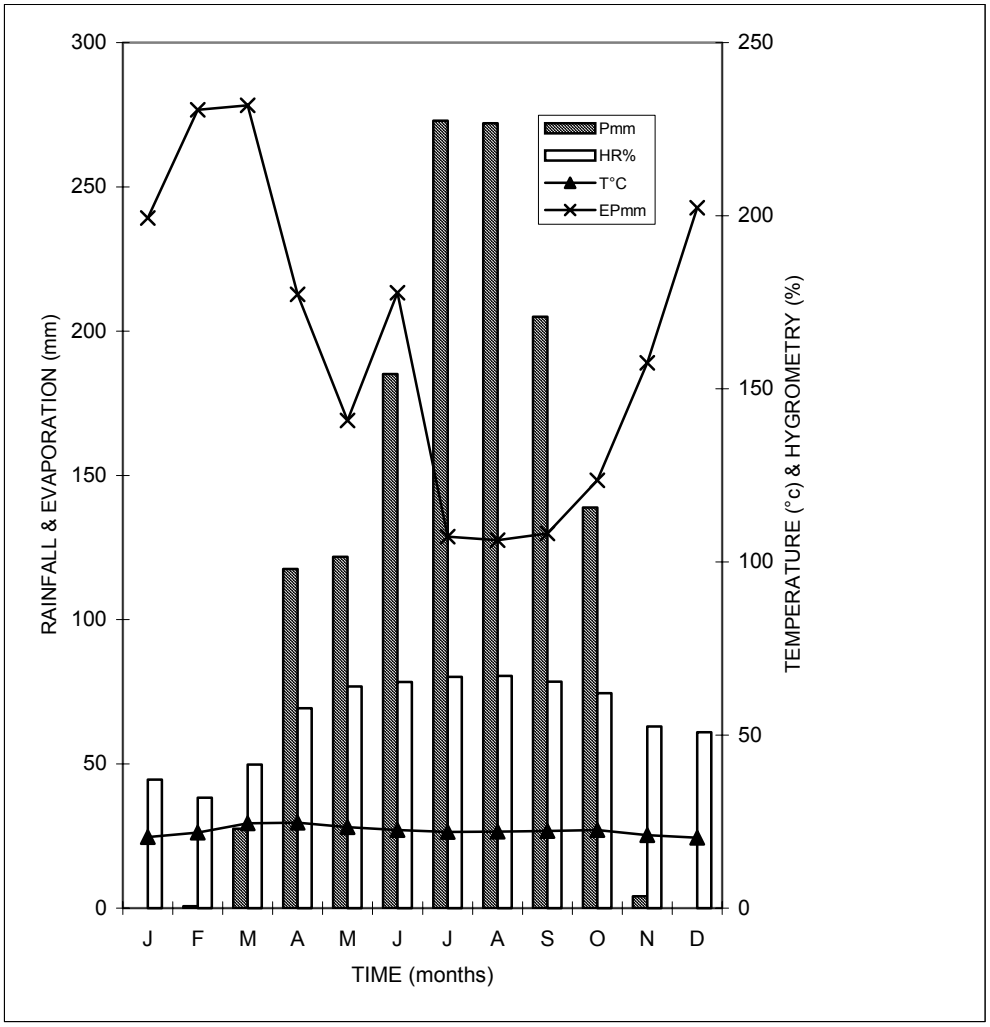

Figure 1. Meteorological feature of the Sudano-Guinean Savannah.

month. A tree is defoliated if it shades off all its leaves and refoliated when at least 75 % of the branches renew leaves. It is in flowers or in fruits when at least a flower or a fruit is observed on the tree (Grouzis, 1991; Poupon, 1980; Mapongmetsm *et al*., 1995; Mapongmetsem, 2005b).

2.3. Seed germination

Verbenaceae are known to have dormancy. To improve the germination of the present species, 6 pretreatments were used to fragilize the integuments of the seeds in order to enhance their germination. They were manual scarification with a blade razor, soaking in sulphuric acid (98%) for an hour, soaking in ordinary water(48h), soaking in boiling water (100 °C) (12h) after the suppression of the heat source, soaking in ordinary water (24h) and soaking in ordinary water during the same duration as above and then drying twice in the sun. The experimental design was a randomised complete bloc with 4 replications. The different pretreatments were the treatments. The experimental unit was made up of 50 seeds. The duration of following up the trial was 6 months.

2.4. Vegetative propagation

2.4.1. Propagation by cuttings

The rooting process of cuttings of woody plants is complex in that there are numerous factors that influence rooting ability and if any one is overlooked, the result can be failure (Leakey, 1989). In attempt to develop better stockplant

management techniques, adult trees were felt in different locations in the natural savannah (Dang, Borongo and Bini) at different heights: 0, 50, 100, 150, 200 and 250 cm. After three months, young shoots yielded, were harvested very early in the morning and carried in an ice box from the field to the nursery. Shoots were cut into single node and leafy cuttings, and were inserted in the rooting bed in a randomised complete block design with three replications. The polypropagator was built with local materials according to the method developed by Leakey (1989). The experimental unit was made up of 30 cuttings. The different heights of the rootstock represented the treatments. The rooting media was constituted by sand /sawdust mixture which was give high rooting percentage. For the cuttings, only those from the second and third positions were considered. Cuttings from different node positions vary in many ways. Those from the abovementioned positions yielded high rooting percentage (Leakey, 1989). Concerning the growth hormone, seradix 3 was used. Cuttings were sprayed twice a day (morning and evening).

2.4.2. Aerial layering (marcottage)

Investigations were undertaken in the locations of Bini, Borongo and Dang. Marcots were set up on healthy and untraumatized trees. Branches selected were classified in two categories: branches with diameter (sizes) less than and greater than 6.67 cm. In addition to the diameter of the branch, the type of wood was also taken into consideration. They were hard (base of the branch or mature wood), semi-hard (semi mature) and soft (green wood, summit of the branch) woods. A sharp knife was used to make annulations of 6 cm long each, on orthotrope branches. Then a film of a white polyethylene paper was placed under the area where the bark was removed. The paper was hermetically adjusted and a rube was fixed to its two extremities. There was only one marcot per branch. Cow dung and Seradix 3 were chosen respectively as rooting media and growth hormone substance (Mapongmetsem, 2001). Marcots were harvested after 5 months when roots were formed, and brought to the nursery for acclimatizing.

The experimental design was a split-plot with three replications corresponding to the above locations. The experimental unit was made up of 10 marcots. The main treatment was represented by the type of wood whereas the sub-treatment corresponded to the size of the branch. The observation frequency was twice a month for a period of five months.

2.5. Data collection and analysis

Data collected during the various investigations were: number of trees defoliated, refoliated, bloomed and fruit set; the number of fruits per tree; the number of seeds germinated, the number of cuttings and marcots rooted, the number of roots per cutting and the length of the root. These data were subjected to analysis of variance, correlation and regression. Statistical programmes used, were Statgraphics plus 5.0 and Statistica v6.0 SR. Separation of the means was by Least Significant Difference (LSD) at 0.05.

3. Results and discussion

3.1. Phenology

The ageing of leaves was noticed towards the month of September. However, the shade off started in November and ended in January. Compared to *Vitex doniana*, the defoliation in *Vitex madiensis* was progressive (Mapongmetsem *et al*., 2005). The maximum number of defoliated trees was obtained in Mid-December. The deciduous period ranges from 3 to 5 weeks. The species renews leaves during the dry season from January to March. Neofoliation is associated to flowering. The association between vegetative function and reproductive function has been reported in *Cordia platythyrsa*, *Milicia excelsa*, *Ricinodendron heudelotii* and *Terminalia superba* (Mapongmetsem *et al*., 2002). The species blooms from December to April. The peak of flowering is observed in

February and fruiting occurred from March to August. The first fruits mature and ripen in April. The ripe fruit are dark. The harvesting period is scheduled between March and April. The phenological patterns of the species vary from year to year (Fig.2a). For the productivity of the species in terms of fruits, the year 2001 was the most productive (Fig.2b)

A good knowledge on the fruiting period helps to know when and where to harvest seeds and to program the nursery activities and farm plantations.

3. 2. Seed germination

Of the six pretreatments applied on the seeds, only the manual scarification induces the germination of the species. The percentage germination obtained from the

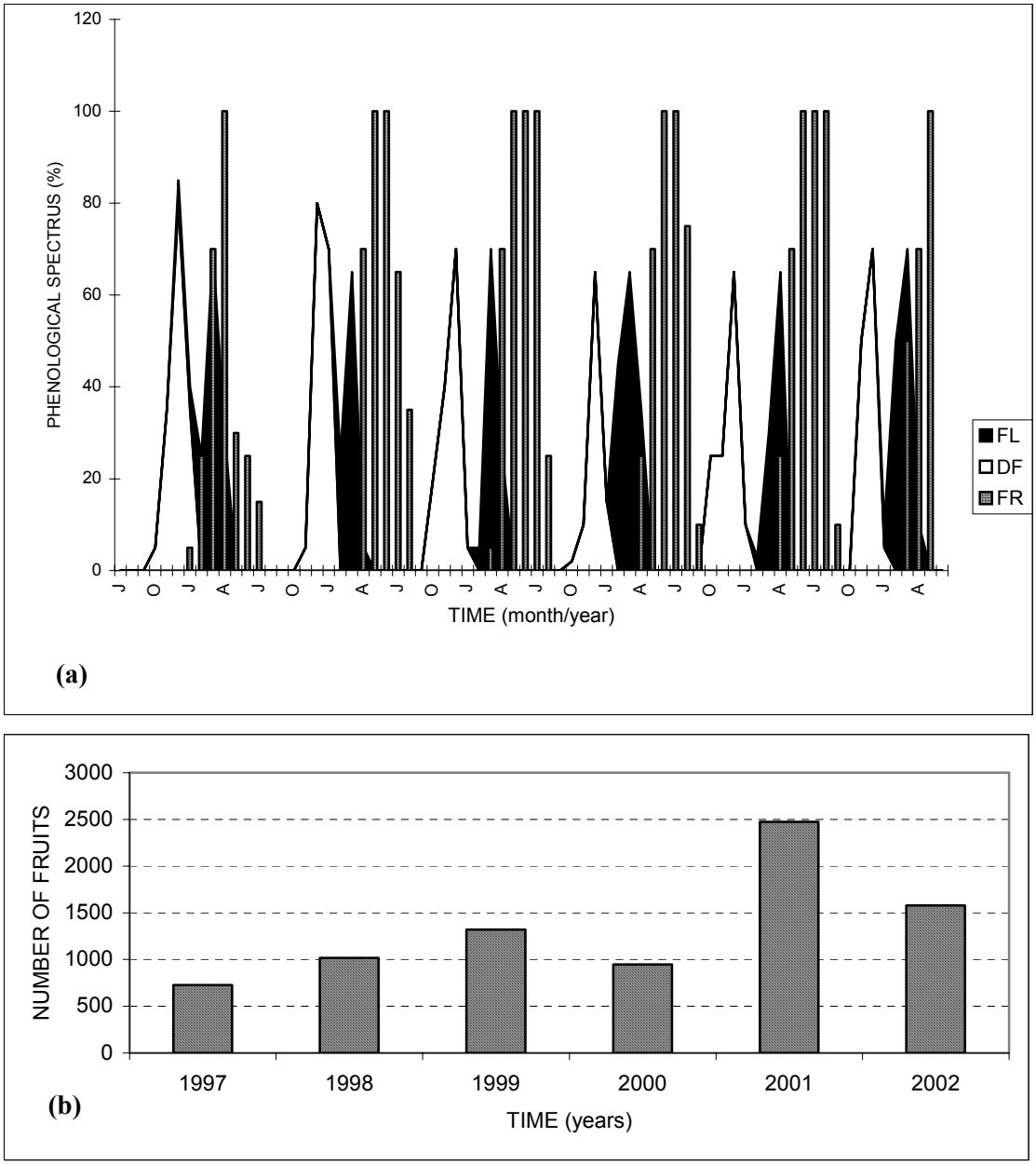

Figure 2. Phenogramme showing interannual variability of phenological spectrus (a) and productivity (b) of *Vitex madiensis* in the Sudano-Guinean savannahs (DF = Defoliation, FL = Flowering and FR = Fruiting).

mechanical scarification is 5.68 %. This result indicates that the seeds have hard seed coat. In *Vitex doniana* belonging to the same family, the germination percentage was still been low: 11.25% (Mapongmetsem, 2005b). These results differ from those of Maghembe *et al*. (1992).

Trees coming from the same mother tree are not similar among themselves and they are scarcely similar to the mother tree. This results in a great diversity of vegetative, pomologic and organoleptic characters. Vegetative propagation helps to obtain clonal material from individuals having interesting characteristics.

3.3. Vegetative propagation

3.3.1. Rooting of single node cuttings

In *V. madiensis*, rooting had started to occur after five weeks. This period is in agreement with the one reported on forest tree species like *Triplochyton scleroxylon* (Leakey, 1983; Leakey, 1989). During the first weeks in the polypropagator, a greater proportion of cuttings from stockplant of 0 cm in height rooted (45.8%) than cuttings from rootstock of more than 25 cm in height (Fig.3). After eight weeks, rooting exceeded 30% in cuttings from stock plants with 25 and 50 cm in height. At the end of the ninth week period of propagation, a significant difference ($0.000 < 0.001$) in rooting percentage attributable to stock plant height occurred between cuttings from stock plants with 0 - 50 cm in height (45.8-30.0%) and those from height 100 – 250 cm (11.5 – 2.8 %). The rooting potential from the beginning to the end of the experiment was also different independent of the stockplant height ($0.00007 < 0.001$). There was a significant negative correlation between the stock plant height and the percentage of rooted cutting ($r = -0.92$; $0.0030 < 0.001$).

The mean number of roots per cutting varied from 0.21 roots in cuttings from the stock plant height at 150 cm to 8.72 roots for cuttings from the stock plant height at 0 cm (Table 1). The mean number of roots per cuttings varied significantly with the stock plant heights ($0.0089 < 0.01$). There was also a significant inverse correlation between stockplant height and the mean number of roots per cutting ($r = -0.79$; $0.034 < 0.05$).

The mean length of the root per cutting ranged from 0.89 cm in cuttings from stockplants with 200 cm height to 12.73 cm in cuttings from stock plants whose height was 0 cm. The difference between the stock plant heights in terms of root length was significant ($0.019 < 0.05$). There was a significant correlation between the number of roots and their length ($r = 0.95$; $0.0008 < 0.001$). In addition, significant and positive correlations existed between rooting percentage and number of roots per cutting ($r = 0.96$; $0.0006 < 0.001$), lengths of root ($r = 0.87$; $0.01030 < 0.01$). These results indicated that increases in the stock plant height decreased the rooting percentages, the number of roots per cutting and root lengths. Higher the rooting percentages also resulted in higher numbers of roots per cutting and root lengths.

These various results showed that when rootstocks were cut back in different heights, they could develop different numbers of shoots per plant and major differences appeared in their rooting ability.

3. 3. 2. Rooting of marcots

Roots formed in *V. madiensis* were numerous and occupied the totality of the substrate during the period of harvesting after 5 months. Such a pattern was a good sign for the mechanical stability of rooted marcots when planted in the farm. Roots formation was fast compared to other species (Mapongmetsem *et al*., 1999). The first roots appeared after 3 months on semi hard woods (15.46%) after marcots set up. Similar results have been reported for *Dacryodes edulis* (Kengue et Tchio, 1994, 1997; Kengue *et al*., 1998; Mampouya *et al*., 1994).

The rooting percentage ranged from 20% (diameter of branch <6.67 cm) to 46.66% (diameter of branch >6.67 cm) and the effect of diameter size on the marcots rooting was significant ($0.031<0.05$). These results suggested that big branches (diameter > 6.67 cm) were suitable for marcots than the small ones.

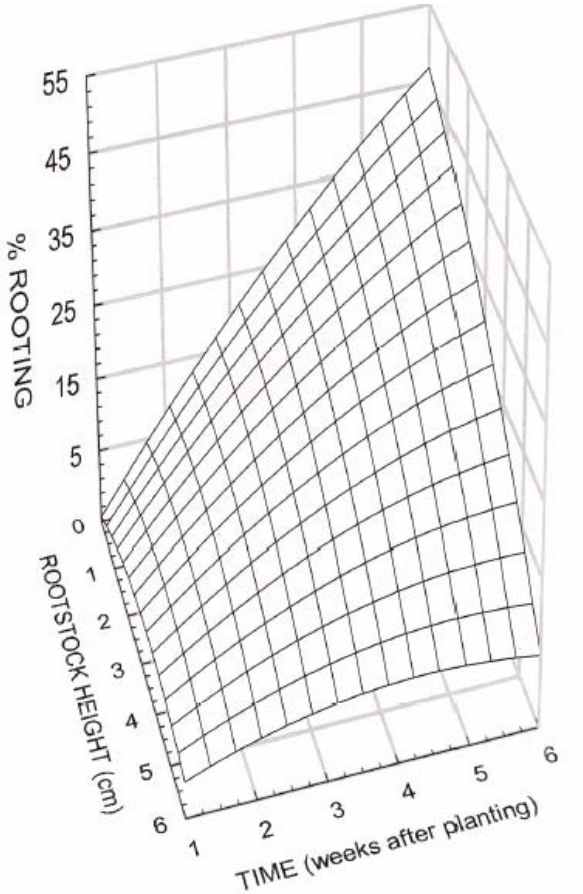

Fig.3. Rooting potential of *Vitex madiensis* cuttings (1 = 0 week after planting, 2 = 5 , 3 = 6, ….6 = 9 weeks after). Rootstock height: 0 = 0 cm; 1 = 25; 2 = 50, 3 = 100 cm, 4= 150, 5= 200 and 6 = 250 cm).

Table 1. Rooting percentage, numbers and length of roots in *V. madiensis* cuttings

Stock plant height (cm)	Rooting (%)	Root Number (roots/cutting)	Length of the longest root (cm)
0	45.83	8.72	12.73
25	30.70	6.45	10.87
50	30	1.66	6.03
100	11.0	2.34	3.44
150	7.5	0.21	0.97
200	3.1	0.55	0.89
250	2.8	0.91	1.77
Mean	18.70	2.98	5.24
LSD.05	5.53	1.24	0.69

The rooting percentage of the marcots according to their position (indicated wood maturity) on the branch varied significantly from 40% (hard wood) to 100 % (semi - mature wood) (0.00231< 0.01).

The wood type x diameter interaction was significant (0.000 < 0.001). It was due to the fact that 100 % marcots rooted in medium wood (semi-hard wood) (Fig. 4). The superiority of the medium wood (semi-hard wood) has been equally reported in *Ricinodendron heudelotii* (Mapongmetsem *et al*., 1999). The median wood is made up of totipotent cells contrary to hard and green woods which are constituted with mature and undifferentiated cells respectively.

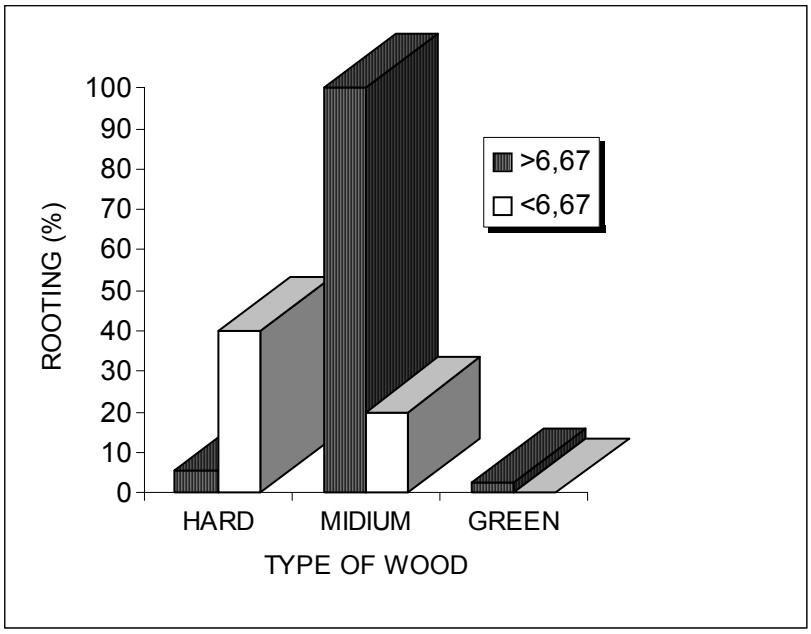

Figure 4. Rooting percentage of the marcots, 5 months after setting up. Hard (mature wood, basal wood), semi–hard (semi–mature, medium wood) and soft (immature wood, green wood).

Rooted marcots were harvested and brought to the nursery for acclimatizing. They were introduced in polypropagators and wet twice a day (morning and evening) from a month after which new leaves appeared. Then they were subjected to new conditions. The rhythm of sprinkling remained the same but the propagator stayed open during the night. In so doing, marcots were submitted progressively to more environmental constraints until they were transferred to the field.

4. Conclusion

The phenological pattern of *V. madiensis* varies from year to year. The blooming activities are associated to leaves renewal. The tree is deciduous and fruiting period ranges from March to August. *V. madiensis* bears flowers and fruits every year and produces a hard coat seed.

To conclude our investigations, we can say that, stock plant heights between 0 and 25 cm are the best to induce maximum rooting ability in *V. madiensis*. The rooting percentages decline in cut-back stock plants with increasing heights, and are related to the number of shoots per plant. The production of easily rooted cuttings from stock plants is a complex process with many interacting factors influencing rooting ability.

Concerning the aerial layering, the median wood (semi-hard wood) is suitable for rooting. In addition during acclimatizing, it is very resistant. *Vitex madiensis* can be classified among species which can be easily propagated by single node cutting and aerial layering. It is therefore possible to circumvent the dormancy in the species, using these techniques. Vegetative propagation helps to obtain clonal material from individuals having interesting characteristics. One of the advantages of vegetative propagation is the conservation of the mother tree characteristics. For the successful management of the stock plants, we intend to study the effect of diameter and orientation and node position on the rooting potential of the species. *V. madiensis* can be recommended for agroforestry programme.

The make up of the grafting techniques will permit us to alleviate some constraints which subsist (for e.g.: improvement the size and the organoleptic characteristics of the fruit) on the propagation of the species. Parallel studies shall be pursued for post-harvest acclimatization of cuttings and marcots.

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