Journal of Arid Environments 133 (2016) 122–124

Contents lists available at ScienceDirect

Journal of Arid Environments

journal homepage: www.elsevier.com/locate/jaridenv

Vegetative propagation of *Boswellia papyrifera*: Time of collection and propagule size affect survival and establishment

Abrham Abiyu [a, b, *, 1], Tatek Dejene [c], Abeje Eshete [c], Kibruyisfa Sisay [a, b]

[a] Amhara Agricultural Research Institute, P.O. Box 527, Bahir Dar, Ethiopia
[b] University of Natural Resources and Life Sciences, Peter Jordanstraße 82, A-1190 Vienna, Austria
[c] Ethiopian Environment and Forestry Research Institute, Addis Ababa, Ethiopia

ARTICLE INFO

Article history:
Received 24 December 2015
Received in revised form
9 May 2016
Accepted 6 June 2016
Available online 5 July 2016

Keywords:
Parent stock
Planting size
Planting season
Northwest Ethiopia

ABSTRACT

In the dry woodlands of Africa, stem cuttings of some tree species can root easily for successful vegetative propagation. Successful rooting and establishment of planted cuttings can be affected by size of cutting, planting season, age of parent stock and part of plant used. Propagule length and four collection times were studied on their effect on the survival of branch cuttings of *Boswellia papyrifera* over a six-year period. The study was carried in a semi-arid area of northwest Ethiopia, where the rainfall occurs from June to September and the other part of the year being too dry to normal plant physiological functioning. Collection time, cutting length and their interaction showed significant differences in mean survival rate. The higher mean survival value was observed from those cutting materials collected in May. The weakest performance was observed from those cutting materials collected in October. The observed difference may be effect of phenological calendar of the species, especially the effect of dormancy period and leaf bud breaking times. Longer stem cuttings did not show persistent better performance across time. This technique could be an alternative solution for restocking the declining *B. papyrifera* population and fast restoration of degraded dry lands.

1. Introduction

Boswellia papyrifera (Del.) Hochst. ex A. Rich is a multipurpose tree species. Its tree population is declining in the majority of its growing area. The tree population structure showed little representation of smaller individuals and regeneration is impeded with many kinds of limitations (see Abiyu et al., 2010).

Vegetative propagation by means of stem cutting did give positive results (Haile et al., 2011). Vegetative propagation methods are useful tools for timely production of quality propagules for reforestation, genetic conservation or domestication programmes. The timing of collection of propagule (Welander, 1994; Danthu et al., 2002), age of ortet and position on the parent stock (Husen and Pal, 2006, 2007; Opuni-Frimpong et al., 2008) reported to affect root growth and survival of cuttings in vegetative propagation experiments. Hence, the objective of this experiment was to study the effect of cutting size and planting season on the survival of branch cuttings of *Boswellia papyrifera*.

2. Method of data collection and analysis

The study was carried out in the lowlands of Metemma area of northwest Ethiopia. The experiment was established in a wide gap adjacent to the forest. Healthy branches were obtained from different mature *B. papyrifera* trees in the immediate vicinity chosen randomly. The cuttings were collected on four different occasions between July 2003 and May 2004.

Three factors with different levels and their combination were considered as a treatment. The factors and their levels are (1) length of the branch cutting (i) 1.0 m, (ii) 1.5 m and (iii) 2.0 m; (2) cutting butt diameter (i) 10–15 cm, (ii) 16–20 cm and (iii) 21–25 cm; and (3) planting season (i) first week of May, (ii) second week of July, (iii) third week of October, and (iv) third week of March. A treatment assigned to an experimental unit is a combination of one level of each of length of the branch cutting, cutting butt diameter and

* Corresponding author. Permanent address: Amhara Agricultural Research Institute, P.O. Box 527, Bahir Dar, Ethiopia.
E-mail addresses: abrham.abiyu@gmail.com (A. Abiyu), tdejenie@yahoo.com (T. Dejene), abejeeshete@yahoo.com (A. Eshete), kibru122@yahoo.com (K. Sisay).
[1] Temporary address: Friedrich-Alexander University Erlangen-Nuremberg, Glueck strasse 5, 91023 Erlangen, Germany.

http://dx.doi.org/10.1016/j.jaridenv.2016.06.006
0140-1963/

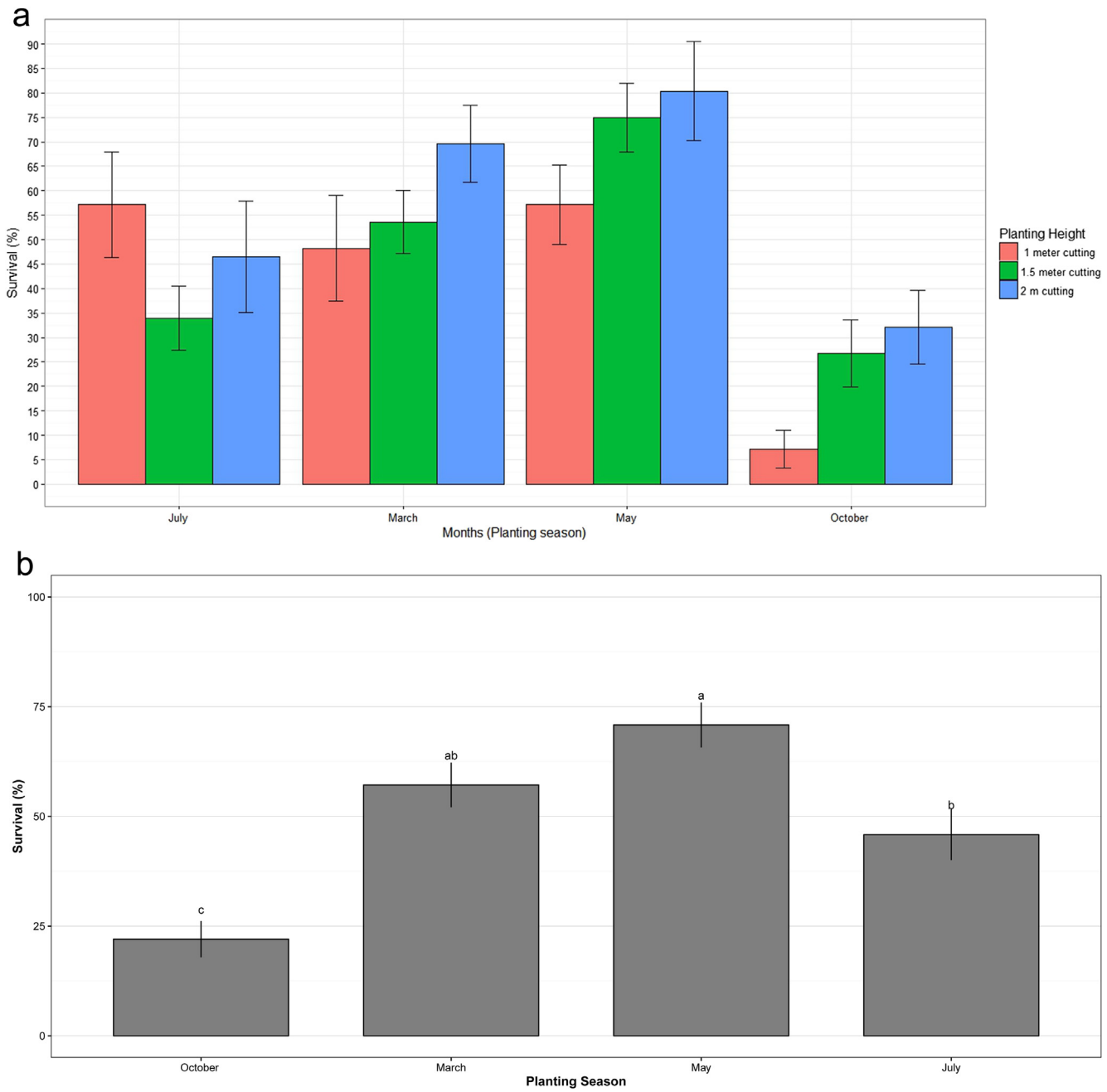

Fig. 1. a. Mean survival value of different sized cuttings of *B. papyrifera* across different seasons of planting time b. Mean survival values across planting season.

planting season. The plots were the experimental units. Thus, there were 36 treatments in a block. For each treatment, there were seven branch cuttings. The spacing between plants was 2 m, and the spacing between rows of plants was 4 m. The design used for the experiment was the Randomized Complete Block Design replicated Four times.

The dependent variable was the survival rate taken at the end of the sixth year. Data were arc-sine transformed prior to analysis and analyzed using the General Linear Model procedures of SAS. When there were no interactions and terms that were not significant in the full model, the reduced model was employed for analysis. The terms indicating the effects of cutting materials butt diameter and its interaction with season of planting and cutting length were not included in the statistical analysis.

3. Result

The effect of cutting collection time and its interaction with length of planting material on the survival of cuttings of *Boswellia papyrifera* showed significant difference ($F = 2.5$, $P = 0.03$). When cutting collection time is considered alone the difference was also significant ($F = 9.39$, $P < 0.01$), and better survival was obtained from those materials prepared and planted in May followed by March, July and October (Fig 1b).

With regard to the effect of interaction of cutting collection time and planting material length, the mean survival value for 1.0, 1.5, and 2.0 m cuttings was 57, 75 and 80% in May. October cuttings showed less than 50% survival values. In March, greater than 50% survival was obtained only from 1.5 and 2.0 m cuttings. For a given

planting material length, more than 200% survival advantage was recorded when the planting season was changed. For instance, 1.0 m length cutting average survival in October was 7.14%, but for the same cutting length the survival for May was 57.14%. The mean survival value of cutting length 2.0 m was 32% in October and 80% in May (Fig 1a).

Planting in July gave better survival rates than planting in October. Planting in October gave a poor survival rate and cutting size improved survival negligibly.

4. Discussion

Our result showed that branch cuttings of *B. papyrifera* gave above average survival rates when cuttings were collected in May. In case the month of collection is March, then propagules should be longer than one meter in order to obtain more than a 50% survival rate. This result is different from the findings of Haile et al. (2011), who reported, from a different tree population, that the best performance was obtained when cutting materials were collected in February–March. The weakest performance was recorded when a cutting was collected in May. This may be attributed to the different agro-ecological locations of the two populations and thus difference in phenological calendar of the two populations, especially in length of dormancy period and leaf bud breaking times.

The higher mean survival value was observed from those cutting materials collected in May when the plant was dormant. The weakest performance was observed from those cutting materials collected in October when there is leaf colour change and eventual leaf shedding. Danthu et al. (2002) reported that cuttings root better when sampled while the ortet is dormant, rather than it being in active growth. This may be from the accumulation and composition of carbohydrates in cuttings or the rise of temperature as shown by Leakey et al. (1982) and Leakey and Coutts (1989).

Our result showed that, within a specific month, the marginal survival improvement with increased cutting length showed a diminishing trend. For instance, in the planting season of May, increasing the planting material's length from 1.0 to 1.5 m increased its survival by 18% but it only brought a 5% improved survival rate when the cutting length was increased from 1.5 to 2.0 m. Therefore, in case a shortage of planting materials prevails, the planting season can be restricted to May. This can enhance the possibility to obtain enough short length propagules with low mortality rates.

Acknowledgement

The authors thank ARARI, Ethiopia, for logistic support. The authors thank also the Austrian Partnership Programme in Higher Education and Research for Development (APPEAR), Vienna, Austria, and the International Foundation for Science (IFS) D4682 Sweden, Stockholm, for financial support AA. Oscar Geerts of Sesame Business Network provided English language editing and correcting support. We thank the reviewers who helped us to improve an earlier version of the manuscript.

References

Abiyu, A., Bongers, F., Eshete, A., Gebrehiwot, K., Kindu, M., Lemenih, M., Moges, Y., Ogbazghi, W., Sterck, F.J., 2010. Incense woodlands in Ethiopia and Eritrea: regeneration problems and restoration possibilities. In: Bongers, F., Tennigkeit, T. (Eds.), Degraded Forests in Eastern Africa: Management and Restoration. Earth scan.

Danthu, P., Soloviev, P., Gaye, A., Sarr, A., Seck, M., Thomas, I., 2002. Vegetative propagation of some west African *ficus* species by cuttings. Agrofor. Syst. 55 (1), 57–63.

Haile, G., Gebrehiwot, K., Lemenih, M., Bongers, F., 2011. Time of collection and cutting sizes affect vegetative propagation of *Boswellia papyrifera* (Del.) Hochst through leafless branch cuttings. J. Arid Environ. 75 (9), 873–877.

Husen, A., Pal, M., 2006. Variation in shoot anatomy and rooting behaviour of stem cuttings in relation to age of donor plants in teak (*tectona grandis* linn. F.). New For. 31 (1), 57–73.

Husen, A., Pal, M., 2007. Metabolic changes during adventitious root primordium development in *tectona grandis* linn. F. (teak) cuttings as affected by age of donor plants and auxin (iba and naa) treatment. New For. 33, 309–323.

Leakey, R., Chapman, V., Longman, K., 1982. Physiological studies for tropical tree improvement and conservation. factors affecting root initiation in cuttings of *triplochiton scleroxylon k. Schum.* For. Ecol. Manag. 4, 53–66.

Leakey, R., Coutts, M., 1989. The dynamics of rootings in triplochiton scleroxylon cuttings: their relation to leaf area, node position, dry weight accumulation, leaf water potential and carbohydrate composition. Tree Physiol. 5, 135–146.

Opuni-Frimpong, E., Karnosky, D., Storer, A., Cobbinah, J., 2008. Key roles of leaves, stockplant age, and auxin concentration in vegetative propagation of two african mahoganies: Khaya anthotheca welw. and Khaya ivorensis a. Chev. New For. 36 (2), 115–123.

Welander, M., 1994. Influence of environment, fertilizer and genotype on shoot morphology and subsequent rooting of birch cuttings. Tree Physiol. 15, 11–18.