PLANT SOCIOLOGY

formerly FITOSOCIOLOGIA

Volume 54 (1) - Suppl. 1 - June 2017

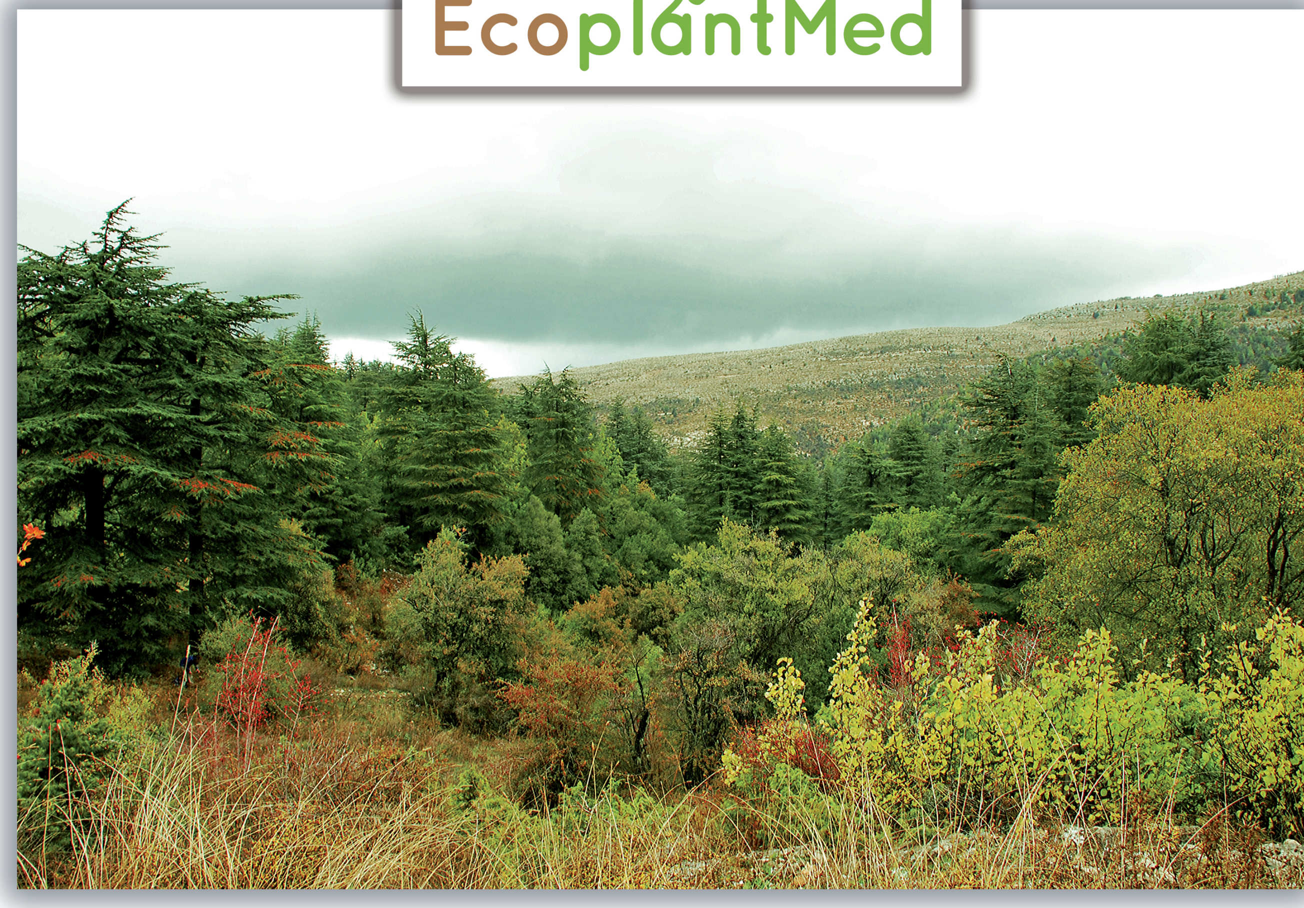
EDITO DALLA SOCIETA' ITALIANA DI SCIENZA DELLA VEGETAZIONE ONLUS - PAVIA - DIRETTORE RESPONSABILE PROF. E. BIONDI - SUPPLEMENTO 1 - VOLUME 1 - I° SEMESTRE 2017

USJ 1875
Université Saint-Joseph de Beyrouth
Faculté des sciences

Project funded by the EUROPEAN UNION

ENPI CBCMED
CROSS-BORDER COOPERATION IN THE MEDITERRANEAN

EcoplantMed



Journal of the Italian Society for Vegetation Science

Plant Sociology, Vol. 54, Suppl. 1, June 2017, pp. 29-32
DOI 10.7338/pls2017541S1/04

PLANT SOCIOLOGY
©Italian Society for
Vegetation Science

Assessing the quality of seedlings in small-scale nurseries using morphological parameters and quality indicators to improve outplanting success

I. Touhami[1], A. Khorchani[1], M. Bougarradh[2], M.T. Elaieb[1], A. Khaldi[1]
[1]Laboratory of Management and Valorization of Forest Resources, National Research Institute for Rural Engineering, Water and Forestry, INRGREF. BP 10, 2080, Ariana. University of Carthage, Tunisia.
[2]Faculté des Sciences de Tunis, Campus Universitaire 2092 - El Manar, Tunis.

Abstract
In Mediterranean region and especially in North Africa, forest seedlings for reforestation objectives are often produced in small-scale nurseries. The quality of the seedlings influences the success of forest plantation initiatives. This study uses morphological parameters to assess the quality of seedlings of five Tunisian native species (*Lavandula dentata*, *Ruta chalepensis*, *Laurus nobilis*, *Capparis spinosa*, and *Myrtus communis*). Some growth parameters like (seedling height, root collar diameter, shoot dry weight and root dry weight) and quality indicators (Root-to-shoot ratio, Sturdiness quotient Root and Dickson quality index) of seedlings produced were compared between some forest Tunisian nursery. The comparison of morphological parameters show significant differences between nurseries (at p=0.05). Seedlings produced in Fernana nursery were uniform in terms of growth characteristics and quality indicators. These differences could be attributed to better environmental conditions and to the quality of substrate used

Key words: Dickson quality index, forest seedlings, Growth parameters, Root-to-shoot ratio, Sturdiness quotient Root, quality indicators.

Introduction

In Tunisia, the General Direction of Forestry makes a great effort to increase the forest area in the country. For this purpose several hundred hectares of forest land is replanted every year. Since 1995 to 2010, the forest service have made about 400 162 ha of reforestation (DGF, 2010). However, many plantations fail to survive or grow satisfactorily after outplanting. These failures are often associated with transplant shock (Struve & Joly, 1992), deer browsing (Tripler *et al*., 2002), and competing vegetation (Crow, 1988). Additionally, poor soils or nutrient deficiencies and poor seedling quality (Clark *et al*., 2000) may account for the failure of oak plantings. For this raison high-quality seedlings, that can survive and grow rapidly after out-planting, are highly recommended. Hence, identification and quantification of superior seedling morphological attributes that can be quantitatively linked with improved field response and early plantation success is warranted.

Several morphological attributes, such as seedling shoot height and diameter are often used as indicators of seedling quality and predictors of field response because they are relatively simple to measure (Dey & Parker, 1997). However, despite advances in seedling quality testing and prediction of field performance, no single test has proved suitable across a multitude of species and conditions (Davis & Jacobs, 2005), indicating that seedling attributes need to be determined at the species level and to take into account specific environmental and management conditions (Bayala *et al*., 2009). Due to a lack of technical and skilled staff, testing of seedling quality has not been adopted by most nursery operators in the forest nurseries of Tunisia.

The main purpose of this work is the use of the morphological parameters to assess and compare the growth quality indicators of five native produced seedlings in three Tunisian forest nurseries.

Materials and methods

Plant material

The material of the study is the seedlings of *Lavendula dentata*, *Ruta chalepensis*, *Laurus nobilis*, *Capparis spinosa* and *Myrtus communis* produced in INRGREF, Borj El Amri and Fernana nurseries (Fig. 1). A summary of the nurseries origin and physico-chemical analysis of different substrates are reported in tables (1 and 2). In the three nurseries, seedlings are produced from seeds collected from the local area of each nurseries. After the germination, the seedlings were potted with substrate previously prepared by each nursery operator and cared for in the nursery for a period of 2 years. All seedlings were received the same treatment (watering frequency, etc.) in the three selected nurseries. In each nursery, 15 seedlings were randomly selected per native species, to give a total of 75 seedlings.

Corresponding author: Issam Touhami. *Laboratory of Management and Valorization of Forest Resources, National Research Institute for Rural Engineering, Water and Forestry, INRGREF. BP 10, 2080, Ariana. University of Carthage, Tunisia; e-mail: issam_touhami@yahoo.fr*

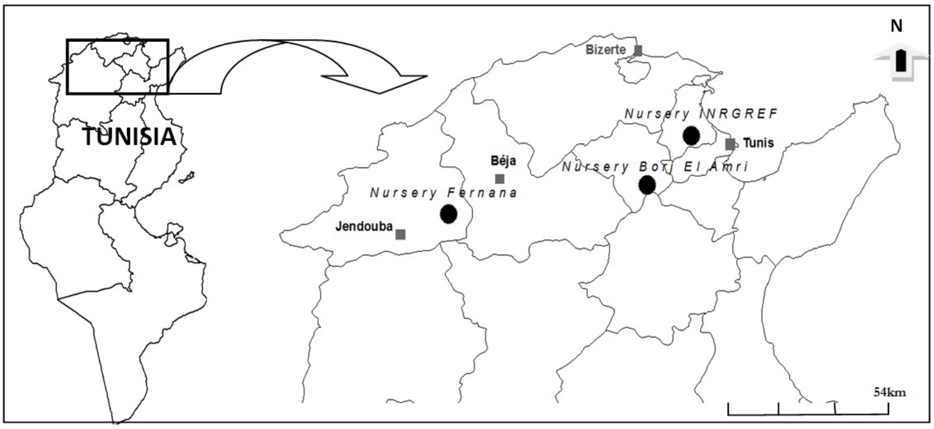


Fig. 1 - Distribution map of the study nurseries in Tunisia.

Tab. 1 - Characteristics of the selected species and nurseries.

Species	Age	Origin	Nurseries origin	Localization		Containers
				Latitude	Longitude	Dim (cm)
Lavandula dentata	2	sowing	Borj El Amri	36°43'7"N	9°53'27"E	10*17
Ruta chalepensis	2	sowing	Borj El Amri	36°43'7"N	9°53'27"E	10*17
Capparis spinosa	2	cutting	INRGREF	36°50'45"N	10°11'42"E	10*17
Myrtus communis	2	sowing	Fernana	36°45'9"N	8°44'56"E	07*20
Laurus nobilis	2	sowing	Fernana	36°45'9"N	8°44'56"E	12*25

Tab. 2 - Physico-chemical analysis of different substrate samples.

Textures	Nurseries origin		
	INRGREF	Borj El Amri	Fernana
Coarse sand (%)	31	35.5	40.5
Medium sand (%)	18	17	10.1
Fine sand (%)	17	16	9.8
Coarse silt (%)	14.5	11.5	12.5
Fine silt (%)	12.3	11.6	14.2
Clay (%)	7.2	8.3	12.6
Organic carbon (%)	0.6	0.72	2.1
Organic Matter (%)	1.03	1.24	3.62
pH $_{(2/5)}$	8.36	8.45	6.9
C.E$_{(1/5)}$ in mS/cm^{-1}	1.08	0.95	0.72
Limestone total (%)	14	13.5	-
Active limestone (%)	13	13	-

The morphological features used for the determination of seedling quality were measured for each seedling, including shoot height, root length, root collar diameter, and shoot and root dry weight. The dried weight was determined after drying the samples in an oven at 70°C for 48 h. We used measuring tape for the determination of shoot height and root length (in cm), vernier caliper for measuring root collar diameter (mm), and a sensitive electronic balance for measuring the shoot and root dry weights (g). The above-ground dry mass was separately measured from root dry mass.

Morphological features data of seedlings were used to compute seedling quality parameters. (1) *The sturdiness quotient* (SQ) refers to the ratio of the height (H) of the seedling to the root collar diameter (D) and expresses the vigor and robustness of the seedling. Roller (1976) found that black spruce seedlings with sturdiness quotients greater than six were seriously damaged when exposed to wind, drought, and frost. In general, sturdiness quotient should closely parallel diameter in predicting survival and growth in the field. The ideal value for a seedling to be considered sturdy is less than six (Jaenicke, 1999). (2) *The root-shoot ratio* (RS) refers to the proportion of the root dry-weight to the shoot dry-weight. This parameter reflects the capacity of the roots to support the above-ground biomass not only for anchorage but also in absorbing water and nutrients from the soil. A high root-shoot ratio indicates high absorption and storage capacity of water, which is an advantage especially when the soil moisture is limited. A root-shoot ratio between one and two is considered as optimal (Jaenicke, 1999). (3) *The dickson quality index* (DI) refers to the ratio of seedling dry-weight to the sturdiness quotient and it is more efficient than the root-shoot ratio.

The quality index was conceived by evaluating how well a number of possible combinations of a predicted morphological field parameters performance of white spruce and white pine seedlings and selecting the best combination (Dickson *et al*., 1960). In a subsequent test, this index was able to predict quality based on the nutrient environment (soil fertility) in which the seedlings were grown (Dickson *et al*., 1960). This index was successfully used by Roller (1976) to differentiate between successful and failure containerized seedlings.

The statistical analysis was performed using the SPSS v.18 package (SPSS Inc., Chicago, IL, USA). Tukey's HSD post hoc tests of independence (5 % significance level) were used.

Results and Discussion

Assessment of seedlings growth parameters

The results of statistical analysis show a difference between species concerning dry weight of the different part of the plant. The analysis of data in Figure 2 shows that fine roots with diameter <2 mm are much more developed in *Laurus nobilis*, *Lavandula dentata*, *Ruta chalepensis* and *Myrtus communis* than roots with diameter >2 mm. For the other morphological parameter, *Myrtus communis* and *Laurus nobilis* from Fernana nursery, show The highest values than the others species. Mexal and Landis (1990) founded that seedlings with larger stem diameters tend to have higher survival rates and greater growth potential than those having smaller diameters.

Significant differences at p<0.05 between nurseries were found for seedling height, shoot dry weight, root dry weight and root collar diameter across the five species (Tab. 3). However, no significant differences were detected in height principal root except for *Capparis spinosa* (p<0.001). The average values of the morphological parameters are much high for *Myrtus communis* and *Laurus nobilis* in Fernana nursery than others species, except in root dry weight (BR) for *Capparis spinosa* in INRGREF nursery. The above results cannot be conclusive without establishing the link between the growth estimates and the seedling quality indicators assessed in this study.

Assessment of seedlings quality indicators

The results analysis of quality indicators are shown in Table 4. For the all studied species, the Sturdiness quotient presents lower values, up to 9 and Dickson Quality Index (DQI) present values between 0 < DQI <2. In terms of the difference between species, only the parameter Cs is significant at p<0.05. Therefore,

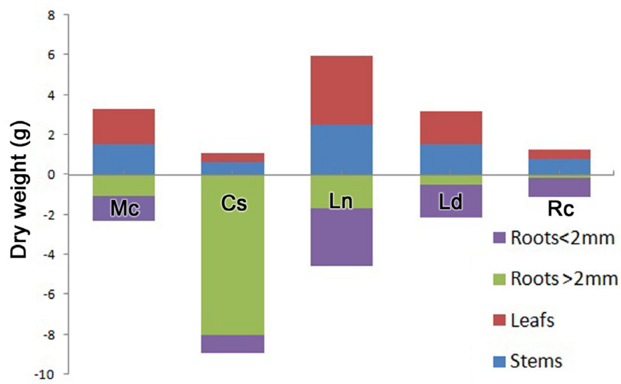


Fig. 2 - Dry weight for different part of the studied native species. Mc: *Myrtus communis*; Cs: *Capparis spinosa*; Ln: *Laurus nobilis*; Ld: *Lavandula dentata*; and Rc: *Ruta chalepensis*.

Tab. 3 - Morphological parameters of seedlings for the five species. (Mean ± standard error; N= 75); Tukey's HSD *post hoc test*.

Growth parameter	Species	Range		Mean	Statistic t-test	
		Min	Max	(x±s.e)	t-value	Probability
Seedling height (cm)	*M. communis*	37.5	43	40.00±1.61b	14.34	< 0.0001***
	L. nobilis	30	33	38.50±0.88a	9.25	< 0.0001***
	L. dentata	37	41	32.00±1.26b	13.43	< 0.0001***
	R. chalepensis	15.1	16.5	15.93±0.56c	14.34	< 0.0001***
	C. spinosa	15	19	16.50±1.26c	14.24	< 0.0001***
Root collar diameter (mm)	*M. communis*	3.96	5.33	4.73±0.40b	-3.67	0.004*
	L. nobilis	5.75	6.42	6.05±0.20b	-1.95	0.079*
	L. dentata	5.1	5.62	5.44±0.17b	-2.74	0.021*
	R. chelepensis	3.78	3.88	3.82±0.04b	-4.85	0.001**
	C. spinosa	5.32	8.71	7.56±1.12a	13.87	<0.0001***
Height of the principal root (cm)	*M. communis*	21	30	24.66±2.73b	-0.994	0.344 ns
	L. nobilis	33.5	54	41.17±6.46b	1.529	0.157 ns
	L. dentata	21	23	22.00±0.58b	-1.402	0.191 ns
	R. chalepensis	22	25	23.33±1.16b	-1.198	0.259 ns
	C. spinosa	21.5	46	31.17±7.53a	6.739	< 0.0001***
Dry shoot weight (g)	*M. communis*	2.378	4.621	3.32±0.67a	4.261	0.002*
	L. nobilis	5.81	6.24	5.99±0.13b	9.391	< 0.0001***
	L. dentata	2.77	4.05	3.21±0.42a	4.051	0.002*
	R. chalepensis	1.1	1.44	1.27±0.13c	0.31	0.763 ns
	C. spinosa	0.86	1.4	1.11±0.16c	3.011	0.013*
Dry root weight(g)	*M. communis*	1.54	2.864	2.32±0.40ab	-5.987	0.000***
	L. nobilis	3.99	4.98	4.55±0.29ab	-3.965	0.003*
	L. dentata	1.64	2.7	2.13±0.31ab	-6.161	0.000***
	R. chalepensis	0.98	1.16	1.09±0.07a	-7.106	< 0.0001***
	C. spinosa	5.65	10.84	8.91±1.64b	11.454	< 0.0001***

[a-b] the values followed by the same letters within rows do not differ significantly at p = 0.05.ns : not significant, *: significant effect, **: highly significant effect , ***: very highly significant effect.

Tab. 4 - Seedling quality indicators measured for the five native species. (Mean ± standard error; N=75); Tukey's HSD *post hoc test*.

Seedling quality indicator	Species	Range		Mean (x±s.e)	Statistic t-test	
		Min	Max		t-value	Probability
Root-shoot ratio	*M. communis*	1.16	1.61	1.44±0.19b	0.872	0.403 ns
	L. nobilis	1.19	1.45	1.33±008b	2.41	0.037 ns
	L. dentata	1.35	1.72	1.52±0.11a	0.56	0.588 ns
	R. chalepensis	0.95	1.28	1.17±0.15a	13.333	<0.0001***
	C. spinosa	0.1	0.15	0.13±0.02b	12.023	<0.0001***
Sturdiness quotient	*M. communis*	7.04	9.97	8.59±1.12a	9.226	<0.0001***
	L. nobilis	4.67	5.74	5.25±0.31a	8.441	<0.0001***
	L. dentata	6.61	8.04	7.11±0.47a	9.822	<0.0001***
	R. chalepensis	3.99	4.34	4.17±0.13a	7.327	<0.0001***
	C. spinosa	1.79	2.82	2.26±0.30b	1.286	<0.0001***
Dickson quality index	*M. communis*	0.34	0.72	0.58±0.16a	9.366	<0.0001***
	L. nobilis	1.54	1.67	1.60±0.04a	4.418	0.001**
	L. dentata	0.46	0.83	0.63±0.11a	7.163	<0.0001***
	R. chalepensis	0.39	0.49	0.44±0.03a	2.819	0.018*
	C. spinosa	2.79	6.03	4.29±0.94b	4.739	0.001**

[a-b] the values followed by the same letters within rows do not differ significantly at p = 0.05.ns : not significant, *: significant effect, **: highly significant effect , ***: very highly significant effect.

we can concluded that species produced in Fernana and Borj El Amri nurseries have a good quality and better chance to survive after outplanting than specie produced in INRGREF nursery. These differences among seedlings of the selected nurseries were explained principally for the quality of substrate used and the environmental conditions (light availability, humidity, mineral nutrition, etc.).

Conclusion

The morphological parameter such as seedling height, root collar diameter, and the quality indicators such as Root-to-shoot ratio, Sturdiness quotient Root and Dickson quality index can be used with success to characterize nursery seedling quality and to guess the field response. Output of this study may be used to help Tunisian nursery operators to improve seedling quality, which will enhance early establishment after out-planting.

There is a real need to organize the public seedling sector in Tunisia and put in place a policy that governs the production of high quality seedlings.

References

Bayala J., Dianda M., Wilson J., Ouedraogo S.J. & Sanon K., 2009. Predicting field performance of five irrigated tree species using seedling quality assessment in Burkina Faso West Africa. New Forests 38 (3): 309-322.

Clark S.L., Schlarbaum S.E. & Kormanik P.P., 2000. Visual grading and quality of 1-0 northern red oak seedlings. South. J. Appl. For. 24: 93-97.

Crow T.R., 1988. Reproductive mode and mechanisms for self replacement of northern red oak (*Quercus rubra*) -a review. For. Sci. 34: 19-40.

Davis A.S. & Jacobs D.F., 2005. Quantifying root system quality of nursery seedlings and relationship to out planting performance. New Forest 30: 235-251.

Dey D.C. & Parker W.C., 1997. Morphological indicators of stock quality and field performance of red oak (*Quercus rubra* L.) seedlings under planted in a central Ontario shelter wood. New Forest 14: 145-156.

DGF, 2010. Résultats du deuxième inventaire forestier et pastoral national (IFPN). Document réalisé par la Direction Générale des Forêts (DGF) et le Centre National de Cartographie et de Télédétection (CNCT).

Dickson, A., Leaf A.L. & Hosner J.F., 1960. Quality appraisal of white spruce and white pine seedling stock in nurseries. For. Chron. 36: 10-13.

Jaenicke H., 1999. Good tree nursery practices: practical guidelines for research nurseries. ICRAF, Nairobi, pp 8-15.

Mexal J.G. & Landis T.D. 1990. Target seedling concepts: height and diameter. In: Rose R, Campbell SJ, Landis TD (eds) Target seedling symposium: combined proceedings of the western forest nursery associations: 17-35. Roseburg, Oregon.

Roller K.J., 1976. Field performance of container-grown Norway and black spruce seedlings. Can. For. Serv. Dept. Environ. Inf. Rep. M-X-64.

Struve D.K. & Joly R.J., 1992. Transplanted red oak seedlings mediate transplant shock by reducing leaf surface area and altering carbon allocation. Can. J. For. Res. 22: 144-1448.

Tripler C.E., Canham C.D. & Inouye R.S., 2002. Soil nitrogen availability, plant luxury consumption, and herbivory by white-tailed deer. Oecologia 133: 517-524.