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Appropriate watering interval for *Prunus africana* nursery seedlings in Egerton University, Njoro, Kenya

Shadrack Kinyua Inoti * and Doris Cherop

Department of Natural Resources, Faculty of Environment and Resources Development, Egerton University, Kenya.

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Abstract

Water is essential in raising seedlings but needs to be efficiently utilized since it is a scarce resource. Hardening off of nursery seedlings through reduction of watering regime leads to better survival. Watering interval is not well determined and this can vary with species type and locality. An experiment was set up in dry season to determine the most appropriate watering interval for African stinkwood (*Prunus africana*) seedlings in Egerton University, Kenya. The experiment was laid down as a Completely Randomized Design with 4 treatments replicated 3 times. Treatments comprised of different watering intervals, which were as follows; twice daily, once daily, 2 days and 4 days, which were applied for 2 months on seedlings during January to March 2018. ANOVA was used to determine treatment differences while SED was used to determine the significantly different treatment means at $p \leq 0.05$. Results showed that watering twice daily gives the best growth of Prunus seedlings but encourages succulent foliage growth which is not favourable for planting out seedlings. Therefore two days watering interval is the most ideal for hardening off seedlings that are non-succulent in the highlands since it reduces foliage growth and encourages woodiness. The recommended interval is 2 days since it showed good growth with minimal water use equivalent to 25% of the water used by seedling watered twice daily. The results can be applied in the Kenyan highlands for non-succulent species. Further studies needs to be done for different pot sizes and soil mixtures.

Keywords: Nursery seedlings; *Prunus Africana*; Watering interval; Hardening off

1. Introduction

Water is a vital component in living organisms since it is involved in biochemical processes which are essential for growth. Water stress decreases the growth of plants in terms of stem height, leaf number, leaf area, biomass weight and stomata conductance (Qaderi *et al*., 2012). Efficient use and availability of quality water sources has been a major concern in the nursery industry for many years (Zhu *et al*., 2005). Due to lack of scientific methods that guides watering practices, many tree nurseries often apply water to plants without knowing how much water is lost.

Prunus Africana belonging to the family Rosaceae is a highly valued tree in the highlands for herbal medicine. The species is common for its bark whose extract is used for prostrate cancer treatment and timber. It's listed to be threatened by extinction in the IUCN red list, hence a very important plant. Plants have wide diversity in their response to watering intervals depending on the soil and climate. Variation in water availability can influence seedling resource allocation (Blain and Kellman, 1991) which further affect water uptake and food manufacture, hence plant growth.

* Corresponding author: Shadrack Kinyua Inoti; E-mail: sinoti@egerton.ac.ke
Department of Natural Resources, Egerton University, Kenya.

Water being a scarce resource there is need to produce seedlings efficiently and to reduce the amount of water used. According to Ochoa *et al*. (2002), regulating the amount of water available to plants resulted in stocky, stress-resistant seedlings able to withstand environmental stresses after transplanting to the field. Restricting the water supply has been also used as a technique to avoid excessive vegetative growth in many species (Cameron *et al*., 2006). Increasing the understanding of morphological and physiological shoot and root responses of seedlings to water management is critical for optimizing the production of high quality seedlings. Other studies by Bañon *et al*. (2006) stated that deficit irrigation is the most commonly used pre-conditioning technique to produce high quality seedlings.

Despite the need to control amount of water used, plants cannot be allowed to be water stressed, since this has a great effect on plants and may lead to losses in the nursery. Water stress led to substantial losses in dry weight, leaf area, root dry weight and length (Bañon *et al*., 2006). The limited osmotic adjustment reached by the plants may not maintain leaf turgor and growth. Therefore it's appropriate to ensure a balance between efficient water use and production of quality seedlings.

Hardening off is very important operation in the nursery, it involves controlling the amount of water applied to seedling before transplanting into the field. Changes in water availability can affect seedling resource allocation which subsequently affect water uptake and photosynthesis thus modifying growth and survival of planted seedlings (Blain and Kellman, 1991).

2. Material and methods

2.1 Study site

The study was conducted at Agroforestry tree nursery, Egerton University, Njoro, Kenya, within the Mau water catchment. The University is located in Njoro, a small community approximately 25 kilometres southwest of the town of Nakuru. This is located approximately 182 kilometres, by road, northwest of Nairobi. The study site lies on a latitude 0°22'11.0"S, Longitude 35°55'58.0"E and an altitude of 2238 m above sea level.

The area falls in agro ecological zone Lower Highland 3. The experimental site receives mean annual rainfall of 1200 mm. The distribution of rain is bimodal with long rains between April and August and short rains between October and December yearly. The temperatures in the field lie between 10.2 and 22.0°C (Ngetich *et al*., 2014). Soils at the site are mollicandosols (Kinyanjui, 1979).

2.2 Experimental design

The experiment was laid down as a complete randomized design (CRD) with 4 treatments replicated 3 times. Treatments comprised of different watering intervals, which were as follows: twice daily, once daily, 2 days and 4 days intervals. These treatments were applied for 2 months on 8 months old seedlings during January to March 2018.

The variables measured included; survival %, height, root collar diameter, 3rd internode length, number of leaves and branches, leaf length and width, root length, shoot, root and total biomass.

2.3 Data analysis

Analysis of variance (ANOVA) of the measured variables was done using Genstat statistical package (2013) while the means were separated at $P< 0.05$ using Standard error deviation (SED).

3. Results

3.1 Watering interval effect on shoot growth and survival of *Prunus Africana* seedlings

Results showed that four days watering interval had significantly ($p<0.05$) lower survival (93%) compared with all the other treatments which showed 100% survival (Table 1). Watering interval for twice and once daily showed significantly ($p<0.01$) higher shoot and total fresh plant biomass compared with two and four days interval.

Watering twice daily was also significantly higher in height compared with all the other treatment. Similarly, watering twice daily showed significantly superior seedling shoot volume (4.72 cm^3) compared with two (2.31 cm^3) and four days interval (2.89 cm^3). Watering twice and once daily was similar in all the shoot variables except height. This shows

that watering once daily is more preferred compared with twice daily since it will save 50% of the water used in the latter.

Table 1 Effect of watering interval on survival and shoot growth of *Prunus africana* seedlings at Egerton University, Kenya

Watering interval	Survival %	Height (cm)	Shoot biomass (g)	Total fresh plant biomass (g)	Seedling shoot volume (cm^3)
Twice daily	100[a]	37.04[a]	6.19[a]	8.52[a]	4.72[a]
Once daily	100[a]	33.1[b]	6.02[a]	7.97[a]	4.17[ab]
Two days	100[a]	29.85[b]	3.96[b]	5.22[b]	2.31[c]
Four days	93[b]	32.7[b]	3.53[b]	4.92[b]	2.89[bc]
P value	0.05	0.01	0.01	0.01	0.05
SED	2.04	1.38	0.53	0.62	0.61
% CV	2.9	5.1	13.2	11.5	21.2

Means with the same letter(s) in each column are not significantly different to each other using SED at $p<0.01$ and $p<0.05$

3.2 Watering interval effect on root growth of *Prunus africana* seedlings

Results on root variables showed that watering twice and once daily showed significantly ($p<0.05$) higher root collar diameter (4.9 mm) compared with two (3.8 mm) and four days interval (4.1 mm) (Table 2). A similar trend was repeated for root biomass although in this case watering once daily showed significantly lower root biomass (1.95 g) compared with watering twice daily (2.33 g).

Table 2 Effect of watering interval on root growth of *Prunus africana* seedlings at Egerton University, Kenya

Watering interval	Root collar diameter (mm)	Root length (cm)	Root biomass (g)	Root: shoot ratio	Seedling sturdiness quotient
Twice daily	4.9[a]	13.0	2.33[a]	0.38	7.69[ab]
Once daily	4.9[a]	12.42	1.95[b]	0.32	6.77[b]
Two days	3.8[b]	11.66	1.26[c]	0.32	7.82[ab]
Four days	4.1[b]	12.62	1.39[c]	0.4	7.99[a]
P value	0.05	0.33	0.001	0.26	0.05
SED	0.3	0.68	0.15	0.43	0.5
% CV	8.4	6.7	10.8	14.9	8.1

Means with the same letter(s) in each column are not significantly different to each other using SED at $p<0.001$ and $p<0.05$

Four days watering interval showed significantly superior seedling sturdiness quotient (7.99) compared with watering interval of once daily (6.77). These results shows that four days watering interval could be the best for field survival, however, this watering interval compromised greatly growth in root collar diameter and root biomass as compared to frequent watering.

3.3 Watering interval effect on foliage growth of *Prunus africana* seedlings

Results on foliage variables showed that watering interval of twice daily had significantly ($p<0.05$) higher leaf length (9.04 cm), single leaf area (23.4 cm^2) and total leaf area (291.3 cm^2) compared with four days watering interval (6.82 cm, 11.94 cm^2 and 114.5 cm^2 respectively) (Table 3).

Similarly, watering twice daily showed significantly higher leaf width compared with all the other treatments. On the other hand, watering once daily and also two days interval showed significantly superior leaf width and single leaf area

compared with four days interval. These results shows that four day watering interval compromised foliage growth and therefore should not be encouraged since it also leads to low survival of seedlings in the nursery. However, the best hardening off watering interval was two days since it does not compromise growth but reduces succulent foliage growth.

Table 3 Effect of watering interval on foliage growth of *Prunus africana* seedlings at Egerton University, Kenya

Watering interval	Leaf length (cm)	Leaf width (cm)	Number of leaves	Single leaf area (cm^2)	Total leaf area (cm^2)
Twice daily	9.04^{a}	3.76^{a}	12.52	23.4^{a}	291.3^{a}
Once daily	8.29^{ab}	3.16^{b}	8.76	19.09^{a}	168.1^{ab}
Two days	8.14^{ab}	3.07^{b}	8.81	18.52^{a}	163.3^{ab}
Four days	6.82^{b}	2.43^{c}	9.57	11.94^{b}	114.5^{b}
P value	0.05	0.05	0.56	0.05	0.05
SED	0.77	0.21	2.87	2.52	58.29
% CV	11.7	8.3	35.7	16.9	38.7

Means with the same letter(s) in each column are not significantly different to each other using SED at $p<0.05$.

4. Discussion

4.1 Watering interval effect on shoot growth and survival of *Prunus africana* seedlings

Environmental conditions and propagation methods used in the nursery can produce different hardening degrees in seedling. Results showed that four days watering interval was significantly lower in survival compared with all the other treatments. This is in line with the findings of Jones (2004) and Tambussi *et al*. (2007) who reported that plants exhibit different strategies for survival and growth under limited water supply. These plants that receive less water are the ones that are more likely to survive in the field. Earlier studies by Franco *et al*. (2001, 2002) argued that plants receiving the least amount of water best adapt to post planting stress. Reduced watering leads to less shoot growth and more sturdy plants which are better preferred for planting out (Inoti, 2018; Inoti, 2020).

4.2 Watering interval effect on root growth of *Prunus africana* seedlings

There was significance difference in the root biomass with exception of two days and four days intervals. This may have been attributed to the high amount of water in the soil substrate absorbed by the roots making them turgid. This is supported by earlier findings by Bañon *et al*. (2004) who stated that deficit irrigation reduced root dry weight and volume by 53–62% and 88–91%, respectively.

The study showed that there was no significance difference in growth estimates for the different watering intervals. Seedling sturdiness quotient postulates higher value than the recommended (Jaenicke, 1999), there was significant difference found in mean sturdiness quotient. This means that the seedlings might have a lower chance of survival in the field, since they are tall and thin with exception of those which were watered once daily especially in windy or dry areas.

According to earlier studies by Takoutsing *et al*. (2014), a small quotient (<6) indicates sturdy plants with greater chance of survival. Seedlings with quality indicators out of acceptable ranges are likely not to perform well once they leave the nursery (Zida *et al*., 2008; Bayala *et al*., 2009). This notwithstanding, (Zida *et al*., 2008) mentioned that other factors like degree of disturbance to the root system during lifting, transportation and planting can result to low survival in the field especially in drought prone areas. This is further supported by the findings of Bayala *et al*. (2009) who stated that it is difficult to define morphological attributes which can predict field performance. Other studies show that after eighteen months of planting out, seedling survival and growth were not affected by initial seedling size based on the root to shoot ratio rather due to other factors like drought stress and herbivory (Zida *et al*., 2008). Therefore the result of this study shows that the plant will survive in the field if handled and planted in the right manner.

4.3 Watering interval effect on foliage growth of *Prunus africana* seedlings

Watering twice daily was significant higher in most of the foliage characteristics compared with four days watering interval. This could have been attributed to the more water the plant was receiving in twice daily which promoted growth. These findings corroborate with the earlier findings by Bañon et al. (2004) who stated that deficit irrigation strongly reduced the aerial part and root in plants and that leaf area was higher in well irrigated plants. Where high amount of water was maintained, it resulted to higher relative growth rate of leaf and root biomass, as well as leaf area than when the water supply was low (Ky-Dembele *et al*., 2010).

5. Conclusion

Results show that twice daily watering gives the best growth of Prunus seedlings, however, since it encourages succulent foliage growth, it is therefore not preferred for planting out seedlings due to its low field survival. Therefore, two days watering interval is the most ideal for hardening off seedlings that are non-succulent in the highlands since it reduces foliage growth and encourages woodiness for better field survival.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors state that there is no conflict of interest as pertaining to the authorship of this paper.

References

[1] Bañon S, Fernandez JA, Franco JA, Torrecillas A, Alarcón JJ, Sánchez-Blanco MJ. Effects of water stress and night temperature preconditioning on water relations and morphological and anatomical changes of Lotus creticus plants. Scientia Horticulturae.10 Sep 2004; 101(3): 333-42.

[2] Bañon S, Ochoa J, Franco JA, Alarcón JJ, Sánchez-Blanco MJ. Hardening of oleander seedlings by deficit irrigation and low air humidity. Environmental and Experimental Botany. 1 May 2006; 56(1): 36-43.

[3] Bayala J, Dianda M, Wilson J, Ouedraogo SJ, Sanon K. Predicting field performance of five irrigated tree species using seedling quality assessment in Burkina Faso, West Africa. New Forests. 1 Nov 2009; 38(3): 309-22.

[4] Blain D, Kellman M. The effect of water supply on tree seed germination and seedling survival in a tropical seasonal forest in Veracruz, Mexico. Journal of Tropical Ecology. Feb 1991; 7(1): 69-83.

[5] Cameron RW, Harrison-Murray RS, Atkinson CJ, Judd HL. Regulated deficit irrigation–a means to control growth in woody ornamentals. The Journal of Horticultural Science and Biotechnology. 1 Jan 2006; 81(3): 435-43.

[6] Franco JA, BañÒ S, Ferna Ndez S, Leskovar DI. Effect of nursery regimes and establishment irrigation on root development of Lotus creticus seedlings following transplanting. The Journal of Horticultural Science and Biotechnology. 1 Jan 2001; 76(2): 174-9.

[7] Franco JA, Cros V, Bañón S, González A, Abrisqueta JM. Effects of nursery irrigation on postplanting root dynamics of Lotus creticus in semiarid field conditions. HortScience. 1 Jun 2002; 37(3): 525-8.

[8] Genstat. General statistical software. Learning and Development Centre Resource. Warwick University, UK. May 2013.

[9] Inoti, S.K. Effect of watering interval on the growth of jojoba (Simmondsia chinensis L.) seedlings in the drylands of Kenya. Researchjournali's Journal of Forestry. 10 Aug 2018; 5(1): 1-8.

[10] Inoti, S.K. Ideal Hardening off Watering Interval of East African Greenheart (Warburgia ugandensis), Nursery Seedlings in East Mau Watershed, Njoro, Kenya. Abstract presented during Egerton University International conference. 18 Oct 2020

[11] Jaenicke H. Good tree nursery practices: practical guidelines for research nurseries. World Agroforestry Centre; 25 Nov 1999.

[12] Jones HG. Irrigation scheduling: advantages and pitfalls of plant-based methods. Journal of experimental botany. 1 Nov 2004; 55(407): 2427-36.

[13] Kinyanjui, H.C. Detailed soil survey of Tatton farm, Egerton College, Njoro. Ministry of Agriculture- National Agricultural Laboratories, Nairobi, Kenya. Feb 1979.

[14] Ky-Dembele C, Bayala J, Savadogo P, Tigabu M, Odén PC, Boussim IJ. Comparison of growth responses of Khaya senegalensis seedlings and stecklings to four irrigation regimes. Silva Fennica. 1 Jan 2010; 44(5): 787-98.

[15] Ngetich, K.F; Mucheru-Muna, M. and Mugwe, J.N. Length of growing season, rainfall temporal distribution, onset and cessation dates in the Kenyan highlands. Agricultural and Forest Meteorology 14 April 2014; 188: 24-32.

[16] Ochoa J, Franco JA, Sánchez-Blanco MJ, Alarcón JJ, Torrecillas A, Ferrández T, Bañón S. Hardening of Olea europaea var. sylvestris seedling by application of water and humidity ambiental stress treatments. In VI International Symposium on Protected Cultivation in Mild Winter Climate: Product and Process Innovation. 8 Mar 2002 ; pp. 515-520.

[17] Qaderi MM, Kurepin LV, Reid DM. Effects of temperature and watering regime on growth, gas exchange and abscisic acid content of canola (Brassica napus) seedlings. Environmental and Experimental Botany. 1 Jan 2012; 75: 107-13.

[18] Takoutsing B, Tchoundjeu Z, Degrande A, Asaah E, Gyau A, Nkeumoe F, Tsobeng A. Assessing the quality of seedlings in small-scale nurseries in the highlands of Cameroon: the use of growth characteristics and quality thresholds as indicators. Small-scale Forestry. Mar 2014; 13(1): 65-77.

[19] Tambussi EA, Bort J, Araus JL. Water use efficiency in C3 cereals under Mediterranean conditions: a review of some physiological aspects. OPTIONS Méditerranéennes Ser B. 2007; 57: 189-203.

[20] Zhu H, Krause CR, Zondag RH, Brazee RD, Derksen RC, Reding ME, Fausey NR. A new system to monitor water and nutrient use in pot-inpot nursery production systems. Journal of Environmental Horticulture. Mar 2005; 23(1): 47-53.

[21] Zida D, Tigabu M, Sawadogo L, Odén PC. Initial seedling morphological characteristics and field performance of two Sudanian savanna species in relation to nursery production period and watering regimes. Forest Ecology and Management. 20 Apr 2008; 255(7): 2151-62.