Correlation of Selected Germination Indices for *Melia volknesii*seed collected from Kibwezi seed orchard

Abstract

Melia volkensii is an important drought tolerant dryland species with characteristics that make it adoptable to harsh environments. The species is primarily propagated by seeds that are produced in fruits (drupes) that contain a single nut with each nut having two to five seeds. To collect data on the germination indices of *M. volkensii,* fruits were collected from a seed orchard in Kibwezi and the nuts were extracted immediately. The nuts were stored in open containers for three months and seeds were extracted from the nuts. The extracted seeds were stored for two weeks prior to experimentation and prepared for germination testing. The seeds were then germinated in the glasshouse and nursery at KEFRI Seed Center Muguga using shallow drills and light covering. The sown experiments were then covered with a transparent polythene bag and observed for 25 days. Germination data was collected on daily basis for 25 days and analyzed to generate germination indices. The output was subjected to ANNOVA using Genstat Version 14, and correlations were done. Onset germination was observed between day five and six with 77% germination in the glasshouse and 54% germination in the nursery. Peak germination was reached between day 19 and day 24, with germination rate highest between day 7 and day 19. From the current study, germination outcomes related positively with all other indices with the exception of T_{50}, the index whose increase corresponds with poor germination outcomes. Comparatively, Mean Daily Germination, Germination Value, and Peak Value (indices that indicate a fast germination rate) had a strong positive correlation to germination percentage for the sown *M. volkensii* seeds.

Introduction

With regard to its characteristics, *Melia volknesii* is a drought tolerant deciduous species that grows to approximately 20 meters tall (Muok*et al.,* 2010; Orwa *et al.*, 2009). This feature provides capacity for production of high quality timber (Wekesa, *et al.,* 2012; Githae&Mutiga, 2021). In addition, due its capacity for drought tolerance, it has manageable water requirements and can be utilized as a source of fodder during harsh climatic conditions (Wekesa, *et al.,* 2012). This ability to thrive under harsh conditions therefore makes the species significantly important in environmental conservation and restoration efforts. Besides food, fodder and conservation, the species is also utilized as a source of bee forage and medicines (Omondi *et al.,* 2004; Muok*et al.,* 2010; Stewart &Blomley, 1994), as well as a potential pesticide source (Jaoko*et al.,* 2021). Across the Keyan land scape, M. volkesii is common in the coastal areas and the Eatern regions, covering areas such as Taita, Makueni, Kitui, and Kibwezi.

Kibwezi is located in the Eastern part of Kenya at an altitude of 861 meters above sea level and a longitude 37.9667. The area is considered as part of the Kenyan drylands, characterized by high mean temperatures of $26^{o}C$ and annual rainfall of 112.49 mm. The region is also characterized by bushed grassland to bushland vegetation (Njoki, 2006) and a tree cover that is dominated by

Acacia, Balanites, Commiphora and Adansonia species (Gachambi, 1990; Njoki, 2006). With regard to *M. vokensii*, the area is considered as a natural habitat for the species with its adaptation to water deficient environments making it an important conservation and economical species for the region. Generally, propagation of the species is done by the use of seed, with the natural population as the main means for conservation and maintenance of genetic diversity. This diversity has provided materials for the establishment of seed orchards through use of high value individuals for seed production (Kariuki *et al*., 2021).

In addition, the exceptional value for the species has resulted in increased demand and utilization of quality seed (Kamondo*et al.,* 2021). However, forestry tree seeds have varied germination characteristics based on genetics as well as provenance (Gupta and Sehgal, 1999). This therefore necessitates detailed research on seed source and handling related effects germination characteristics (Wani & Singh, 2016). Such results are important for large scale restoration programs as well as for tree improvement programs that depend on both seed germination and seedling survival. In addition, according to Zobel and Talbert (1984) such information is important in advising large scale forestry restorations programs on applicability of seed sources as a measure against seed quality related losses. However, studies on seed viability are based on measurement of seed germination indicies that are dependent on inherent and external seed germination factors. This current study therefore seeks to assess the correlation dynamics of seed germination indices for*Melia volknesii* seed from a seed orchard, as a baseline for demining seed and seed source performance, as well as influenced by germination environments. The seeds for the study were sourced from Kibwezi seed orchard established and maintained on the principles outlined by Mulawarman et al (2003) and Mbora et al (2009), as outlined by Kariuki et al (2021).

Objectives

- To compare the variations in germination of *Melia volkensii*seed under different germination environments.
- To assess the correlation dynamics of seed germination of *Melia volknesii* seed.

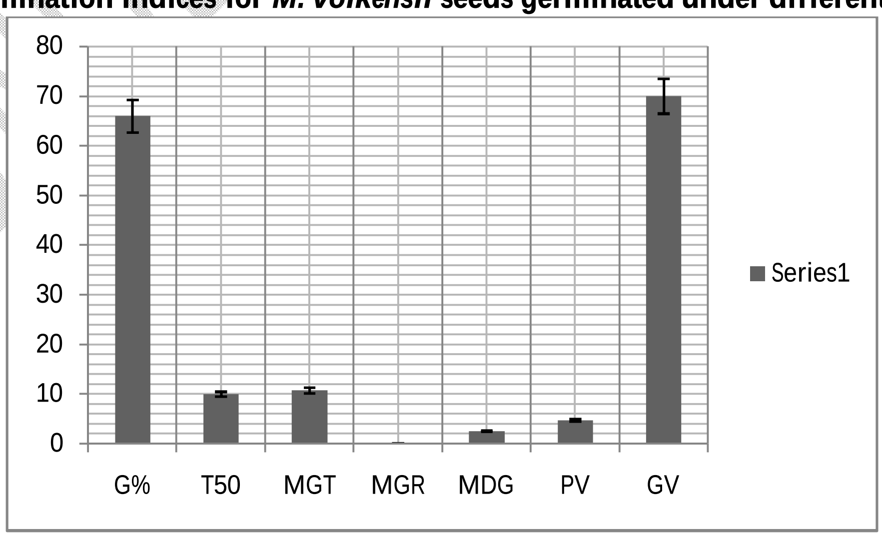
Methodology

*M. volkensii*fruits were collected from a seed orchard in Kibwezi and the nuts were extracted immediately from the fruits. The nuts were subsequently stored in open containers for three months and seeds were extracted from the nuts after the storage period. The extracted seeds were stored for two weeks prior to experimentation in airtight containers. The experiment used sand as the germination media, which was prepared through sieving and washing then drenching with NaOCl, then draining with clean water. After preparing the media, the seeds were pretreated by breaking the cruncle then soaking overnight in Ridomil solution made (4g of Ridomil per liter of water) to minimize chances of fungal infection on the seed during germination. The soaking solution was strained and the seeds rinsed with distilled water then carefully nicked by slitting the seed coat along the longitudinal side of the seed using a sterilized razor blade (not a scalpel blade). The nicked seeds were then placed in 500g plastic containers,that had been sterilized using 70% ethanol, and soaked in water for 30 minutes. The soaked seeds were then sowed in four replicates of twenty five seeds each in the glasshouse and nursery, with the experiment laid out seven times by seven participants in both glasshouse and nursery. The seedpre-sowingfor germination testing was done according to the procedure described by Olung'ati et al (2023), and sown in shallow drills (5 mm deep) and covered lightly, using sand. The sown experiments were then covered with a transparent polythene bag and observed for 25 days according to Njehu et al (2021) as described by Olung'ati et al (2023). Watering was stopped on the day of sowing and only resumed after day 12, with the sand watered to field capacity in the evening each day. Germination data was collected on daily basis for the 25 days and analyzed to generate germination indices values according based on the formulas as cited in Dastanpoor*et al* (2013), and Djavanshir&Pourbeik (1976), and edited by the author using Excel software. The output was subjected to ANNOVA using Genstat Version 14, and the correlations were done and assed as described by Schober et al (2018). Data on temperature and humidity was recorded for the sowing environments using a dataloger.

Results

Onset germination was observed between day five and six and the overall germination capacity of the seeds varied statistically across the germination sites ($p<.001$). Germination capacity (G%) at the glasshouse had a general mean of 77% while germination capacity at the nursery had an overall mean of 54%. The seeds however had a general germination percentage of 66%. This percentage translated to a Germination value (GV) of 70%, indicating the potential for complete germination at optimal speeds for at least seven tenths of the material regardless of site. Between the two sites, GV was higher in the glasshouse at 92% as compared to in the 48% in the nursery. Comparatively, T_{50} for the two sites was not significantly different with a mean of 10 days across sites, 12 days in the glasshouse and 11.5 days in the nursery. This resulted in a Mean Germination Time (MGT) of between 10 to 11 days for both sites (Figure 1).

Figure 1: Germination indices for *M. volkensii* seeds germinated under different conditions.



Of all the germination indices, only T_{50} had a net negative correlation to germination percentage. This correlation was however weak at 9%. On the other hand, Mean Daily Germination (MDG) and Peak Value (PV) had a strong positive correlation to germination percentage at 97% and 92% respectively. Similarly, GV had a strong positive correlation to germination percentage at 81%, but the correlation value was lower than that of MDG and PV. The weakest correlation to germination percentage was recorded from Mean Germination Time (MGT) and MGR. However, both MGT and Mean Germination Rate (MGR) had a weak positive correlation to germination percentage at 10% and 19.6% respectively. For the other indices, T_{50} had negative correlations with all other indices with the exception of MGT (93%, strong) and GV (12%, weak).

Comparatively, GV had positive correlations with all indices with the exception of MGR with a strong negative correlation of 77% (Table 1).MGR also had strong negative correlation MGT at 98%. While the other indices had weak positive correlations to GV, MDG had a strong positive correlation to GV (77%). In addition, MDG had positive correlations with other indices with the exception of MGT and T_{50} that had negative correlation to MDG at 11% and 9.1% respectively. MGT also had weak negative correlation PV at 28%, while PV also had a weak negative correlation to at T_{50} at 24% (Table 1).

	G%	T_{50}	MDG	MGR	MGT	PV	GV
G%	-						
T_{50}	-0.091	-					
MDG	0.972***	-0.091	-				
MGR	0.196	-0.917	0.169	-			
MGT	0.1	0.937***	-0.11	-0.981	-		
PV	0.927***	-0.243	0.92	0.363	-0.281	-	
GV	0.081	0.124	0.77	-0.77	0.126	0.043	-

Table 1: Correlation for germination indices for *M.volkensii* seeds germinated under different conditions(G% - germination capacity/germination percentage, MDG–mean daily germination, MGR–mean germination rate, MGT–mean germination time, PV–peak value, GV–germination value).

<u>Discussion</u>

Comparatively, the glasshouse recorded an average temperature of 23°C and an average RH of 93%, while the nursery showed an average temperature of 31°C and RH of 38%. Therefore, the variation in germination indices between the sites could be linked to the variations in temperature and relative humidity. The negative correlation between T_{50} and germination percentage is indicative of the effect of slow germination times on the overall achieved germination. In addition, it indicates the possibility that fast germinating seeds, as a cause of higher germination outcomes, could indicate higher seed quality and vice versa. This relationship is however opposite to that that expressed by mean daily germination (MDG) and peak value (PV), where an increase in the MDG as well the PV corresponds to an increase in the overall germination. These results therefore quantify that higher daily germinations result in lower T_{50} and conversely higher PV and germination outcomes. According to Djavanshir&Pourbeik (1976), higher peak values are an expression of seed quality, and generally correlates positively with germination speed. According to Finch-Savage & Bassel (2016) a faster germination is an indication of vigour which subsequently affects field uniformity positively. In addition, a higher vigour of seedlings can likewise be provided as an indicator for seedling survival (Finch-Savage & Bassel, 2016; Khan *et al.,* 2012).

On the other hand, out of all evaluated indices, only MGT had a strong positive correlation with T_{50}. This indicates that seed lots with a longer germination time consequently will require a longer time period to achieve T_{50}, as increase in one index results in an increase in the other. On the other hand, all the other indices expressed a decrease with increase in $T_{50,}$ vice versa. While a longer time to T_{50} can be considered negative for species considered as having relatively fast germination, it may vary between forestry species depending on average germination time. On the other hand, MDG correlated positively with all other indices with the exception of T_{50} and MGT. This relationship indicates that an increase in daily germination lowers the overall germination time as well as time to T_{50}. Daily germination and germination time can be affected by seed physiology, seed germination environment (Tonguç*et al*.,2021), and for forestry seed the skill of germinating practitioners(Luna *et al.,* 1949; Olung'ati *et al.,* 2023; Omondi *et al.,* 2004).

Of all the Indices, germination value (GV) had a significant correlation with MDG and mean germination rate (MGR). While the relationship was positive for MDG it was negative for MGR. These results therefore quantify that seeds with a higher MDG have a higher GV, and that increase in the GV corresponds to a decrease in MGR. Comparatively, seed germination rate is higher at onset of germination and slows down as it approaches peak value, then plateaus. The highest GV is recorded after the plateau at the point when MGR is lowest, hence a negative correlation between GV and MGR. The relationship therefore has no implication on seed quality, only on the nature of seed germination over time. For *M. volkensii* seed germination, while T_{50} did not vary between the glasshouse and nursery, overall germination, GV, PV, and MDG were better under glasshouse conditions.

Conclusion

The study also identifies the glasshouse as the best site for germination of M. volkensii seed in areas similar to Muguga. This could be due to the high constant relative humidity in the glasshouse and RH, generated by the plastic covering. Research to determine the provenance related variations in such relationships should be pursued to build on information of seed germination and seed germination behavior. For the *M. volkensii* seeds tested the results indicate, high germination potential when for orchard sources seed when freshly extracted. Therefore, indices for stored seed should likewise be investigated.

Recommendations

From the current study, germination outcomes related positively with all other indices with the exception of T50, the index whose increase corresponds with poor germination. Additionally, all other factors varied between the glass house and nursery with the exception of T50, indicating that this trait is based more in inherent seed quality than the environment. As such, under similar conditions T50 is a fundamental metric for comparing seed and seed source quality for the species. Comparatively, Mean Daily Germination, Germination Value, and Peak Value (indices that indicate a fast germination rate) had a strong positive correlation to germination percentage. The relationship between germination indices provides an important means for understanding and apportioning effects of different factors that lead to germination issues. In addition, such relationships highlight the actual panting value of a seed lot with regard to seed germination as well as seedling vigour and survival. For M. volkensii, GV, PV, and MDG are the best indices for use in evaluating overall seed germination and seedling vigour value in correlation to germination.

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

References

Dastanpoor, N., Fahimi, H., Shariati, M., Davazdahemami, S., & Hashemi, S. M. M. (2013). Effects of hydropriming on seed germination and seedling growth in sage (Salvia officinalis L.). *African Journal of Biotechnology*, *12*(11), 1223-1228.

Djavanshir, K., &Pourbeik, H. (1976). Germination value-a new formula. *Silvaegenetica*, *25*(2), 79-83.

Finch-Savage, W. E., & Bassel, G. W. (2016). Seed vigour and crop establishment: extending performance beyond adaptation. *Journal of experimental botany*, *67*(3), 567-591.

Gachambi, L. N. (1990). *Land degradation and its control in the Kibwezi area, Kenya* (Doctoral dissertation).

Githae, E. W., &Mutiga, I. M. (2021). Ecological restoration of pastoral landscapes in the drylands of East Africa. *Journal of Dryland Agriculture*, *7*(3), 34-41.

Gupta T and Sehgal RN (1999) Genetic estimates for the seed traits of Toonaciliata. Range Mgmt. Agrofor., 20 (2): 188-193.

Jaoko, V., Nji Tizi Taning, C., Backx, S., Mulatya, J., Van den Abeele, J., Magomere, T., Olubayo, F., Mangelinckx, S., Werbrouck, S., &Smagghe, G. (2020). The Phytochemical Composition of *Melia volkensii* and Its Potential for Insect Pest Management. *Plants (Basel, Switzerland)*, *9*(2), 143. https://doi.org/10.3390/plants9020143

Kamondo, B., Njuguna, J., Omondi, W., Angaine, P., Meso, M., &Machua, J. (2021). *Tree seed supply chain for commercial tree species in Kenya*: KEFRI - GATSBY AFRICA. Retrieved from https://www.kefri.org/assets/questionaire/KEFRI%20GATSBY%20SUMMARY%20SEED%20SUPPLY%20CHAIN%20REPORT%20JM.pdf

Kariuki, J. G., Miyashita, H., Ndufa, J. K., &Kamondo, B. M. (2021). Manual for establishing and managing Melia volkensii seed orchards in Kenya.

Khan, N., Kazmi, R. H., Willems, L. A., Van Heusden, A. W., Ligterink, W., & Hilhorst, H. W. (2012). Exploring the natural variation for seedling traits and their link with seed dimensions in tomato.

Luna, T., Wilkinson, K.M. and Dumroese, R.K. (1949). Seed germination and sowing options. Nursery Manualfor Native Plants: A Guide for Tribal Nurseries, 1, 133-151.

Njehu, J.M., Wabuyele, E., Mutune, A.N., Omollo, K. and Kamondo, B.M. (2021). Optimizing germination of*Meliavolkensii*Gurkeafterstorageofseedsandnutsindifferentstorageconditions.*InternationalJournalof Plant, Animal and Environmental Sciences*, **11**, 532-544.

Mbora, A., Lillesø, J.B., Schmidt, L., Angaine, P., Meso, M., Omondi, W., Ahenda, J., Mutua, N.A., Orwa, C. and Jamnadass, R. (2009). Tree seed source re-classification manual. *World Agroforestry Centre, Nairobi, Kenya. 34pp*.

Mulawarman ,Roshetko, J. M., Sasongko, S. M., &Iriantono, D. (2003). Tree seed management: seed sources, seed collection and seed handling. A field manual for field workers and farmers. *Tree seed management: seed sources, seed collection and seed handling. A field manual for field workers and farmers.* International Centre for Research in Agroforestry (ICRAF) and

Winrock International. Bogor, Indonesia.

Muok, B., Mwamburi, A., Kyalo, E., & Auka, S. (2010). Growing Melia volkensii. *A Guide for Farmers and Tree Growers in the Drylands*, *3*.

Njoki, P, M., (2006). *Land use change and its effects on soil and vegetation degradation in Kibwezi district.* ^ (Master of Science). EGERTON UNIVERSITY.

Olung'ati, E.O.,Kamondo, B., Jepchumba, M., Njuguna, J., Kimondo, J., Kariuki, J., Kyalo, E., Masecha, M., Ntalalai, F., Wafula, A., LeparakuoL., and Khaemba L. (2023).The role of skill in successful germination of *Melia volknesii* seed. *Seed Science and Technology journal*, 51 (2), 259-265. https://doi.org/10.15258/sst.2023.51.2.10

Omondi, W., Maua, J. O., &Gachathi, F. N. (2004). Tree seed handbook of Kenya. GTZ Forestry Seed Centre.

Orwa C, MutuaA ,Kindt R , Jamnadass R, Simons A. 2009. AgroforestreeDatabase:a tree reference and selection guide version 4.0 (http://www.worldagroforestry.org/af/treedb/)

Schober, P., Boer, C., & Schwarte, L. A. (2018). Correlation coefficients: appropriate use and interpretation. *Anesthesia & Analgesia*, *126*(5), 1763-1768.

Stewart, M., &Blomley, T. (1994). Use of Melia volkensii in a semi-arid agroforestry system in Kenya. *The Commonwealth Forestry Review*, 128-131.

Tonguç, M., Önder, S., &Mutlucan, M. (2021). Determination of germination parameters of safflower (Carthamus tinctorius L.) cultivars under salt stress. *Süleyman Demirel Üniversitesi Fen Bilimleri Enstitüsü Dergisi*, *25*(2), 155-161.

Wani, M. R., & Singh, S. S. (2016). Correlation dynamics of germination value, germination energy index and germination speed of Pongamiapinnata (L.) Pierre seeds of Pendra Provenance, Chhattisgarh, India. *International Journal of Research*, *28*.

Wekesa, L., Muturi, G., Mulatya, J., Esilaba, A., Keya, G., &Ihure, S. (2012). Economic viability of Melia volkensii (Gurkii) production on smallholdings in drylands of Kenya. *Int. Res. J. Agric. Sci. Soil Sci*, *2*, 364-369.

Zobel B and Talbert J (1984) Applied Forest Tree Improvement. John Wiley and Sons, New York: 505