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Comparative performance of *Moringa oleifera* and *Moringa ovalifolia* seeds and seedlings establishment in central Namibia

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ABSTRACT

Trees and shrubs can serve as fodder to supplement shortage of feeds for livestock particularly in arid and semi-arid environments where palatable grasses or browse plants could be limited due to low rainfall pattern and constant droughts. However, in Namibia Moringa tree species show the potential to curb shortage of feeds in livestock. A completely randomized design (CRD) was used in this study to compare the performance of *M. ovalifolia* and *M. oleifera* seed germination and seedlings establishment. Seeds of *Moringa* spp. were sown in nursery in 253 polythene bags (149 for *M. oleifera* and 104 for *M. ovalifolia*) at uniform sowing depths. The parameters measured were germination rate and seedling growth rates. The results in the study show that *M. ovalifolia* had higher seed germination rate compared to *M. oleifera*. Also, *M. ovalifolia* germinated faster than *M. oleifera*. Conversely*, M. oleifera* had faster seedlings establishment compared to *M. ovalifolia* which had slower growth rate over time. ANOVA result revealed that *M. oleifera* and *M. ovalifolia* mean germination rates and germination days were significantly different ($p < 0.05$), which indicated that the two *Moringa* spp. germinated at different rates and days. Furthermore, both *Moringa* spp. growth rates (heights) per week were significantly different ($p < 0.05$). Therefore, from the results, the null hypotheses (H_o) that both *Moringa* spp. were not different in germination and growth rates were rejected.

Keywords: Germination rates, growth rates, *Moringa oleifera*, *Moringa ovalifolia*, nursery.

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INTRODUCTION

The incorporation of tree and shrub species in livestock production systems is a viable alternative that could improve the utilization of land resources and quality of feeds for livestock species particularly for ruminants (Sanchez et al., 2006). Further, fodder trees and shrubs are quite essential in livestock farming particularly in semi-arid environments where palatable grasses or browsers are scarce predominantly during drought times (Franzel et al., 2014). However, *Moringa* tree species shows the potential to curb the shortage of feeds for livestock.

Moringa oleifera tree is native to India but has been planted worldwide. It is naturalized in many countries with high growth rate and capacity to produce large quantities of biomass even in poor soils (Sanchez et al., 2006; Price, 2007; Alhakman et al., 2013; Hassan and Ibrahim, 2013). The leaves are readily eaten by cattle, sheep, goats, pigs and rabbits with high nutritional and medicinal benefits. The leaves contain high proportion of nutrients such as protein, minerals, vitamins, carbohydrates, and fats (Olson, 2001; Fuglie, 2001; Moringa Mission Trust, 2005) that are essential for improving the performance of both animals and humans (Price, 2007; Thurber and Fahey, 2009; Philips, 2014). Furthermore, *Moringa ovalifolia*, which also belongs to *Moringaceae* family and described as a bottle tree because of its trunk, is a native tree to Namibia and Angola. This specie is generally uncommon, but widespread in western Namibia, as far south as 26° S; scattered localities in the Karstveld and occasional in the south, and common in the central areas. It grows in the wild in both countries. It is a small deciduous tree with a distinctive, squat, swollen stem and branches and is commonly known as “ghost tree or phantom tree”. The roots, bark and wood are eaten by goats; trees are also browsed by giraffe (Olson, 2001; Curtis and Mannheimer, 2005; Wyk et al., 2011). However, *M. ovalifolia* and *M. oleifera* are yet to be cultivated and the agronomical information for their cultivation is not available in Namibia. This information is vital in order to enable understand the appropriate methods required for the cultivation of different species of *Moringa* as fodder for livestock, particularly during droughts when feedstuffs are most scarce. Starting with germination trial and establishment, this could pave a way for the cultivation of *Moringa* spp. for livestock consumption in the country. Therefore, to fill these gaps, a comparative study was conducted to assess the performance of *M. ovalifolia* and *M. oleifera* seed germination and seedlings establishment. It was hypothesized that the performance of *M. ovalifolia* and *M. oleifera* seed germination and seedlings establishment do no differ significantly and similarly can adapt to diverse environmental conditions.

With seed propagation, trees and shrubs cultivation begins with the sowing of seeds and raising of seedlings either in the nursery or in the fields. For faster germination, a forced scarification has to be done on seeds to weaken the seed coats for moisture penetration under favorable oxygen and temperature conditions. This was done using several methods including soaking of seeds in water (Haferkamp et al., 1984; Evans and Blazich, 1999). A germination research conducted by Saeed and Thanos (2006) revealed that seeds germination rate was faster when scarification was done before sowing and the final germination was achieved within two weeks. Plants that have not been domesticated like *M. ovalifolia* need germination experiment to establish the level of scarification, germination and growth rates.

M. oleifera is a new and exotic species in Namibia while *M. ovalifolia* only grows in the wild. There is no known study comparing the propagation of these two species to the best of our knowledge in Namibia. Therefore, the objective of this study was to firstly document the agronomy of *M. ovalifolia* and *M. oleifera* propagated by seeds in nursery and to compare the germination rates and seedlings growth rates of both species in Namibian conditions. Secondly, the study aimed at comparing their survival and adaptability rates at nursery level as *M. ovalifolia* was only known to grow in the wild while *M. oleifera* was only being introduced into Namibia. Finally, this research was undertaken to establish the germination rates of *M. ovalifolia* in comparison to *M. oleifera* under the same scarification (seed coats treatment) that may serve as germination inhibitors as suggested by Haferkamp et al. (1984).

MATERIALS AND METHODS

Study area

This study was conducted at the Neudamm Campus of the University of Namibia, about 30 km east of Windhoek with an area of 10, 187 hectares of land on the campus’ agronomy site. Neudamm Campus is located at 22° 30′ 07″ latitude South and at 17° 22′ 14″ longitude East, and at an altitude of 1762 meter above sea level. The farm receives an annual average rainfall of 360 mm which is higher than the national annual average of 270 mm. The temperature ranges between a minimum of -7°C and a maximum 44°C (University of Namibia, 2011). The study was conducted during the period stretching from November, 2013 to January, 2014.

Experimental design

A completely randomized design (CRD) was used for the experiment in which two seed types were used for sowing. The two species of *Moringa* seeds were sown in two plots of 104 polythene bags of *M. ovalifolia* and 149 polythene bags of *M. oleifera* in rows of 10. From each *Moringa* type germination counts were made and growth measurements were randomly taken from 20 seedlings at weekly intervals as described by Manh et al. (2005). Means comparison was used to determine any differences in seed germination rates and seedlings growth rates of both *M. oleifera* and *M. ovalifolia*. The analysis of variance (ANOVA) as suggested by Haferkamp et al. (1984), was used to analyze the data and parameters such as standard error of means, standard deviation, means, minimum, maximum, number of cases were calculated in the current study as well as regression analysis to determine if there is significant difference in germination and growth rate of the two *Moringa* spp. The null hypotheses (H_0) that there were no significant differences in the seeds germination and growth rates in *M. oleifera* and *M. ovalifolia* were tested.

Preparation of Moringa nursery and management of seedlings

In this study, both *M. oleifera and M. ovalifolia* were propagated by seeds in the nursery as recommended by Prevost and Le Glorus (1997). The pit soil, river sand and cow manure at a ratio of 6:2:3 were thoroughly mixed and filled in one-liter polythene bags as suggested by Fuglie and Sreeja (2001). Thereafter, the polythene bags were placed in a wire mesh fence to protect them from animals. The filled polythene bags were watered 24 h before being sown. *M. oleifera* and *M. ovalifolia* seeds were soaked in hot water overnight as a treatment of the seed coats before being sown the following day as described by Haferkamp et al. (1984). Two seeds of each *Moringa* spp. were sown in each polythene bag as suggested by Sanchez et al. (2006). Seeds are planted in nurseries, either bare-rooted or in polythene pots. However, bare-rooted seedlings cost less to produce than potted seedlings but are more susceptible to drought after transplanting argued Franzel et al. (2014). Polythene bags are therefore important to nursery making to avoid future loses; that is why they were used in the current study. The seedlings were watered twice a week. Evans and Blazich (1999) also emphasized that seeds only germinate when conditions are favorable for germination; this also applies for their growth and survival.

After germination, the seedlings were thinned to reduce the number of seedlings to one in each polythene bag. The process of thinning was done after watering the seedlings for easy uprooting and transplanting of thinned seedlings in other polythene bags with the same soil mixture content. The transplanted seedlings were placed in the shade for a week to avoid sun stress after transplanting.

Procedures for data collection

The germination of both *Moringa* spp. was thoroughly monitored and recorded weekly in the nursery. *Moringa ovalifolia* germination started on the seventh day with two shoots. However, growth measurement only started on the eleventh day when the shoots were completely surfaced with at least two leaves. On the other hand, *M. oleifera* started germination on the twelfth day but was also only measured after it had fully surfaced with two leaves. The survival of thinned seedlings was monitored and recorded to determine their adaptability. This was done by monitoring them on a daily basis to see if there was any mortality until they had properly recovered and well established. In this study, heights of *M. ovalifolia* and *M. oleifera* seedlings were measured to determine their growth rates at nursery level. The heights of seedlings were measured using the method suggested by Heady (1957), that is from the ground surface to the tip of the plant leaves using a 30-centimeter ruler with the ruler placed along-side the plant vertically. The heights of 20 seedlings were measured for each *Moringa* spp. on a weekly basis as suggested by Manh et al. (2005). Maximum, minimum and average heights were determined during each measurement.

RESULTS AND DISCUSSION

The results of the present study indicated that both *M. ovalifolia* seeds and *M*. *oleifera* seeds started to germinate in the 2nd week; however, *M. ovalifolia* seeds started to germinate earlier on day 9 while *M. oleifera* seeds only started to germinate from day 11 after sowing. The results agree with those reported by Fuglie and Sreeja (2001) who found that *M. oleifera* starts to germinate within 5 to 12 days. They are in agreement with the findings of a study conducted in Malawi which reported that viable seeds germinate within two weeks (Nalivate et al., 2011). The early seed germination of *M. ovalifolia* observed in the present study could probably be attributed to the quality of its seeds. Further, the results showed that on the 11th day the number of emerging seedlings of *M. ovalifolia* in polythene bags was higher (72%) than that of *M*. *oleifera* (only 3.8%). The results revealed that *M. ovalifolia* ended germination earlier in the 3rd week (day 18) with higher overall germination rate (99.03%) whereas *M. oleifera* ended relatively late in the 4th week (day 23) with lower overall seed germination rate (25.17%). These results are in disagreement with those reported by KOMEHO Namibia (2015), who obtained 98% germination rate for *M. oleifera* seeds. This discrepancy probably could be associated with differences in storage conditions, age and pre-treatment methods of seeds (Fuglie and Sreeja, 2001). On the other hand, out of the 97 *M. ovalifolia* thinned seedlings, only 18 (18.55%) died while out of 8 *M. oleifera* thinned seedlings, 2 (25%) died.

Germination and seedlings establishment

The seeds of both *Moringa* spp. were soaked in hot water overnight and sown the following day. According to the Pace Project (n.d.), in order to get the seeds to germinate quickly, they need to be treated with hot water. That is, boil some water, cool it for 5 min and then soak the seeds overnight, using at least three times more water than seeds to cover the seeds completely. Scarification speeds up the germination process which is considered to be safer under semi-arid conditions as is the case of Namibia. Tables 1 and 2 show the results of *M. ovalifolia* and *M. oleifera* cumulative germination rates per polythene bag over a period of time. Accordingly, *M. ovalifolia* started germination on the 7th day with two shoots (0.96%) while for *M. oleifera* germination started on the 11th day with 4 shoots (1.34%). Furthermore, *M. ovalifolia* germinated more rapidly within 18 days (3 weeks) of sowing with 99.03% germination rate (208 seeds sown in 104 polythene bags). All the 104 (100%) polythene bags had germinated seedlings. Conversely, *M. oleifera* germinated slowly within 28 days (4 weeks) with 15.06% germination rate (75 out of 298 seeds). Seventy-four out of 149 (49.66%) polythene bags had germinated seedlings. A germination test conducted by Haferkamp et al. (1984) showed that final germination was more than 75%, although the speed of germination was slower. Germination was considered completed when there was no additional seed germinated as described by Saeed and Thanos (2006). Besides the viability of the seeds, *M. ovalifolia* seeds are smaller with softer seed coats compared to *M. oleifera* seeds, which may have also contributed to the faster and rapid germination rate of *M. ovalifolia*.

Table 3 presents the results of analysis of variance of seedlings that germinated and comparison between *Moringa* spp. seeds. The analysis revealed that there is a significant difference ($p < 0.05$) of seedlings that germinated and *Moringa* spp. seeds between groups (*M. oleifera* and *M. ovalifolia*). The results of statistical analysis hence support the information on germination presented in Tables 1 and 2 in which the two *Moringa* spp. germinated at different rates. Hence, the null hypothesis that there is no significant difference between *Moringa* spp. seeds and germination rates is rejected.

Table 4 presents the statistical results in terms of the mean, number of cases, standard deviation, minimum, maximum and standard error of the mean for both *Moringa* species seeds and seedlings. From the means of the two species, *M. ovalifolia* had a higher number of seedlings that germinated (34.33), whereas the number of *M. oleifera* seedlings that germinated was relatively lower (9.375) but could still be placed in the maximum column.

The analysis of variance showed that there was no significant difference ($p > 0.05$) between *M. oleifera* and *M. ovalifolia* with regard to seedlings' germination over

Table 1. Daily and cumulative germination of *M. ovalifolia*.

Germination after sowing (days)	Germinated seedlings (cumulative)	Germination difference of seedlings	Germination rate (%)	# Polythene bags	% Polythene bags
7	2	2	0.96	2	0.96
9	50	48	24.04	30	28.84
11	113	63	54.34	75	72.11
13	136	23	65.38	100	96.15
16	203	67	97.59	104	100.00
18	206	3	99.03	104	100.00

Table 2. Daily and cumulative germination of *M. oleifera*.

Germination after sowing (days)	Germinated seedlings (cumulative)	Germination difference of seedlings	Germination rate (%)	#. Polythene bags	% Polythene bags
7	0	0	0.00	0	0.00
9	0	0	0.00	0	0.00
11	4	4	1.34	4	2.68
13	20	16	6.71	19	12.75
16	32	12	10.74	29	19.46
18	53	21	17.79	47	31.54
25	55	2	18.46	50	33.56
28	75	20	25.17	74	49.66

Table 3. ANOVA – *Moringa* spp. seeds and seedlings' germination.

Germination difference * Moringa seeds	Sum of squares	d_f	Mean square	F	Sig.
Between groups (combined)	2135.720	1	2135.720	5.351	.039
Within groups	4789.208	12	399.101		
Total	6924.929	13			

Eta = 0.308 and n = 14.

Table 4. *Moringa* species seeds and seedlings germination over time.

Moringa seeds	Mean	N	Std. deviation	Std. error of mean	Minimum	Maximum
M. oleifera	9.3750	8	8.92729	3.15627	.00	21.00
M. ovalifolia	34.3333	6	29.09066	11.87621	2.00	67.00
Total	20.0714	14	23.08001	6.16839	.00	67.00

the observation period. However, the germination of *Moringa ovalifolia* seeds was found to be statistically different from *M. oleifera* as seen in Table 3. The difference in germination between the two *Moringa* spp. may be rather attributed to the thinness of their seed coats than to the days. *M. ovalifolia* seed coats are thinner and softer than *M. oleifera* seedcoats. They may germinate faster due to their permeability and gaseous exchange abilities. This was demonstrated by Saeed and Thanos (2006) who observed that thin and soft seed coats are readily permeable to water and gaseous exchange in the first few days of imbibition when seeds are in "activation" stages with increased requirement for oxygen, which causes fast germination.

The mean statistics analysis result of the cumulative number of seeds that germinated and germination days can be found in Table 5. Results presented in Table 5 show the mean, number of cases, standard deviation, minimum, maximum and standard error of the mean in which germination rate over time (days).

These results show that germination rate is higher around days 16 and 18 (week 3) with 117.5 and 129.5

Table 5. Germination of *Moringa* spp. over time (days).

Time (Days)	Mean germination rate	*Moringa* spp.	Std. deviation	Minimum	Maximum	Std. error of mean
7	1.00	2	1.414	0.00	2.00	1.00
9	25.00	2	35.355	0.00	50.00	25.00
11	58.50	2	77.074	4.00	113.00	54.50
13	78.00	2	82.024	20.00	136.00	58.00
16	117.50	2	120.915	32.00	203.00	85.50
18	129.50	2	108.187	53.00	206.00	76.50
25	55.00	1	0.000	55.00	55.00	0.00
28	75.00	1	0.000	75.00	75.00	0.00

Table 6. Cumulative mortality of Moringa seedlings.

Moringa spp.	Mortality after emergence	Mortality due to cold (frost)	Mortality due to pests	Mortality after thinning	Mortality due to waterlog (rain)	Total mortality	Mortality (%)
M. ovalifolia	5	4	2	18	9	38	18.45
M. oleifera	1	2	0	2	0	5	6.67
Total	6	6	2	20	9	43	15.30

means, respectively. Seedlings mortality rates of *M. oleifera* and *M. ovalifolia* in the current study are presented in Table 6. During the period under study, 38 (18.44%) seedlings died out of 206 of *M. ovalifolia* seedlings which had germinated and 5 (6.66%) out of 75 *M. oleifera* seedlings, which brings the total mortality cases to 43 out of 281 total seedlings (15.30%). Overall, *M. ovalifolia* had 81.56% survival rate while *M. oleifera* survival rate was 93.33% which gives a total cumulative survival rate of 84.70%. This indicates that *M. oleifera* had greater survival and adaptability rates compared to *M. ovalifolia*. This survival difference may be attributed to the difference between their shoots' diameters as observed; indeed, *M. oleifera* shoots had larger diameters (circumferences) than *M. ovalifolia* giving them survival and adaptability edge in this harsh environment that gets either too cold or too hot at any unexpected time. However, Hiawacha Bey (2010) supported that *M. oleifera* is found in many tropical and sub-tropical regions, which can be grown in even the harshest and driest of soils, where barely anything else will grow. It was emphasized that one of the nicknames of *M. oleifera* is “never die” due to its incredible ability to survive harsh weather including drought which are typical of Namibian climatic conditions.

Growth performance of *M. ovalifolia* and *M. oleifera* seedlings

The results on growth performance of *M. ovalifolia* and *M. oleifera* seedlings are shown in Figures 1 to 4. The results of the present study show that *M*. *oleifera* grew faster than *M*. *ovalifolia* seedlings after germination. The results also show that the height of M. *oleifera* seedlings had an increasing pattern for the entire study period. On the other hand, the height changes of *M. ovalifolia* were faster in the first three weeks after germination but became slow and steady thereafter for the entire study period. These results suggest that growth characteristics of *M*. *oleifera* seedlings could probably be attributed to its early maturation and large biomass production that require little amount of water to survive in the nursery. In addition *M*. *oleifera* belongs to slender trees whose stems and roots contain tissues that store less water than the other *Moringa* species. Also, if propagated from the seeds, it also develops tubers that store energy for use during adverse conditions (survival mechanism). This might be the reason why most of the time the stems of *M*. *oleifera* die during harsh conditions and sprout soon after conditions improve. Therefore, these results suggest that *M*. *oleifera* tree could be tolerant to light frosts but cannot survive as a perennial crop under freezing conditions (Hassan and Ibrahim, 2013).

Table 7 presents a regression analysis of the heights of *Moringa* spp. over time in weeks. The results show highly significant differences ($P < 0.05$) between *M. oleifera* and *M. ovalifolia* heights over weeks. This means that the two species grew at different rates over time. *M. oleifera* grew faster and increased in heights weekly than *M. ovalifolia* even though it germinated lately. Thus, the null hypothesis that there was no significant difference between *M. oleifera* and *M. ovalifolia* growth rates per week was rejected. The variable *Moringa* species is a

Figure 1. Emergence of *M. ovalifolia* (day 12).

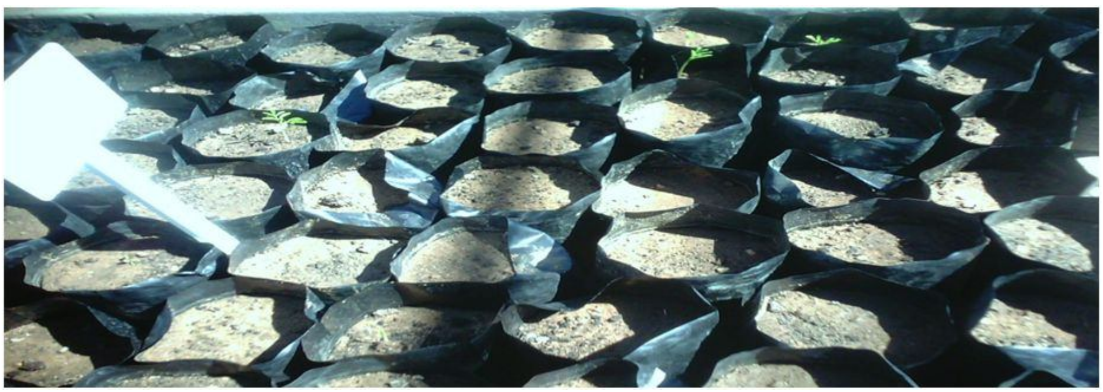

Figure 2. Emergence of *M. oleifera* (day 12).

Figure 3. *M. ovalifolia* seedlings (day 25).

dummy variable with a value of 1 if the species is *M. ovalifolia* and 0 otherwise. The coefficient shows that there are significant differences in the growth of the two species with *M. oleifera* growing faster than *M. ovalifolia*. Many literatures concurred with the faster growth of *M. oleifera* based on one of its active substances known as *Zeatin*, a plant hormone from the cytokines group that supports faster plants growth. This may be attributed to faster growth of *M. oleifera* in comparison to its counterpart *M. ovalifolia* (Hiawacha Bey, 2010).

Figure 4. *M. oleifera* seedlings (day 25).

Table 7. Regression analysis of *Moringa* spp. heights and weeks.

Model	Unstandardized coefficients		Standardized coefficients	t
	B	Std. Error	Beta	
Constant	1.981	.303		6.549
Moringa Species	-1.488	.229	-.171	-6.504
Week 3 Dummy	2.950	.396	.253	7.447
Week 4 Dummy	6.575	.396	.564	16.599
Week 5 Dummy	8.338	.396	.715	21.048
Week 6 Dummy	9.400	.396	.806	23.731
Week 7 Dummy	11.500	.396	.987	29.032

F-statistics = 201.721, R-square = 0.839, n = 240 and Sig. was 0.000 throughout.

Table 8. Descriptive statistics of *M. oleifera* and *M. ovalifolia* heights and weeks.

Weeks	Mean	N	Std. Deviation	Std. error of mean	Minimum	Maximum
1	0.000	20	0.0000	0.0000	0.0	0.0
2	2.475	20	0.4435	0.0992	2.0	3.0
3	4.188	40	0.3702	0.0585	4.0	5.0
4	7.813	40	1.4619	0.2311	6.0	11.0
5	9.575	40	1.5382	0.2432	7.0	12.0
6	10.638	40	1.6641	0.2631	8.0	13.0
7	12.737	40	3.6162	0.5718	8.0	18.0

Table 8 gives the results of descriptive statistics of the heights of *M. oleifera* and *M. ovalifolia* with mean, standard error of mean, standard deviation, minimum and maximum heights of *Moringa* spp. per week. The results show a steady growth in heights culminating into a mean of 12.737 cm with a maximum of 18.0 cm by week 7. Note that week two appeared twice in Table 8 because when *M. ovalifolia* heights were measured in week two, *M. oleifera* was unmeasureable due to its late germination which caused the zeros in the descriptive statistics in week two.

Tables 9 and 10 present the relationship between *Moringa* spp. and their heights. The analysis of variance (Table 9) presents a significant difference ($P < 0.05$) between *M. oleifera* and *M. ovalifolia*. The heights were different because of the difference between the two spp.

Table 9. ANOVA - Heights of *Moringa* spp.

Heights * *Moringa* spp.	Sum of squares	d_f	Mean square	F	Sig.
Between groups (Combined)	132.759	1	132.759	7.187	0.008
Within groups	4396.590	238	18.473		
Total	4529.349	239			

R-Square = 0.823 and n = 240.

Table 10. *Moringa* spp. and their heights.

Moringa spp.	Mean	N	Std. deviation	Std. error of mean	Minimum	Maximum
M. oleifera	8.442	120	5.3778	0.4909	0.0	18.0
M. ovalifolia	6.954	120	2.8329	0.2586	2.0	11.0

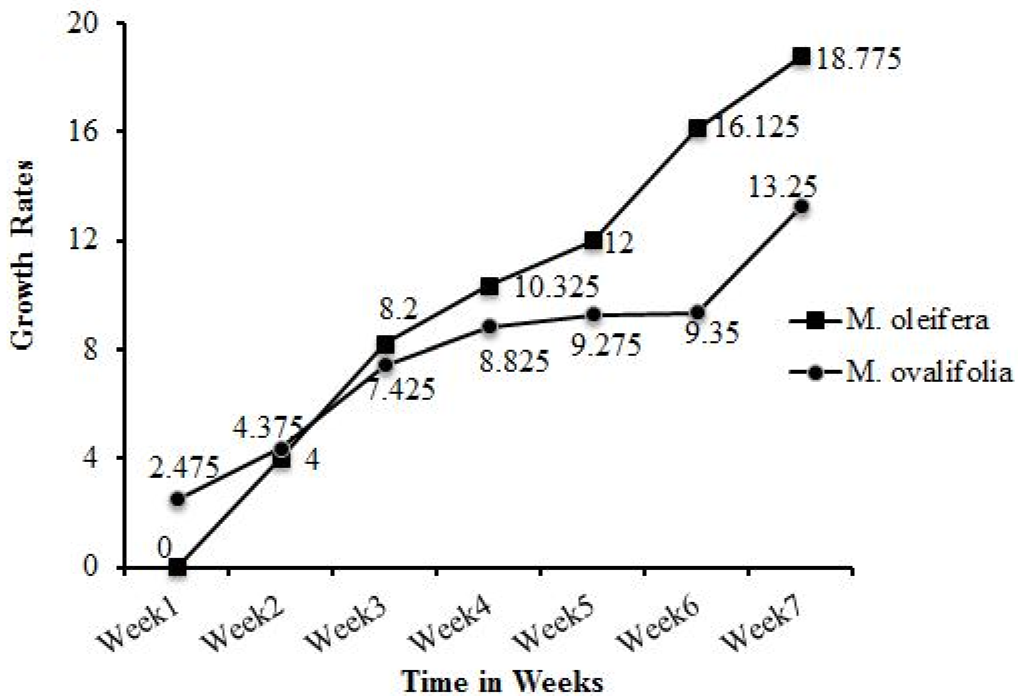

Figure 5. Average heights of *Moringa* spp. over time.

as revealed in Table 7 in which *M. oleifera* was noticed to have grown faster than *M. ovalifolia*. Consequently, the null hypothesis that there is no significant difference between the two *Moringa* spp. heights (growth rates) was rejected while the alternative hypothesis is accepted, because there is a significant difference in heights (growth rates) between *Moringa* spp. More specifically, Table 10 reveals that the mean of *M. oleifera* heights (8.467 cm) is higher than *M. ovalifolia* heights (6.833 cm). This a clear indication that *M. oleifera* grew faster although it germinated late compared to *M. ovalifolia* which grew slower over time.

Figure 5 shows the average heights of *M. oleifera* and *M. ovalifolia* over time in weeks. It was noticed that *M. ovalifolia* grew faster at first and later slower. Besides germination that was slower, *M. oleifera* grew at the same rate throughout the research period. This contributed to *M. oleifera* increase in elongation compared to *M. ovalifolia*.

The data in Figure 5 show that the fastest growth was observed in *M. ovalifolia* seedlings from week 2 till week 5. This could be due to the development of its sprout. Plant growth is most active during the first months of the cycle under favorable environmental conditions as suggested by Prevost and Le Glorus (1997). However, the growth observed in *M. ovalifolia* seedlings between week

Figure 6. Special “tuberous” roots of *M. ovalifolia* (4 months).

5 and week 7 after germination in the present study could probably be due to roots development into tubers to serve as a support for its further elongation. During this time, energy is being accumulated into the roots as a survival mechanism against winter or drought (Figure 6). Besides the absorption of water and nutrients needed by the roots, they produce growth substances that are used for the normal functioning of the plant, and serve as storage of food materials as in the case of root crops, such as sweet potato and carrot (AVRDC, 1990); this is also the case with *M. oleifera* roots. Further, *M. ovalifolia* belongs to bottle trees which are filled with pulpy water-storing tissues (Olson, 2001) that make them to survive in dry environments.

CONCLUSION

In conclusion, this study was able to reveal that M. *oleifera* seeds had poor germination rate compared to M. *ovalifolia* seeds. However, M. *oleifera* seedlings had faster growth than *M. ovalifolia* which grew slower over time. Both thinned and transplanted *M. oleifera* and M. *ovalifolia* seedlings had high survival and low mortality rates. Based on its fast growth rate, *M. oleifera* cultivation can be encouraged in Namibia which is predominantly semi-arid. In addition, *M. oleifera* being a “never die” tree has the ability to withstand drought and water shortage that is frequent in Namibia. *M. oleifera* has high biomass production ability due to its fast growth which can be used for human and animal consumption. Similarly, *M. ovalifolia* cultivation should be encouraged since it is native to Namibia and growing in the wild and has the ability to survive on its own with little care. Ecologically, it will have an edge of survival due to its adaptability to this region compared to *M. oleifera* which is exotic to Namibia. Although it grows slower and produces little biomass at first, once established, it can grow into a bigger tree with more biomass. This can be even enhanced by this species domestication. However, the major challenge to the cultivation of o *M. oleifera* in Namibia is frost susceptibility. Nevertheless, the cultivation of both *Moringa* spp. is paramount to the Namibian dry environmental conditions.

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