International Scholars Journals

International Journal of Agricultural Sciences ISSN 2167-0447 Vol. 10 (11), pp. 001-007, November, 2020. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Germination and growth performance of *Aloe turkanensis* and *Aloe secundflora* under different substrates

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Accepted 21 October, 2020

Income generated from indigenous *Aloe* sap taping has been a source of livelihoods to most communities in drylands of Kenya. Most of the *Aloe* leaf harvesting takes place in the wild, threatening the natural *Aloe* populations. This calls for establishment of *Aloe* plantations as alternative source of sustainable sap tapping. Currently there is lack of information on propagation methods of commercial indigenous Aloes in Kenya. Investigation undertaken to establish *Aloe* propagation methods showed that different factors determine *Aloe* germination and growth which need to be considered in *Aloe* propagation. Findings showed that *Aloe* seed germination under greenhouse began on the 9th day and maximum germination took place between 2nd and 3rd week of sowing. Addition of vermiculite and sawdust to soil from natural *Aloe* growing zones improved germination. *Aloe turkanensis* showed better germination percentage as compared to *Aloe secundflora* in most of the growing substrate. Forest humus soil blended with sawdust, showed the highest germination of 28%, after 21 days for *Aloe turkanensis* followed by substrate containing soils from natural habitat blended with vermiculite, then loam soil at 18 and 11% blended with sawdust and vermiculite, respectively. The vermiculite and sawdust blended media showed poor growth performance as revealed after 5 months of germination. Substrate from natural habitat enriched with manure showed good growth performance, while those enriched with sawdust had poor growth performance. Results indicate that different substrate may be used for germination and potting. Those that show high germination are not good for *Aloe* growth, but those enhancing growth did not show better germination.

Key words: Livelihoods, sustainability, *Aloe* propagation, substrate.

INTRODUCTION

*Aloe*s have rosettes of succulent leaves and tall candle like inflorescence, whose life form varies from miniature grass plants to tree Aloes, all have similar leaves (Carter, 1994). There are over 450 taxa in the genus *Aloe* concentrated in the Southern and Eastern Africa and Madagascar. *Aloe* products ranging from extracts, live plants and leaves, have been used at both subsistence and international trade contributing significantly to cultural and livelihood of many dry lands inhabitants (Newton, 1987). For instance, most dry land areas of Africa. *Aloe*s have been found contributing significantly in improving the living standards of the people who rely on them for income among other things. Studies by Mukonyi et al. (2001, 2005) reveals that the main harvested commercial indigenous *Aloes* species in Kenya include *Aloe secundflora, Aloe turkanensis, Aloe megalocantha, Aloe scabrifolia* and to some extent *Aloe rivae*. Some of the Kenyan commercial *Aloe*s have wider ecological distribution like *A. secundflora* while others are limited like *A. turkanensis, A. scabrifolia* and *A. megalocantha*, with *A. rivae* being more localized to Badha Huri hills of Marsabit.

Most of the sap collection taking place from the wild species, poses a threat to their natural populations. With increasing human populations, given limited alternative income sources in most parts of Kenyan dry lands will

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Abbreviations: KARI, Kenya agricultural research institute; **VSM,** volumetric soil moisture.

Table 1. Summary of substrate material used.

	Enrichment with vermiculate, sawdust, manure and combination of the three			
Substrate	**Addition of vermiculate**	**Addition of sawdust**	**Addition of manure**	**Addition of VSM**
Pure sand (PS)	PS + Vermiculate	PS + saw dust	PS + manure	PS + VSM
70% sand loam (7SL)	7SL + Vermiculate	7SL + saw dust	7SL +manure	7SL + VSM
Loam soil (LS)	LS + Vermiculate	LS + saw dust	LS + manure	LS + VSM
Forest humus soil (FHS)	FHS + Vermiculate	FHS + saw dust	FHS + manure	FHS + VSM
Soil format Baringo (SATB)	SATB + Vermiculate	SATB + saw dust	SATB + manure	SATB + VSM
Soil from AS Rodat(SASR)	SASR + Vermiculate	SASR + saw dust	SASR + manure	SASR + VSM

Legends in parenthesis are abbreviations. VSM=Combination of vermiculate, saw dust and manure. AT=*Aloe turkanensis*, AS= *Aloe secundflora.*

lead to heavy reliance on wild *Aloe* populations threatening species occurrence.

This call for concerted effort is to support livelihood as well as enhance conservation through identifying effective *Aloe* production methods. For example, establishment of *Aloe* plantations at various dry land areas will supplement the natural occurrence of wild *Aloe* species. Therefore right and effective propagation materials and methods are needed by farmers in order to enhance plantation of *Aloe*s in Kenya and other neighbouring countries. Currently there are no propagation guidelines for Kenyan indigenous *aloe*s. A number of studies indicate that *A. rivae, A. megalocantha, A. turkanensis* and *A. secundflora* can be propagated from seeds. However, *A. megalocantha, A. turkanensis, A. scabrifolia and A. vera* can as well be propagated through suckers with A*. vera* being easier to propagate from suckers than seeds (Newton, 1994; Mukonyi et al., 2005). Therefore the objective of this study is to establish appropriate propagation method based on selected substrate for *A. turkanensis* and *A. secundiflora* under glasshouse conditions.

MATERIALS AND METHODS

Substrate material

Soil samples from various sites were used in this study. These included 70% loam soil and sand from Kibwezi Forest humus soil, pure sand and loam soils from Nguriunditu-Muguga. In addition, soil samples from natural habitats for *A. turkanensis* and *A. secundiflora* in Baringo and Kelelwa in Radar at Koibatek were collected, respectively. In each of these germination media, vermiculate, manure from Kenya Agricultural Research Institute (KARI), saw dust from Karura and combination of both manure, sawdust and vermiculate were added (Table 1). The addition of manure, sawdust and vermiculate were meant to enrich the substrates with nutrients and increase porosity, respectively.

Seed material

Seeds for both *A. turkanensis* and *A. secundflora* were bought from farmers in Loruk and Koibatek, respectively. All seeds used in this study were not screened and tested for their germination viability.

Experimental design

Various substrates as shown in Table 1 were used to set the experiment in green house at Muguga headquarters to investigate the effect of substrate type on germination and growth of *A. turkanensis* and *A. secundflora.* The enrichment of the main substrates with sawdust, vermiculate, manure and combination of vermiculate, sawdust and manure (1:1:1) resulted to 30 different germination media under assessment. Each of these substrates was packed in perforated plastic basins at bottom for aeration. The experimental design laid in the green house was randomized complete block with each substrate replicated four times. Within each substrate, 50 seeds, 25 each of *A. turkanensis* and *A. secundflora* were sown separately.

Measurements

Germination count began after one week (7days) and continued till the 10^{th} week (70 days) concurrently with survival. However, germination count parse was expected to stop after 4^{th} week (28 days). Growth height and number of leaves were as well assessed. Only those seedlings that were above or equal 1cm high were measured.

Data analysis

The data were analyzed using generalized linear modeling with Poisson distribution for germination count and ANOVA procedures for growth assessment. Comparisons were made between main substrates and the effect of enrichment in each germination media. All the analyses were done using Genstat version 8.1 release and Ms excel 2003.

RESULTS

Germination for both *A. turkanensis* and *A. secundflora* were noticed on the 9^{th} day with 6% (100) germination of *A. turkanensis* under pure sand enriched with sawdust and 3% (100) germination of *A. secundflora* under soil collected from *A. turkanensis* habitat in Baringo enriched with combination of vermiculate, sawdust and manure. Nine substrates showed no germination for both *A. turkanensis* and *A. secundflora* as shown Table 2. Overall, *A. turkanensis* had started germinating in most of the germination media as compared with *A. secundflora*.

Table 2. Summary of percentage germination for AT and AS under different substrates after 8 days.

Aloe species	None added		Addition of vermiculate		Addition of sawdust		Addition of manure		Addition of vermiculate, sawdust and manure	
Germination media	**AT**	**AS**	**AT**	**AS**	**AT**	**AS**	**AT**	**AS**	**AT**	**AS**
Pure sand	0	0	0	0	6	2	1	1	0	0
70% sand loam	4	0	1	0	2	0	0	1	0	0
Loam soil	1	0	3	0	0	0	0	0	1	0
Forest humus soil	1	0	0	0	3	2	0	0	0	0
Soil from ATHB	0	1	5	0	2	0	1	0	5	3
Soil from ASHR	3	0	0	0	2	0	1	1	0	1

AT = *Aloe turkanensis*, AS = *Aloe secundflora.*

Table 3. Summary of percentage germination after 14days for A. turkanensis and A. secundflora under different germination media with addition of various substrates.

Aloe species	None added		Addition of vermiculate		Addition of sawdust		Addition of manure		Addition of vermiculate, sawdust and manure	
Germination media	**AT**	**AS**	**AT**	**AS**	**AT**	**AS**	**AT**	**AS**	**AT**	**AS**
Pure sand	0	3	9	3	9	4	3	0	4	4
70% sand loam	6	4	1	0	10	7	7	4	10	4
Loam soil	6	5	8	0	14	2	0	1	9	4
Forest humus soil	6	3	1	0	24	8	7	0	4	3
Soil from ATHB	6	3	19	1	9	3	2	4	13	7
Soil from ASHR	3	3	3	2	22	13	5	5	5	1

AT=*Aloe turkanensis*, AS= *Aloe secundflora.*

Table 4. Summary of percentage germination change as a result of various enrichments.

Aloe species	None added		Addition of vermiculate		Addition of sawdust		Addition of manure		Addition of vermiculate, sawdust and manure	
Germination media	**AT**	**AS**	**AT**	**AS**	**AT**	**AS**	**AT**	**AS**	**AT**	**AS**
Pure sand	0	3	+6	0	+9	+1	+3	0	+4	+1
70% sand loam	6	4	0	0	+4	+3	+1	0	+4	0
Loam soil	6	5	+2	0	+8	0	0	0	+3	0
Forest humus soil	6	3	0	0	+18	+5	0	+1	0	0
Soil from ATHB	6	3	+13	0	0	+6	0	0	+7	+4
Soil from ASHR	3	3	0	0	+19	+10	+2	+2	+2	0

AT=*Aloe turkanensis*, AS= *Aloe secundflora.*

Tables 3, 4 and 5 show the germination percentage for *A. turkanensis* and *A. secundflora* under different substrates after 14, 21 and 28 days, respectively. Results summarized in Table 3 shows that there was no significant difference ($p>0.05$) in germination between substrates without any enrichment for both *A. turkanensis* and *A. secundflora*. However, *A. turkanensis* had recorded higher number of germination in all substrates without enrichment except in pure sand. Addition of vermiculate significantly ($p<0.05$) improved germination of *A. turkanensis* under pure sand and soil from *A. turkanensis* habitat in Baringo by 9 and 13%, respectively. Vermiculate addition did not show much influence on other germination media.

On the other hand, *A. secundflora* did not show any significant improvement ($p>0.05$) in germination under 70% sand loam, loam soil and forest humus soil enriched with vermiculate. Germination of *A. turkanensis* under enrichment of saw dust to pure sand, 70% sand loam, loam soil, forest humus soil and soil from *A. secundflora*

Table 5. Summary of percentage germination after 21 days for *Aloe turkanensis* and *Aloe secundflora* under different germination media with addition of vermiculate, Saw dust, Manure and combination.

***Aloe* species**	**None added**		**Addition of vermiculate**		**Addition of sawdust**		**Addition of manure**		**Addition of vermiculate, sawdust and manure**	
Germination media	**AT**	**AS**	**AT**	**AS**	**AT**	**AS**	**AT**	**AS**	**AT**	**AS**
Pure sand	0	3	12	7	10	7	6	0	7	3
70% sand loam	9	3	3	1	15	7	10	6	13	6
Loam soil	7	6	11	3	18	5	1	3	14	6
Forest humus soil	7	4	2	1	28	14	6	2	9	4
Soil from ATHB	6	5	24	4	11	5	3	4	17	9
Soil from ASHR	7	5	4	4	19	17	7	6	6	3

AT= *Aloe turkanensis*, AS = *Aloe secundflora.*

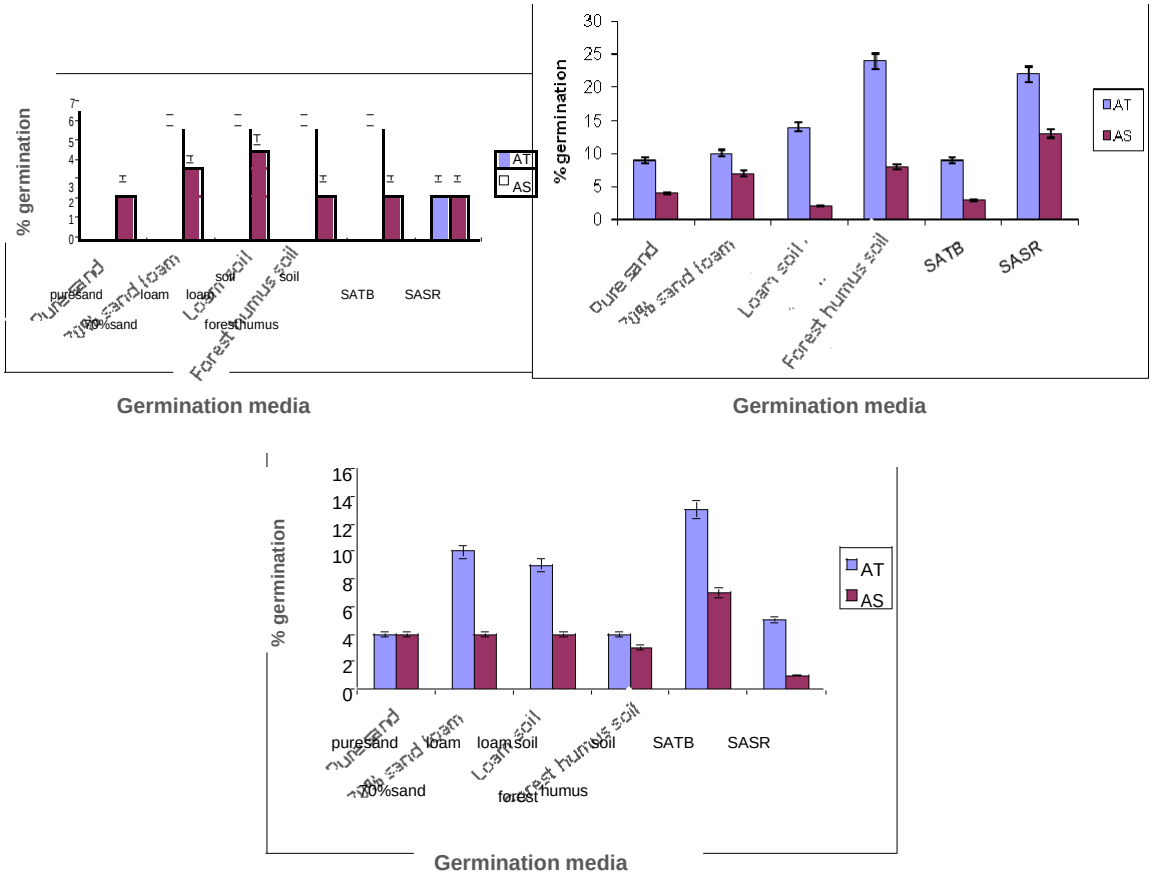

Figure 1. Percentage of germination of AT and AS (a) without enrichment (b) with enrichment of saw dust (c) with enrichment of VSM after 14 days.

in Radat was significantly higher ($p<0.05$) than substrates without enrichment, whereas *A. secundflora* had 10% improvement in germination under enriched soil from *A. secundflora* in Radat with sawdust. Addition of manure did not show any significant improvement in germination for both *A. turkanensis* and *A. secundflora*. Combination of both vermiculate, sawdust and manure did not show much improvement in germination for both *A. turkanensis* and *A. secundflora* except in soil from *A. turkanensis* habitat in Baringo for *A. turkanensis*. Table 4 shows a summary of percentage change in germination for both *A. turkanensis* and *A. secundflora* under various substrates enriched with vermiculate, sawdust, manure and combination of vermiculate, sawdust and manure whereas Figure 1a, b and c shows germination differences of *A. turkanensis* and *A. secundflora* under

Table 6. Summary of percentage germination after 28 days for *Aloe turkanensis* and *Aloe secundflora* under different germination media with addition of various substrates.

***Aloe* species**	**None added**		**Addition of vermiculate**		**Addition of sawdust**		**Addition of manure**		**Addition of vermiculate, sawdust and manure**	
Germination media	**AT**	**AS**	**AT**	**AS**	**AT**	**AS**	**AT**	**AS**	**AT**	**AS**
Pure sand	2	3	12	7	15	8	6	0	8	4
70% sand loam	11	2	4	1	17	8	11	6	12	13
Loam soil	8	7	12	3	21	15	0	5	16	11
Forest humus soil	9	3	2	0	21	10	6	1	19	14
Soil from ATHB	8	5	27	4	13	6	4	4	21	10
Soil from ASHR	7	5	4	5	23	16	8	6	9	6

AT = *Aloe turkanensis*, AS = *Aloe secundflora.*

Table 7. Average growth height of *A. turkanensis* in some substrates.

Germination media	**Average growth ht cm AT**
LS	4.5
SASR + manure	8
SATB	2.5
SATB + manure	9.9
SATB + vermiculate	5.3
FHS + manure	12
7LS + manure	9.2

Table 8. Average growth height of *A. secundflora* in some substrates.

Germination media	**Average growth ht cm AS**
FHS + saw dust	1
LSM +	1
LSV	6
PSM	11
SASR	2
SASRM	11
SASRV	7.2
SATBM	6
SATBV	4.3
FHSM	2.2
7LSM	6.1

different substrates. After 21 days, there was no significant improvement in germination for *A. turkanensis* and *A. secundflora* under various substrates with and without enrichment. There was only additional of 1, 2, 3 or 4 seeds that germinated in some substrates as shown in Table 5. It was also noticed that some seedlings were attacked by ants and died during this time of assessment.

The results in Table 6 shows that *A. turkanensis* had significant improvement in germination under pure sand enriched with saw dust, 70% sand loam enriched with sawdust and combination of VSM, loam soil enriched with sawdust and VSM and soil from *A. turkanensis* habitat Baringo enriched with vermiculate. *A. secundflora* had improvement in germination under 70% sand loam enriched with VSM, loam soil enriched with sawdust, and VSM and forest humus soil enriched with VSM. *A. turkanensis* seedlings mortalities were as well noted in FHS enriched with saw dust, 70% sand loam enriched with VSM, loam soil enriched with manure and soil from *A. secundflora* habitat in Radat, whereas, mortalities of *A. secundflora* seedlings were noted in forest humus soil enriched with manure, saw dust and vermiculate, forest humus soil, pure sand enriched with vermiculate and soil from *A. secundflora* habitat in Radat.

Results of height growth assessment

Tables 7 and 8 show the average growth height of *A. turkanensis* and *A. secundflora*, respectively in some substrates. The average height was recorded in the 5th month after germination (Table 8). It was observed that most seedlings had died in various substrates. But substrates from natural *Aloe* habitats enriched with manure showed good growth performance as indicated in Tables 7 and 8.

DISCUSSION

Results indicate under favorable conditions germination for *A. turkanensis* is more rapid and has higher germination percentage as compared to *A. secundflora*. Findings reveal addition of vermiculate and sawdust to the growing media improves germination of both, and as shown in Tables 5 and 6. The enhanced germination could be due to improved porosity, since soils from natural habitat specifically for Baringo became compact on watering, which could affect germination. In overall, there was poor *Aloe* seed germination as shown from

Table 9. Research work on *A. secundiflora* seed propagation conducted by KARI research station.

Plot label	Treatment	Planting depth (cm)	Addition inputs	Time to attain 50% germination (days)
T1	Soaked seeds	0.5	DAP fertilizer, manure, irrigation water.	21.7
T2	Soaked seeds	1.0	DAP fertilizer, manure, irrigation water.	23
T3	Soaked seeds	2.0	DAP fertilizer, manure, irrigation water.	26
T4	Unsoaked seeds	0.5	DAP fertilizer, manure, irrigation water.	20.7
T5	Unsoaked seeds	1.0	DAP fertilizer, manure, irrigation water.	23
T6	Unsoaked seeds	2.0	DAP fertilizer, manure, irrigation water.	26

KARI result showed: soaked seeds did not have significance impact on percentage seed germination. Shallow seed sowing resulted in early attainment of 50% germination. The report further indicated that growth rate of *A. Secundflora* is slow and an average of leaves per plant were attained when 8 months old.

Tables 2, 3, 4 and 5. The highest being 28% for forest humus soil blended with sawdust. In general, germination was poor as compared to previous observations. Reasons for this could be due to poor seed quality. Seed viabilities were not done.

The seeds had been bought from farmers. There was fungal outbreak which affected both *Aloe* inflorescence and seeds in the 2005, in most parts of Kenya (Mukonyi et al., 2005; Mwangi et al., 2005). Also flowering period was followed by severe drought in most parts of Kenya. The drought could affect *Aloe* seeds maturity, therefore viability. *Aloe* seed maximum germination was observed between 14 and 21 days after that there was no significant difference. There are various factors that affect germination. Like in warm moist conditions, *Aloe* seeds take short time to germinate as compared to cool areas. The findings shows upon onset of germination, in which maximum germination can take place within the first 21 days. The investigation reveals that loam soil, forest humus soil and soil from natural as well as growing zones under enrichment with either vermiculate or sawdust improves germination of these two species. Therefore farmers can establish nurseries based on these substrates and enrich them accordingly with vermiculite or sawdust. Results indicated that germination and growth performance was varied. Assessment after 5 months (Tables 7 and 8) showed substrate enriched with sawdust had poor growth performance and many had died or withered. But soil from *A. secundflora* natural habitat enriched with manure had best growth performance. Results reveals selection of appropriate substrates enhancing their porosity and nutrient levels improves *Aloe* germination and growth performance. Research work on *A. secundiflora* seed propagation conducted by KARI research station of different sowing treatment had impact on germination as shown in Table 9. Rate of germination has been noted to vary.

In previous studies, Mukonyi et al. (2004) showed it took about 7 days for germination to begin in Muguga greenhouse and average of 10 days in KEFRI Marigat station. In Taita, *Aloe*-growing communities had shown it takes 8 days for *A. secundiflora* seeds to start germinating. So humidity, temperature and substrate appear to play a role from field observations, whereas profuse seeding by most of the commercial *aloe*s and small-scale regenerations were visible. In some areas, it varied with the slope and direction to sunset. Higher numbers of *Aloe*s were counted on the gentle sunset site of the slope. In areas with well-drained loamy sandy soil with minimum precipitation like West Pokot, showed higher regeneration than other areas. Also regeneration was associated with particular vegetation that provided appropriate substrate. Mukonyi et al. (2004) showed that seed depth had impact on germination. Seed sowed 4 cm deep had poor germination as compared to those sown shallowly. Similar observation was indicated by KARI research Table 9, which showed seed sown shallowly, resulted in early attainment of 50% germination as compared to those planted deeply had poor germination.

CONCLUSION AND RECOMMENDATIONS

Aloe species have different germination and survival rates depending on the prevailing weather pattern. Media containing sawdust gave good germination but the seedlings were weak. This is because C:N ratio is initially increased but after germination, all the N is adsorbed and young seedlings need more N for healthy growth. In overall, poor seed germination percentage, which may be attributed to low seed quality for viability test was not established. In the year 2005, *Aloe* species were affected by severe fungal outbreak as well as drought which could have affected seed quality. Therefore selection of germination and potting substrate is necessary for higher *Aloe* seedlings and survival rates. Seed source and quality is required for high success in nursery establishment. Further research is required to determine soil quality, porosity and mineral content in order to develop appropriate model for *Aloe* nursery establishment from seeds.

ACKNOWLEDGEMENTS

The authors acknowledge the support of G.O.K., through

KEFRI under Project DF/03. Dr. David Odee, Co-ordinator of Drylands project is highly acknowledged for his continuous advice, which led to the success of this work. Also my appreciation goes to the following people, James M. Mwaura, G. Omollo, P. Kibera, S. Kamonde, J. Oyier, K. Kirambi and Margaret Kimondo for their valuable contributions.

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