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Full Length Research Paper

Seed germination of java plum *(Syzigium cumnii)* in three provenances western Kenya

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Indigenous fruits are very important as sources of food security, balanced households nutrition. Deforestation poses a serious threat to their survival. Domestication of these trees can be successful only if successful propagation techniques are applied. In Kenya *Syzigium cuminii* has become a very important indigenous fruit tree for local consumption and income generation and it mainly grows in Siaya, Vihiga and Kisumu districts. Studies were conducted in Maseno, Kenya (2004 - 2005) to investigate variation of seed germination of *S. cuminii* in three districts (provenances) mentioned above. The experimental design used was completely randomized design. The treatments included different watering regimes and light and darkness durations respectively. The results showed that both light and irrigation regimes significantly ($P \leq 0.05$) increased the germination of *S. cuminii* but 24 h darkness inhibited it. The best treatment was 12 h light. *S. cuminii* seeds are therefore photodormant since they require light to germinate. There was no variation of seed germination among the districts (provenances).

Key words: Light, water, photodormancy, provenance, germination.

INTRODUCTION

Indigenous fruit trees are very important as sources of food security and balanced nutrition in Kenyan households. They also contribute immensely to income for the rural population (Saka et al., 2002; 2004b; Akinnifesi et al., 2004a; Kaaria, 1998; Schoraburg et al., 2002). Indigenous fruit trees are also sources of timber for construction (Campbell et al., 1997). In many African countries, 80% of the indigenous fruit producers/ collectors process fruits for home consumption (Kadzere et al., 2001). In South Africa 94% of households use them for making Jam and Juice (Shackleton, 2004). Deforestation poses a serious threat to the survival of indigenous fruit trees. In Kenya *Syzigium cuminii* has become a very important indigenous fruit for household consumption and income generation (Icraf, 1992*). S. cuminii* belongs to the family myrtaceae and it is an evergreen tree. Its fruit has one seed which has a low germination rate of 30 - 40% and it is recalcitrant (NAS, 1980). It is also processed locally into jam and juices. Provenance variation of seed germination has been reported in many tree species, including *Podocarpus falcatus* (Negash, 2003); *Uapaca kirkiana* (Mwase et al., 2006), *Juniperus* procera (Mamo et al., 2006; Mkonda et al., 2006) and *Cordia africa* (Loha et al., 2005). The fruit is mainly grown in the Western Kenya districts of Siaya, Kisumu and Vihiga. The objectives of the present study were to investigate seed germination of *S. cuminii* fruits from three provenances namely Siaya, Vihiga and Kisumu.

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MATERIALS AND METHODS

The fruits were obtained from Siaya, Kisumu and Vihiga districts and seeds extracted in warm water. To determine the seed germination the fruit and pericarp were dried in an oven for 48 h at a temperature of 80℃. Fruits of *S cuminii* were collected from the three districts (Siaya, Kisumu and Vihiga) and fermented in gunny bags for three days and then hauled by hand (Atangana et al., 2001). The seeds were then cleaned and the fully occupied non-shrunken ones were selected for germination in a glass house at the Kenya Forestry Research Institute centre, Maseno Kenya. Seedbeds were constructed with stones at the bottom to allow water perculation and sand at the top as germination medium. The soils at Siaya were Luvicphae zones (Anon, 2005) at Vihiga the soils were sandy loam (Anon, 2002), Soils at the provenance were analysed using standard methods (Table 4). In Kisumu eight freshly extracted seeds were sown by spreading them evenly in each seedbed so that none lied on top of the other to avoid damping off disease attack (Gachanga and Ilg 1990). Sand volume equal to the diameter of the seed was used to cover it. Irrigation of the seed bed was done according to the treatment type.

After one week the sand covering the seeds were gently uncovered to check whether germination was evident. The sand was then returned. Germination checks were carried out daily for three weeks and recorded. The experimental design was completely Randomized design (CRD). The treatments were applied as follows:

Light

Three light levels were used for five weeks.

(a) 12 h light, 12 h darkness (L1).
(b) 24 h light, (L2)
(c) 24 h darkness (L3) (control)

Other germination factors e.g. temperature, oxygen etc were kept constant.

Moisture treatments

These treatments were maintained for five weeks.

(a) 0.51 of water per pot was applied in the morning and in the evening daily (W1) control
(b) 0.51 of water per pot was applied in the morning daily (W2).
(c) 0.51 of water per pot was applied in the morning and evening on alternate days (W3).
(d) 0.51 of water per pot was applied in the morning and evening an alternate days (W4).

Potting medium

Top soil dug 15 cm from the surface of the earth and free from organic matter was taken from randomly sampled sites from every district for use in potting. For the top soils from the districts, chemical analysis was done to ascertain the presence of essential minerals such as nitrogen, phosphorous and potassium (Gachanja and Ilg, 1990) (Table 4).

Transplanting seedlings

Young germinated seedlings from each district were transferred (pricked out) into potted soils from respective districts. Adibbler (a small stick of 20 cm length and 3 cm diameter with a pointed end) was used to remove the seedlings from the seedbed to an empty container (500 ml) capacity with clean water. Seedlings from each district were then transplanted into containers potted with topsoils removed from the respective district randomly. The dibblers were used to open a hole in the potted soils of size reasonable enough to accommodate the rooting system of each seedling. The dibblers were again used to loosen soils around seedlings in the seed bed to improve water percolation within the seedling container and finally to push soil to occupy spaces left in the hole after transferring the seedlings into potted soils making the young seedlings firm enough to withstand the pressure of watering and wind (Gachanja and Ilg, 1990).

Data analyses

Percent germination was recorded for 5 weeks for each treatment and subjected to analysis of variance (ANOVA) and mean separation using the least significant difference L.S.D) method.

RESULTS

Seed germination

In Kisumu district both light duration and watering regimes significantly ($P \leq 0.05$) affected percent germination at all sampling dates. Germination increased with the date of sampling (Tables 2), the interaction between light duration and watering regime was generally significant ($P \leq 0.05$). The best treatment was obtained from the treatment 24 h darkness and water applied morning daily followed by 24 h darkness and water applied morning daily and lastly 24 h light and water applied morning and evening daily. All these observation were made during the first week after sowing. Conversely the situation changed two weeks after sowing when the best germination was from 12 h light and water applied morning, midday and evening and alternate days followed by 12 h light and water applied morning daily and 12 h light and water applied morning and evening daily. Under 24 h darkness, applying water every morning daily was the same as under 12 h light and applying water every morning daily, applying more water under 12 or 24 h darkness (Table 2) Similar trends were obtained three weeks after sowing (Table 2). The lowest germination percent was obtained by the treatments with 24 h darkness and this varied with the amount of water applied apparently worsening when water was applied on alternate days. The best treatment occurred with 12 h light followed by 24 h light depending on the frequency of watering. Watering on alternate days tended to give poor germination at any level of light. Therefore from the results of this study germination increased from 0% in the first week to the fifth week 12 h lighting to peak at 24 h lighting with 93%.

In Siaya district germination of *S cuminii* increased as the date of sampling increased. Light duration and watering regimes significantly ($P \leq 0.05$) affected germination percent. During the first week of sampling the 24 h light treatment had very small germination but it was the highest. The rest of the treatments had negligible or no germination (Table 3). By the second week after sowing germination had increased and highest germination was obtained from the 24 h darkness treatment and water applied every morning daily. This was the same as 12 h light with water applied every morning daily and 12 h light with water applied in the morning, evening or alternate days. Similar results were obtained by 12 h light with water applied morning and evening daily, and 24 h light with water applied in the morning daily and 24 h light and water applied in the morning and evenings on alternate days (Table 3).

The least germination was observed in the treatments where 24 h darkness and watering were applied on alternate days. The above situation changed three weeks after sowing (Table 3) when the 12 h light and 24 h light treatments increased in germination as compared to 24 h darkness treatments. As the frequency of watering and light duration increased, germination increased with an exception of the 24 light treatments with water applied morning, midday and evening on alternate days (Table 3). The 24 h darkness treatments had the lowest germination especially watering on alternate days. Similar trends as above were observed at weeks 4 and 5 after sowing that is germination increased with light duration and irrigation frequency with the least germination at 24 h darkness and watering on alternate days (Table 3).

In Vihiga district light duration and watering regime significantly ($P \leq 0.05$) increased germination of *S. cumini*. No germination was recorded one week after sowing in all the treatments. Germination percent increased as the date of sampling increased (Table 1). The highest germination was in the second week after sowing and was obtained from the treatment 12 h light with water applied in the morning daily. The rest of the treatments had very low germination. As the days from sowing increased, germination also increased. Germination increased at the 12 and 24 h light treatment with no definite trends. Generally the 12 h light treatment was better than 24 h light treatment at all irrigation levels (Table 1). By three weeks after germination the12 h light treatment was still had the highest germination followed by the 24 h light treatment at all watering levels. 24 h darkness treatments had the lowest germination (Table 1). Similar trends were obtained four and five weeks after sowing (Table 1) at all watering levels.

These results in germination may also be attributed to the difference in soil types in the provenances as shown in Table 4.

The results of the present study have shown that both light and water are needed to achieve good germination of *S. cumini* seeds. Water is apparently needed for the early metabolic activities of the seed such as enzyme activation and mobilization of food reserves such as proteins, carbohydrates and lipids for the development of embryo (Hartmann et al., 2001). Early seed germination commences with rapid intake of water. For many seeds without dormancy the availability of water is the early factor limiting germination at a suitable temperature. Water deficit reduces germination percent (Doreen and Gilrary, 1943; Ayers, 1952; Hanks and Thorpe, 1956). The germination levels of some seeds especially those with dormancy are inhibited as moisture levels are decreased. Such seeds apparently contain inhibitors that require leaching (Attwater, 1980).

In all the provenances the degree of germination of *S. cumini* appeared to be dictated by light duration. Germination was relatively poor in darkness even when it was watered frequently. This shows that *S. cuminii* is a light sensitive species and needs light for germination but water has to be provided also. Light acts both in dormancy induction and as a mechanism that adapts plants to a specific niche in the environment, often interacting with temperatures (Hartmann et al., 2001). Light appears to break physiological dormancy of *S. cumini* (Welban et al., 1998).

The germination of *S. cumini* in the present study contradicts the reported germination rate of 30 - 40% (NAS, 1980). In the present study the germination rate of S cumini was as high as 90%. This was achieved when the seeds were sown when freshly extracted and balancing of watering regimes and lighting levels with an optimum germination period. For example in Kisumu district germination of 93% was achieved when freshly extracted seeds were sown in the seedbed where 500 ml of water was applied in the morning, midday and evening on alternate days for five weeks and lighting applied for 24 h during the germination period. For Vihiga and Siaya district seeds (in the same conditions as that for Kisumu district above) were shown in the beds with the same lighting and watering conditions as those of Kisumu above and germination percent in each district was 92%.

In both Kisumu and Siaya districts the 24 h darkness treatment had the best germination at the second week of sampling only but not any other date of sampling only but not any other date of sampling. This was an isolated case and is difficult to explain. In the present study the germination rate and trends were generally similar in all the provenances with the 24 h light being superior to all treatments and adding water to the light treatments increased germination. *S. cuminii* seeds are therefore photodormant. Similar results have been reported in *Juniperus procera* by Mamo et al., 2006. Lack of water or enough water in the 24 h darkness treatment reduced germination further. Water and light are therefore essential for the germination of *S. cuminii*. Similar results on effects of light on germination have been reported by Mamo et al., 2006, working on *J. procera.* The results of the present study are at variance with those of Loha et al. (2006), Mamo et al. (2006) who reported provenance variation in seed germination of some indigenous tree species such as *Procera* and *Cardia africana, Podocarpus falcatus* (Negash, 2003) *Strychnos cocculoides* (Mkonda et al., 2005). This could be explained by the different germination requirements between *S. cuminii* and the above mentioned tree species.

Conclusion

The conclusions to be drawn from the present study are:

- Varying levels of light and watering regimes affect the

Table 1. (a) Effects of lighting levels on germination percent of *S. cumini* trees seeds collected from Vihiga district taken four weeks after sowing. Means with the same letter are not significantly different (NS).

Treatment	% Germination
Lighting	
12 h light	68.748 a
24 h light	68.602 a
24 h darkness	28.198 b
LSD	11.799

Table 1. (b) Effects of watering regimes on germination percent of *S. cumini* tree seeds collected from Vihiga district taken four weeks after sowing. Means with the same letter are significantly different (NS).

Treatment	% Germination
500 ml of water	
Applied morning and evening daily	57.935a
Applied morning daily	59.522a
Applied morning, midday and evening on alternate days	45.436b
Applied morning and evening on alternate days	57.837a
LSD	13.624

Table 1. (c) Effect of interaction between lighting levels and watering regimes on mean germination percent of *S. cumini* trees seeds collected from Vihiga district.

Treatment		Mean germination % recorded after sowing		
		Week 2	**Week 3**	**Week 4**
Lighting	**500 ml water**			
12 h	Applied morning and evening	14.288	35.712	80.950
	Applied morning daily	15.478	38.095	78.570
	Applied morning, midday and evening on alternate days	14.288	36.905	80.950
	Applied morning and evening on alternate days	7.140	35.715	86.905
Mean		12.799	36.607	81.844
24 h	Applied morning and evening daily	8.330	32.143	84.525
	Applied morning daily	3.570	58.335	92.860
	Applied morning, midday and evening on alternate days	0.000	36.905	86.805
	Applied morning and evening on alternate days	4.165	37.798	86.881
Mean		4.165	37.798	86.881
Darkness				
24 h	Applied morning and evening daily	9.520	21.430	48.805
	Applied morning daily	11.903	16.668	51.190
	Applied morning, midday and evening on alternate days	0.000	1.190	14.285
	Applied morning and evening on alternate days	1.190	8.335	52.380
Mean		5.653	11.906	41.665
G/Mean		7.539	28.770	70.13
Standard error		0.962	3.462	2.582

Table 1. (d) The effects of lighting levels and watering regimes on mean germination percent of seeds collected from *S. cuminii* trees from Vihiga district.

Treatment		**Mean germination % recorded after sowing**
		Week 2
Lighting	**500 ml of water**	
12 h	Applied morning and evening daily	14.3
	Applied morning and daily	15.5
	Applied morning, mid day and evening on alternate days.	14.3
	Applied morning and evening on alternate days	7.1
	Mean	12.8
24 h	Applied morning and evening daily	4.8
	Applied morning daily	8.3
	Applied morning, mid day and evening on alternate days.	3.6
	Applied morning and evening on alternate days	0.0
	Mean	4.2
Darkness		
24 h	Applied morning and evening daily	9.5
	Applied morning daily	11.9
	Applied morning, mid day and evening on alternate days.	0.0
	Applied morning and evening on alternate days	1.2
Mean		5.6
Grand mean		7.5
Standard error		0.962

Table 1. (e) The effects of lighting levels on germination percent of *S. cuminii* trees seeds collected from Vihiga district taken on the third, fourth and fifth weeks after sowing. Means with the same letter are not significantly different (P > 0.05).

Lighting time	**Mean % germination recorded weeks after sowing**		
	3^{rd}	4^{th}	5^{th}
12 h	36 a	68 a	81 a
24 h	37 a	68 a	86 a
24 h darkness	11 b	28 b	41 b

Table 1. (f) The effects of watering regimes on germination percent of *S. cuminii* tree seeds collected from Vihiga provenance taken four weeks after sowing. Means with the same letter are not significantly different (P > 0.05).

Treatment	**Mean germination%**
500 ml of water	
Applied morning and evening daily	58.0 a
Applied morning daily	59.5 a
Applied morning, midday and evening on alternate days	45.4b
Applied morning and evening on alternate days	57.8 a
L.S.D. $_{(0.05)}$	13.6

Table 2(a). Effect of interaction between lighting levels and watering regimes on mean germination percent of *S. cumini* trees seeds collected from Kisumu district.

Treatment		**Mean germination % recorded after sowing**				
		Week 1	**Week 2**	**Week 3**	**Week 4**	**Week 5**
Lighting	**500 ml water**					
12 h	Applied morning and evening	0.000	16.668	51.190	79.763	81.548
	Applied morning daily	0.000	14.288	44.348	75.000	80.950
	Applied morning, midday and evening on alternate days	0.000	20.240	42.860	76.190	84.525
	Applied morning and evening on alternate days	0.000	11.903	48.810	77.975	84.523
Mean		0.000	14.484	47.472	77.480	83.432
24 h	Applied morning and evening daily	0.893	4.760	41.665	78.570	86.900
	Applied morning daily	0.000	9.520	45.235	75.000	82.140
	Applied morning, midday and evening on alternate days	0.000	8.330	57.499	92.858	93.450
	Applied morning and evening on alternate days	0.000	1.190	59.525	79.166	86.903
Mean		0.000	7.933	50.981	81.400	87.348
Darkness						
24 h	Applied morning and evening daily	1.190	10.710	25.000	40.476	79.760
	Applied morning daily	2.698	14.288	32.143	48.810	53.570
	Applied morning, midday and evening on alternate days	0.000	1.190	2.380	13.393	19.050
	Applied morning and evening on alternate days	1.488	1.190	17.860	32.735	55.953
Mean		1.339	6.845	19.346	33.854	52.083
G/Mean		0.446	9.754	39.267	64.245	77.288
Standard error		0.386	1.866	4.044	5.358	2.521

Table 2(b). Effect of interaction between lighting levels and watering regimes on mean germination percent of *S. cumini* trees seeds collected from Kisumu district.

Treatment		**Mean germination % recorded after sowing**				
		Week 1	**Week 2**	**Week 3**	**Week 4**	**Week 5**
Lighting	500 ml water					
12 h	Applied morning and evening	0.000	16.668	51.190	79.763	81.548
	Applied morning daily	0.000	14.288	44.348	75.000	80.950
	Applied morning, midday and evening on alternate days	0.000	20.240	42.860	76.190	84.525
	Applied morning and evening on alternate days	0.000	11.903	48.810	77.975	84.523
Mean		0.000	14.484	47.472	77.480	83.432
24 h	Applied morning and evening daily	0.893	4.760	41.665	78.570	86.900
	Applied morning daily	0.000	9.520	45.235	75.000	82.140
	Applied morning, midday and evening on alternate days	0.000	8.330	57.499	92.858	93.450

Table 2(b). Contd.

	Applied morning and evening on alternate days	0.000	1.190	59.525	79.166	86.903
Mean		0.000	7.933	50.981	81.400	87.348
Darkness						
24 h	Applied morning and evening daily	1.190	10.710	25.000	40.476	79.760
	Applied morning daily	2.678	14.288	32.143	48.810	53.570
	Applied morning, midday and evening on alternate days	0.000	1.190	2.380	13.393	19.050
	Applied morning and evening on alternate days	1.488	1.190	17.860	32.735	55.953
Mean		1.339	6.845	19.346	33.854	52.083
G/Mean		0.446	9.754	39.267	64.245	77.288
Standard error		0.386	1.866	4.044	5.358	2.521

Table 2(c). The effect of lighting levels and watering regimes on mean percent germination of *S. cuminii* trees seeds collected from Kisumu district.

Treatment		**Mean germination % recorded after sowing**				
		Week 1	**Week 2**	**Week 3**	**Week 4**	**Week 5**
Lighting	**500 ml of water**					
12 h	Applied morning and evening	0.0	16.6	51.1	79.7	81.5
	Applied morning daily	0.0	14.2	44.3	75.0	80.9
	Applied morning, mid day, and evening on alternate days	0.0	20.2	42.8	76.1	84.5
	Applied morning and evening on alternate days	0.0	11.9	48.8	77.9	84.5
Mean		0.0	14.4	47.4	77.4	83.4
24 h	Applied morning and evening daily	0.8	4.7	41.6	78.5	86.9
	Applied morning daily	0.0	9.5	45.2	75.0	82.1
	Applied morning, mid day, and evening on alternate days	0.0	8.3	57.4	92.8	93.4
	Applied morning and evening on alternate days	0.0	1.1	59.5	79.1	86.9
Mean		0.0	7.9	50.9	81.4	87.3
Darkness						
24 h	Applied morning and evening daily	1.1	10.7	25.0	40.4	79.760
	Applied morning daily	2.6	14.2	32.1	48.8	53.5
	Applied morning, midday and evening on alternate days	0.0	1.1	2.3	13.3	19.0
	Applied morning and evening on alternate days	1.4	1.1	17.8	32.7	55.9
Mean		1.3	6.8	19.3	33.8	52.0
G/Mean		0.4	9.7	39.2	64.2	77.2
Standard error		0.3	1.8	4.0	5.3	2.5

Table 3(a). Effect of interaction between lighting levels and watering regimes on mean germination percent of S. *cumini* trees seeds collected from Siaya district.

Treatment		**Mean germination % recorded after sowing**				
		Week 1	**Week 2**	**Week 3**	**Week 4**	**Week 5**
Lighting	**500 ml water**					
12 h	Applied morning and evening	0.000	16.668	51.190	79.763	81.548
	Applied morning daily	0.000	14.288	44.348	75.000	80.950
	Applied morning, midday and evening on alternate days	0.000	20.240	42.860	76.190	84.525
	Applied morning and evening on alternate days	0.298	11.903	48.810	77.975	84.523
Mean		0.075	14.484	47.472	77.480	83.432
24 h	Applied morning and evening daily	0.893	4.760	41.665	78.570	86.900
	Applied morning daily	0.000	9.520	45.235	75.000	82.140
	Applied morning, midday and evening on alternate days	0.000	8.330	57.499	92.858	93.450
	Applied morning and evening on alternate days	0.000	1.190	59.525	79.166	86.903
Mean		0.223	7.933	50.981	81.400	87.348
Darkness						
24 h	Applied morning and evening daily	0.000	10.710	25.000	40.476	79.760
	Applied morning daily	0.900	14.288	32.143	48.810	53.570
	Applied morning, midday and evening on alternate days	0.000	1.190	2.380	13.393	19.050
	Applied morning and evening on alternate days	1.488	1.190	17.860	32.735	55.953
Mean		0.225	6.845	19.346	33.854	52.083
G/Mean		0.174	9.754	39.267	64.245	77.288
Standard error		0.239	1.866	4.044	5.358	2.521

Table 3(b). The effect of lighting levels and watering regimes on mean germination percent of *S. cuminii* trees seeds collected from Siaya district.

Treatment		**Mean germination % recorded after sowing**				
		Week 1	**Week 2**	**Week 3**	**Week 4**	**Week 5**
Lighting	500 ml of water					
12 h	Applied morning and evening	0.0	8.3	40.4	79.7	84.5
	Applied morning daily	0.0	10.7	48.8	72.6	82.1
	Applied morning, mid day, and evening on alternate days	0.0	10.7	41.6	62.4	79.7
	Applied morning and evening and alternate days	0.2	5.9	42.8	76.1	84.5
	Mean	0.0	8.9	43.4	72.7	82.7
24 h	Applied morning and evening daily	0.8	4.4	32.1	79.1	83.3

Table 3(b). Contd.

Treatment		Mean germination % recorded after sowing				
		Week 1	Week 2	Week 3	Week 4	Week 5
	Applied morning daily	0.0	8.3	44.0	72.6	82.1
	Applied morning, mid day, and evening on alternate days	0.0	6.5	58.3	92.8	92.8
	Applied morning and evening on alternate days	0.0	1.1	48.8	79.7	85.7
	Mean	02	5.1	45.8	81.1	86.0
Darkness						
24h	Applied morning and evening daily	0.0	8.3	23.8	33.3	48.8
	Applied morning daily	0.9	10.7	30.9	48.8	52.3
	Applied morning, midday and evening on alternate days	0.0	0.0	1.1	8.3	24.4
	Mean	0.2	4.7	13.9	22.6	31.3
	Grand mean	0.1	4.7	25.8	58.8	66.7
Standard error		0.2	1.0	2.6	2.1	3.3

Table 4. Soil analysis report.

District	Exchange %K in me/100 gm of soil	Total P	% N
Siaya	1.43	0.53	0.164
Vihiga	0.53	0.059	0.1640
Kisumu	2.21	0.05	0.118

germination of *S. cumini.*

- Light is needed for the germination of *S. cuminii* so it has photodormancy.
- The best treatment for germination is 12 h light and the least is 24 h darkness.
- Germination rate of *S. cumini* is over 92% not as reported on 30 - 40%.
- Increasing light and water increase the germination of *S. cumini*.
- There was no geographic variation in seed germination of *S. cuminii.*

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