EFFECT OF DIFFERENT SEED TREATMENTS ON THE GERMINATION CHARACTERISTICS OF TWO LOCAL VARIETIES OF *Corchorus olitorius*

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Abstract

***Corchorus olitorius* is a traditional vegetable in Ghana. It is relatively affordable and has become a popular alternative to okro, especially when it becomes expensive in the market. However, little agronomic research has been done on the crop in Ghana. For example, there is no recommendation for seed treatment for improved germination. A factorial experiment, made up of two local varieties of *Corchorus olitorius* and six seed treatments, was carried out in order to compare the Coefficient of Variation of the Germination Time, Uncertainty of the Germination Process, Synchrony, Percentage, Mean Time and Mean Rate of Germination of seeds. The treatments consisted of soaking seeds in water at room temperature for 24 hours, steeping seeds in water at 100° C for ten seconds, soaking in water at 80° C for 15 minutes, soaking in concentrated sulphuric acid for two, five and ten minutes, respectively; and were laid out in a laboratory in a completely randomized design with four replications. The results of the study indicated that steeping of *Corchorus olitorius* seeds in hot water and concentrated sulphuric acid (98%) significantly ($p < 0.05$) improved germinability to more than 50% compared to 3% in the control; rate to more than 0.02 seeds per day compared to 0.007 seeds per day in the control; and Synchrony of Germination to more than 0.5 compared to 0.1 in the control. Mean Germination Time reduced to less than two days compared to five days in the control. It is recommended that Ghanaian small scale farmers steep their seeds in water at 100 °C for ten seconds prior to sowing.**

Keywords: *Corchorus olitorius*, seed treatment, germination

INTRODUCTION

Some authors categorize *Corchorus olitorius* into the *Malvaceae* family (Nwangburuka et al., 2012; Nyadanu et al., 2016), whilst others categorize it into the Tiliaceae family (Azadbakht et al., 2015; Amoatey et al. 2018; Aluko et al., 2014; Naim et al. 2015). It is an erect, annual, short -day herb, which is usually strongly branched with fibrous and tough stems (Fondio and Grubben, 2011; Amoatey et al. 2018). *Corchorus olitorius* plants grow very fast after germination, seedling growth is rapid, leaf formation, however, is generally slow at the beginning (Amoatey et al., 2018). Grubben and Denton (2004) claimed that *Corchorus olitorius* achieves maximum performance under high temperatures and humidity. Its optimal temperature is 25 °C – 32 °C (Fondio and Grubben, 2011), it is tolerant to a pH of 4.5 to 8.2 (The Department of Agriculture, Forestry and Fisheries of the Republic of South Africa, 2012) and prefers alluvial soils, or those with lots of organic matter and a good water-retaining capacity (Raemaekers, 2001).

In Ghana, *Corchorus olitorius* is an important leafy vegetable and is cropped in most parts of Ghana and the West African sub-region and other places. All parts of the herb are used for medicinal purposes, its stem for jute (Raemaekers, 2001; Fondio and Grubben, 2004) and its leaves for food

(Nyadanu et al., 2016). The leaves of *Corchorus olitorius* are very nutritious, rich in beta-carotene, iron, protein, calcium, thiamine, riboflavin, niacin, folate, vitamin C and E and dietary fibre (Adebo et al., 2015). However, very little information on improved agronomic practices are available and thus there is no recommended seed treatment.

Under favourable ecological conditions, seeds can fail to germinate due to the phenomenon of seed dormancy (Monaco et al., 2001). The importance of this mechanism is to allow the seeds to get dispersed over a larger range and to avoid all the seeds to germinate at once, which in return enhances the survival rate of the species. Dormancy can be caused by water and\or oxygen impermeable seed coats, mechanically resistant seed coats, immature embryos or after-ripening (Monaco et al., 2001).

Dormancy in *Corchorus olitorius* causes slow germination and reduced net germination (Sanchez and Mella, 2004). Since germination percentage increased after seed scarification, Velempini et al., 2003; Chauhan and Johnson (2008) suggested that dormancy in *Corchorus olitorius* seeds is caused by a hard seed coat. Ghanaian farmers harvest seeds when the fruit capsule has turned brown. Usually, at that stage the seeds have become dormant (Oladiran, 1986). Different authors claimed that seed dormancy in *Corchorus olitorius* has a significantly negative effect on the commercial establishment of the crop (Schippers, 2002; Palada and Chang, 2003). The farmers have to sow large quantities of seed in order to compensate for the low germination percentage caused by dormancy and the substandard seed quality of primitively stored seeds from previous harvests (Maina et al., 2011). This makes crop production expensive and decreases the size of land that could be cultivated otherwise (Maina et al., 2011).

It is frequently observed that leftover *Corchorus olitorius* seeds tend to establish on a field after farmers set fire for bush clearing (Denton et al., 2013). Therefore, it was speculated that the heat from the fire has the effect of breaking dormancy caused by a hard seed coat (Denton et al., 2013). Schippers et al. (2002) claimed that dormancy in *Corchorus olitorius* is mitigated by steeping the seeds in hot water. Maina et al. (2011) found that the most effective seed treatment for the *Corchorus olitorius* plant, was mechanical scarification by rubbing the seeds between two sheets of high grade sand paper for three minutes. This was followed by leaching the seeds by placing them in sieves and washing them under running water at room temperature for 24 hours. Soaking the seeds in boiling water at a temperature of 98° C for five minutes was the least effective treatment. This indicates that a hot water treatment exceeding a certain amount of time causes damage to the embryo. Comparatively, Oladiran (1986) found that steeping the seeds in water at 97 °C for five seconds and seed-coat scarification using sandpaper showed a significant improvement in seed germination and seedling emergence. Masarirambi et al. (2018) reported that steeping seeds in water at 100°C for ten seconds was most efficient in improving germination, followed by exposing the seeds to dry heat at 80 °C for 15 minutes. Seeds soaked in sulphuric acid (98%) for 15 minutes came third. Scarification by rubbing the seeds with sand paper, chilling at 6 °C and freezing for 15 minutes were the least effective methods. Tolorunse et al. (2015) concluded that the best treatment for breaking dormancy is soaking the seeds in water at 80–97 °C for five seconds. This method, furthermore, increased and synchronized germination. The methods of dormancy breaking in *Corchorus* *olitorius* seeds, among Ghanaian farmers, are haphazard. Many farmers have no knowledge of any seed treatment at all. High seed germination, uniform crop stands and high crop establishment are pre-requisites for high yield. Therefore, there was the need to come up with the best and easiest dormancy breaking seed treatment for Ghanaian farmers, in order to improve the establishment of their crop.

MATERIALS AND METHODS

Study Site

The experiment was carried out in the Physiology Laboratory in the Department of Crop Science, University of Ghana, using *Corchorus olitorius* seeds of the "Togo" and "Mante" variety from 6th to 19th August, 2018.

Experimental Design

A 2 x 7 factorial treatment combination arranged in a Completely Randomized Design with four replications was used. The two factors used included varieties and types of seed treatments. Thus, the levels for varieties were Togo and Mante, while types of seed treatments included steeping seeds in hot water at 100°C for ten seconds; soaking in hot water at 80 °C for 15 minutes; in concentrated sulphuric acid (98%) for two, five and ten minutes, respectively; in water at room temperature for 24 hours; and untreated seeds as a control.

Experimental Procedure

Seeds of the "Togo" and "Mante" variety were purchased from small scale farmers at Ashale Botwe, in Greater Accra. Petri dishes were sterilized with alcohol, then lined with 90 mm filter paper and moistened with 10 ml distilled water. A total of 100 seeds per treatment were spread uniformly on the moistened filter paper, covered but not sealed and kept in an incubation chamber (Gelman Sciences Australia). The filter paper was moistened every other day.

Data Collection

Germination count was started a day after seeds were sown. Germination was recorded for seeds with visible radicle development. The number of germinated seeds per replicate per treatment were taken daily for a period of two weeks. Germination Percentage (G), Mean Germination Time (MGT), Mean Germination Rate (MGR), Coefficient of Variation of the Germination Time (CV), Synchrony of Germination (Z) and Uncertainty of the Germination Process (U) were calculated using a Germination Spreadsheet Calculator developed by Ranal et al. (2009).

Germination Percentage (GP) for each treatment was determined using the formula proposed by ISTA (2015):

$$GP = \frac{N_g}{N_t} \times 100$$

where, N_g is the number of germinated seeds and N_t is the total number of seeds.

Mean Germination Time ($\overline{T}$) was determined using the formula proposed by Edmond and Drapala (1958); Czabator (1962); Smith and Millet (1964); Gordon (1969); Gordon (1971); Ellis and Roberts (1980); Labouriau (1983a):

$$\overline{T} = \frac{\sum_{i=1}^{k} N_i T_i}{\sum_{i=1}^{k} N_i}$$

where, T_i is the time from the start of the experiment to the ith observation, N_i is the number of seeds germinated in the ith time (not the accumulated number, but the number correspondent to the ith observation) and k is the last time of germination

Mean Germination Rate ($\overline{V}$) was determined using the formula proposed by Labouriau and Valadares (1976); Labouriau (1983b); Ranal and Santana (2006):

$$\bar{V}= \frac{\sum_{i=1}^{k} N_i}{\sum_{i=1}^{k} N_i T_i}$$

where, T_i is the time from the start of the experiment to the i^{th} observation, N_i is the number of seeds germinated in the i^{th} time (not the accumulated number, but the number correspondent to the i^{th} observation) and k is the last time of germination.

Coefficient of Variation (CV_T) of the Germination Time was determined using the formula proposed by Ranal and Santana (2006):

$$CV_T = \sqrt{\frac{s_T^2}{\bar{T}}}$$

where, s_T^2 is the Variance of Germination Time and $\bar{T}$ is the Mean Germination Time.

Uncertainty of the Germination Process (U) was determined using the formula proposed by Shannon (1948); Labouriau and Valadares (1976); Labouriau (1983b):

$$U = -\sum_{i=1}^{k} f_i \log_2 f_i$$

where, f_i is the relative frequency of germination ($f_i = \frac{N_i}{\sum_{i=1}^{k} N_i}$), N_i is the number of seeds germinated on the i^{th} time and k is the last day of observation.

Synchrony of Germination (Z) for each treatment was determined using the formula proposed by Primack (1985); Ranal and Santana (2006):

$$Z = \frac{\sum_{i=1}^{k} C_{N_{i,2}}}{C_{\sum N_{i,2}}}$$

where, C N_i , 2 is the partial combination of the two germinated seeds from among N_i, the number of seeds germinated on the i^{th} time (estimated as $C_{N_i,2} = \frac{N_i(N_i-1)}{2}$)
and $C_{\Sigma N_i,2}$ is the partial combination of the two germinated seeds from among the total number of seeds germinated at the final count, assuming that all seeds that germinated did so simultaneously.

Data Analysis

Data collected were analysed using GenStat statistical software (12^{th} Edition). The Least Siginificant Difference (LSD) at 5% was used to seperate treatment means.

RESULTS AND DISCUSSION

Germination Percentage

Germination Percentage was significantly affected by variety. The "Togo variety" recorded a significantly ($p < 0.05$) higher Germination Percentage than the "Mante variety" (Table 1). Steeping *Corchorus olitorius* seeds in water at 100 °C for ten seconds recorded a significantly ($p < 0.05$) higher Percentage Germination followed by soaking in water at 80° C for 15 minutes, whiles seeds treated by soaking in water for 24 hours and the untreated seeds recorded the lowest germinability (Table 1). There were significant ($p < 0.05$) interactions between variety and seed treatments (Table 1).

The findings from this study are in line with Sanchez and Mella (2004), who concluded that dormancy in *Corchorus olitorius* was displayed both as slow germination and low final germination. All hot water and sulphuric acid seed treatments recorded superior Germination Percentages (above 50 %) than the control. This occurrence could be explained- in that the action of hot water and sulphuric acid caused a weakening or softening of the seed-coat structure, which facilitated the emergence of the embryo (Maina et al., 2011; Masarirambi et al., 2018; Oladiran, 1986; Tolorunse et al., 2015). Highest Germination Percentage in *Corchorus olitorius*, achieved by steeping in hot water for ten seconds, was also reported by Masarirambi et al. (2018).

Mean Germination Time

Mean Germination Time was significantly affected by variety. The "Mante variety" recorded a significantly ($p < 0.05$) higher

Mean Germination Time than the "Togo variety" (Table 2). Except for the control and soaking in water at room temperature for 24 hours, all other seed treatments recorded lower Mean Germination Times (Table 2).

Seeds soaked in sulphuric acid and hot water achieved maximum germination (as determined by radical appearance) within one day (Table 2). Comparatively, untreated seeds and those soaked in water at room temperature for 24 hours, required five and six days, respectively for maximum germination to occur (Table 2). The interaction between variety and seed treatments had no significant ($p < 0.05$) influence on Mean Germination Time (Table 2). The relationship between low germinating seed lots with their corresponding high Mean Germination Times, was reported in stressed cucurbit seeds by Mavi et al. (2010).

Table 1: The effect of variety and seed treatment on Germination Percentage of *Corchorus olitorius*

Germination Percentage (%)			
	Variety		
Seed treatment	Mante	Togo	Means
Control	1.25 a	4.25 a	2.75 a
Soaking in water (24 hr)	2.75 a	2.25 a	2.50 a
Soaking in H_2SO_4 (2 min)	49.25 bc	60.75 cd	55.00 b
Soaking in H_2SO_4 (5 min)	61.75 cd	58.50 c	60.12 b
Soaking in H_2SO_4 (10 min)	50.75 bc	74.00 de	62.38 b
Soaking in water at 80° C (15 min)	38.50 b	86.75 ef	62.62 b
Steeping in water at 100° C (10 s)	89.25 f	86.00 ef	87.62 c
Means	41.90 a	53.20 b	

$LSD_{0.05}$ (Seed treatment) = 9.87 $LSD_{0.05}$ (Variety) = 5.28 $LSD_{0.05}$ (Seed treatment x Variety) = 13.96. Means followed by different letter(s) in a column and row are significant at 5% level of probability.

Table 2: The effect of variety and seed treatment on Mean Germination Time of *Corchorus olitorius*

Mean Germination Time (day)			
	Variety		
Seed treatment	Mante	Togo	Means
Control	4.42	4.86	4.64 b
Soaking in water (24 hr)	7.73	3.63	5.68 b
Soaking in H_2SO_4 (2 min)	1.79	1.17	1.48 a
Soaking in H_2SO_4 (5 min)	1.42	1.29	1.36 a
Soaking in H_2SO_4 (10 min)	1.62	1.16	1.39 a
Soaking in water at 80° C (15 min)	2.25	1.19	1.72 a
Steeping in water at 100° C (10 s)	1.37	1.10	1.23 a
Means	2.94 a	2.05 b	

$LSD_{0.05}$ (Seed treatment) = 1.531
$LSD_{0.05}$ (Variety) = 0.818. Means followed by different letter(s) in a column and row are significant at 5% level of probability.

Mean Germination Rate

Mean Germination Rate was significantly affected by variety. The "Togo variety" recorded a significantly ($p < 0.05$) higher mean germination rate than the "Mante variety" (Table 3). Steeping the seeds of *Corchorus olitorius* in water at 100 °C for ten seconds recorded the highest Mean Germination Rate, whiles both the control and seeds soaked in water for 24 hours recorded the lowest Mean Germination Rate (Table 3). There were no significant interactions between seed variety and the different seed treatments (Table 3).

Coefficient of Variation of the Germination Time

Coefficient of Variation of the Germination Time was significantly influenced by the different seed treatments used in the study. Soaking seeds in sulphuric acid recorded the highest Coefficients of Variation of the Germination Time, which were significantly ($p < 0.05$) greater than the seeds treated by soaking and steeping in water (Table 4).

Uncertainty of the Germination Process

Seeds of the "Mante variety" recorded a significantly ($p < 0.05$) higher value of Uncertainty of the Germination Process than those of the "Togo variety" (Table 5). This indicates that the germination of the seeds of the "Togo variety" was more concentrated in time, whilst that of the "Mante variety" was more spread out. Uncertainty of the Germination Process was not influenced by seed treatment. There were significant ($p < 0.05$) interactions between variety and seed treatment (Table 5).

Synchrony of Germination

Synchrony of Germination was significantly influenced by the different varieties and seed treatments used for the study. The "Togo variety" recorded a significantly ($p < 0.05$) higher value of Synchrony of Germination than the "Mante variety" (Table 6). The control and soaking in water at room temperature for 24 hours recorded significantly ($p < 0.05$) lower values of Synchrony of Germination, compared with all other treatments (Table 6). This finding agrees with Tolorunse et al. (2015), who reported that untreated *Corchorus olitorius* seeds in their study produced a slower and more asynchronous germination than steeping in water at 80 – 97 °C for five seconds. Oliveira (2008) claimed that less synchrony and higher heterogeneity in germination, enhances the survival of *Pseudobombax longiflorum* in its natural environment. This might also apply for *Corchorus olitorius* in the wild. However, as a food crop, more homogeneity in germination is expected.

CONCLUSION

The study was conducted to develop easy and effective seed treatments for *Corchorus olitorius*, leading to better establishment and therefore higher yield. The study showed that dormancy in *Corchorus olitorius* was best broken by soaking the seeds in hot water and concentrated sulphuric acid. Applying hot water and sulphuric acid seed scarification treatments on *Corchorus olitorius*, resulted in superior germinability and a faster and more synchronous germination, which is desirable for crops. It is recommended that Ghanaian small scale farmers steep their seeds in water of 100 °C for ten seconds prior to sowing.

Table 3: The effect of variety and seed treatment on Mean Germination Rate of *Corchorus olitorius*

Mean Germination Rate (day-1)			
	Variety		
Seed treatment	Mante	Togo	Means
Control	0.0025	0.0110	0.0068 a
Soaking in water (24 hr)	0.0049	0.0077	0.0063 a
Soaking in H_2SO_4 (2 min)	0.0099	0.0156	0.0127 ab
Soaking in H_2SO_4 (10 min)	0.0113	0.0121	0.0117 ab
Soaking in water at 80° C (15 min)	0.0175	0.0221	0.0198 bc
Steeping in water at 100° C (10 s)	0.0242	0.0386	0.0314 d
Means	0.0123 a	0.0194 b	

$LSD_{0.05}$ (Seed treatment) = 0.00950
$LSD_{0.05}$ (Variety) = 0.00508
Means followed by different letter(s) in a column and row are significant at 5% level of probability.

Table 4: The effect of variety and seed treatment on Coefficient of Variation of the Germination Time of *Corchorus olitorius*

Coefficient of Variation of the Germination Time (%)			
	Variety		
Seed treatment	Mante	Togo	Means
Control	25.0	94.3	59.6 ab
Soaking in water (24 hr)	50.9	38.3	44.6 a
Soaking in H_2SO_4 (2 min)	116.7	66.0	91.3 b
Soaking in H_2SO_4 (5 min)	98.1	87.6	92.9 b
Soaking in H_2SO_4 (10 min)	91.7	56.9	74.3 ab
Soaking in water at 80° C (15 min)	57.5	45.7	51.6 a
Steeping in water at 100° C (10 s)	44.2	32.2	38.2 a
Means	69.1	60.2	

$LSD_{0.05}$ (Seed treatment) = 37.54
Means followed by different letter(s) in a column and row are significant at 5% level of probability.

Table 5: The effect of variety and seed treatment on Uncertainty of the Germination process of *Corchorus olitorius*

Uncertainty of the Germination Process (bit)			
	Variety		
Seed treatment	Mante	Togo	Means
Control	-0.396 d	-1.211 ab	-0.803
Soaking in water (24 hr)	-0.977 bcd	-0.500 cd	-0.738
Soaking in H_2SO_4 (2 min)	-1.105 bc	-0.464 cd	-0.785
Soaking in H_2SO_4 (5 min)	-0.760 bcd	-0.522 cd	-0.641
Soaking in H_2SO_4 (10 min)	-0.688 bcd	-0.391 d	-0.539
Soaking in water at 80° C (15 min)	-1.856 a	-0.689 bcd	-1.272
Steeping in water at 100° C (10 s)	-0.986 bcd	-0.408 d	-0.697
Means	-0.967 a	-0.598 b	

$LSD_{0.05}$ (Variety) = 0.2503
$LSD_{0.05}$ (Seed treatment x Variety) = 0.6622
Means followed by different letter(s) in a column and row are significant at 5% level of probability.

Table 6: The effect of variety and seed treatment on Synchrony of Germination of *Corchorus olitorius*

Synchrony of Germination			
	Variety		
Seed treatment	Mante	Togo	Means
Control	0.000	0.214	0.107 a
Soaking in water (24 hr)	0.250	0.250	0.250 a
Soaking in H_2SO_4 (2 min)	0.622	0.860	0.741 bc
Soaking in H_2SO_4 (5 min)	0.776	0.842	0.809 c
Soaking in H_2SO_4 (10 min)	0.770	0.884	0.827 c
Soaking in water at 80° C (15 min)	0.313	0.764	0.539 b
Steeping in water at 100° C (10 s)	0.563	0.854	0.709 bc
Means	0.471 a	0.667 b	

$LSD_{0.05}$ (Seed treatment) = 0.2095

$LSD_{0.05}$ (Variety) = 0.1120

Means followed by different letter(s) in a column and row are significant at 5% level of probability.

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