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Effect of Temperature Treatments on Seed Germination and Seedling Growth of Jute Mallow *(Corchorus olitorius)*

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***Abstract*— *Jute mallow (Corchorus olitorius) is one of the common green leafy vegetables used widely throughout Ghana. Jute mallow is cultivated by seeds and the demand for the crop is year-round. Despite the high demand, its efficient production is marred by poor seed germination. Thus, this study seeks to determine the effect of pre-chill, dry and wet heat on germination, seedling emergence and seedling vigor of jute mallow.*

Results revealed that hot water at 70ºC with combination of 70ºC oven heat for thirty (30) minutes produced the best germination, emergence and seedling vigour. The effect of hot water at 70ºC only was also significantly higher than other treatments.

Jute mallow farmers who produce on small scale could use hot water at 70ºC to treat seeds before sowing. Large scale producers, however, could use a combination of hot water at 70ºC and oven heat at 70ºC to treat seeds before sowing.

Keywords*— *temperature treatment, seed germination, seedling vigour, jute mallow, Corchorus olitorius.

I. INTRODUCTION

Corchorus olitorius, also known as Jew or jute mallow or bush okra is one of the popular tropical leafy vegetables in Africa, Asia and some part of the Middle East (Olabode and Sangodele, 2014). Studies have shown that jute mallow is considered as a vegetable in most parts of Africa and is widely consumed among rural communities (Velempini *et al.*, 2003). It is an annual crop popularly known in southern Ghana as "Ademe" and northern Ghana as "Ayoyo". It plays very significant role in household nutrition and it is very affordable. It is used to prepare sauce and soup delicacies and its mucilaginous property when cooked facilitate swallowing of solid foods. Hence most parents introduce it to babies who are learning to eat solid foods for the first time. In Ghana, jute mallow is eaten with starchy foods such as "banku", "akple" and "tuo-zafi" due to its ability to enhance swallowing.

Jute mallow was usually found in the wild but recently the health consciousness of many Ghanaians to eat healthy has increased the demand for its consumption hence making it necessary for farmers to deliberately grow them on commercial scale. However, the hard seed coat of jute mallow seeds cause physical dormancy hence, its delay in seed germination (Tareq *et al.*, 2015). Attempts at breaking seed dormancy in jute mallow include the use of heat under constant temperatures (Wahab, 2011), seed scarification (Emongor *et al* 2004) and use of

chemicals such as sulphuric acid (M. Palada and Chang, 2003). Palada and Chang (2003), reported that when jute mallow seeds are steeped in boiled water, seed germination

and seedling emergence are enhanced. These studies produced germination percentage between 40%-80%.

Mechanical scarification usually makes the surface of seeds permeable to water but reduces seedling vigor. Apart from reducing seedling vigor, the size(small) of the seed makes it difficult to carry out mechanical scarification on jute mallow seeds (Velempini *et al.*, 2003). Some of these treatments involve chemicals which do not only overburden small scale farmers with high production cost but these chemicals are not easily accessible. It is important to exploit feasible and effective methods that can be used by small scale farmers as well as commercial farmers to enhance germination and seedling vigor. Application of heat may be easier than earlier attempts that are more difficult to apply especially by small scale farmers. Thus, this study seeks to assess seed quality of jute mallow in terms of health, purity and viability while assessing rate of seed germination and seedling vigor, following different methods of breaking dormancy using heat treatments.

II. MATERIALS AND METHODS

The experiment was conducted at the laboratory of Ghana Seed Inspection Division (GSID) located at Pokuase, Accra and the Pathology Laboratory of Crop Science Department, University of Ghana. Jute mallow seeds used for the study were farmer saved seeds and were purchased from seed shop in Accra.

Seed viability test was conducted by using floatation method (www.agrifarming.in). In this process, seeds were poured into beaker containing water and allowed to settle for 20 minutes. Viable seeds are usually heavier than unviable seeds hence they settled at the bottom of the glass beaker while the lighter seeds with other impurities floated on the water.

The purity test was conducted according to the rule of International Seed Testing Association (ISTA, 2017). The aim of the purity test was to determine the percentage composition by weight of the seed being used. Two hundred grams (200g) of seeds were weighed and mixed thoroughly by hand. The seeds were poured onto the purity working board with reflected light to enhance vision; this was done with about 150 seeds at a time. Magnifiers were used to aid the separation of seeds into various components by magnifying the seeds and other components. The components were pure seeds, other seeds and inert matter. Pure seeds were seeds with all the features of jute mallow. Other seeds were defined as seeds of other plants that may be present. Inert matter was the materials that were neither pure seeds nor other seeds.

Purity percentage was calculated by dividing the weight in grams of pure seeds by the total seed weight and multiplied by 100 as shown in the equation 1 below:

$$P = \left(\frac{P_{ws}}{T_{ws}} \right) x100\% \qquad \text{Equation 1}$$

Where purity percentage is denoted by P, weight of pure seeds as P_{ws} and total seed weight denoted by $T_{ws.}$

Seed Moisture Test

Seed moisture test was done by weighing one hundred grams (100g) of seeds on a weighing scale. The seeds were poured into a digital moisture meter and calibrated to shallot seed. The calibration did not have jute mallow seeds on the machine so shallot was used since it has similar seed size.

To conduct health test on the seeds, ten (10) glass petri dishes were sterilized in a hot oven sterilizer at 175ºC for 90 minutes. Ten milliliters (10 ml) of Potato Dextrose Agar (PDA) media was poured into each sterilized petri dish. Ten (10) seeds were placed in each petri dish and covered. This was replicated ten (10) times, making a total of hundred (100) seeds. The petri dishes were labeled and incubated for five days to observe the presence of pathogens on the seed surface.

Two grams (2g) of seeds were placed in a conical flask and 1% sodium hypochlorite was poured into the flask for sixty (60) seconds to sterilize the surface of the seed.

The contents in the flask were sieved and the seeds were poured onto a tissue paper to absorb the remaining moisture on it. Ten (10) glass petri dishes were sterilized in a hot oven sterilizer at 175ºC for 90 minutes. Ten milliliters (10 ml) of PDA media was poured into each sterilized petri dish. Ten (10) seeds were placed in each petri dish and covered. This was replicated ten (10) times, making a total of hundred (100) seeds. The petri dishes were labeled and incubated for five days to observe the presence of pathogens within the seed.

Seed Treatments to Break Dormancy

Seeds were subjected to Ten (10) temperature treatments (T) and assessed for germination, emergence and seedling vigor as shown in table 1. A control, where seeds

were sown without temperature treatment was included in the study. For oven treatments, the oven was pre-heated.

Table 1: Seed Treatments Evaluated for Ability to Break Dormancy

Treatment	Procedure
Treatment 1	Soak seeds for 15 hours at 21ºC
Treatment 2	Soak seeds for 15 hours at 21ºC, followed by heating at 70ºC for 30 minutes
Treatment 3	Dip seed in hot water at 70ºC for 5minutes
Treatment 4	Dip seeds in hot water at 70ºC for 5minutes, followed by heating at 70ºC for 30 minutes
Treatment 5	Pre-chill seeds at 5ºC for 24 hours
Treatment 6	Pre-chill seeds at 5ºC for 24 hours, followed by heating at 70ºC for 30minutes
Treatment 7	Oven heat seeds at 70ºC for 30 minutes
Treatment 8	Oven heat seeds at 80ºC for 30 minutes
Treatment 9	Oven heat seeds at 90 ºC for 30 minutes
Treatment 10 (control)	Sowing seeds directly

Germination Test

Germination was done by using the top of paper method. Hundred seeds from each treatment were sown on filter paper. This procedure was replicated four (4) times. Germination counts started on the third day after planting and continued for a total period of 14 days when most of the seeds had germinated. Radicle (root) emergence was used as the criterion for germination (Denton *et al*., 2013). The percentage germination was calculated by dividing the total number of seeds that germinated over the number of seeds sown and multiplied by hundred (Denton *et al*., 2013) as shown in equation 2 below.

$$GP(\%) = \frac{T_{sg}}{T_{ssn}} x100 \quad \text{Equation 2}$$

where germination percentage is denoted by *GP*, total number of seeds germinated is denoted by T_{sg}, and total number of seeds sown denoted by T_{ssn}.

Seedling Emergence and Seedling Vigor Index

The experiment was a complete randomized design. One hundred seeds were taken from each treatment and sown in a germination tray which was filled with sand to about 3cm thick. Each treatment had three (3) replications. The set up was irrigated lightly every day to ensure adequate water supply for germination and to prevent the seed from drifting away from the planted rows.

The numbers of seedling emergence were recorded on daily basis, starting from the third day after sowing until 14 days after sowing. Seedling was scored as emerged when the cotyledons break through the soil surface and the percentage seedling emergence was calculated by dividing the total number of seedlings that emerged by the number of seeds sown and multiplied by hundred.

On the 14th day, measurements of seedling length were carried out on 10 randomly selected seedlings from each replicated tray (Denton *et al*., 2013). The seedling vigor index was calculated by multiplying the seedling length by percentage seedling emergence (Denton *et al*., 2013).

$$EP(\%) = \frac{T_{se}}{T_{ssn}} x100 \quad \text{Equation 3}$$

where emergence percentage (%) is denoted by *EP*, total number of seeds emerged denoted by T_{se}, and total number of seeds sown denoted by T_{ssn}

III. RESULTS

Seed Quality

The seed quality tests revealed that ninety two percent (92%) of the jute mallow seeds were viable and eighty seven percent (87%) pure. Seed health test within the seed revealed no contaminants however test on the seed surface showed that seeds carried 10% fungal pathogens and 5% bacterial pathogens refer to table 2.

Table 2: Results of Seed Quality Tests

Seed Quality test	Results in percentage (%)
Seed viability	92
Seed moisture	11
Seed purity	87
Seed health (within seed)	100
Seed health (seed surface)	85

Effect of Treatments on Percentage Germination and Emergence

Seeds that were treated with hot water and oven heat combination resulted in the highest percentage of

germination of 92%, as well as the highest emergence of 87% (see table 3).

The untreated seeds resulted in the lowest percentage germination (2.5%) and there was no seedling emergence.

Table 2: Effect of temperature treatments on percentage germination and emergence

Treatments	Percent (%) Germination	Percent (%) Emergence
Soak seeds in water at 21ºC for 15 hours	5	1
Soaking in water at 21ºC + oven heat	26	19
Hot water	77	61
Hot water + oven heat	92	86
Pre-chill seeds at 5ºC for 24 hours	8	7
Pre chilling+ oven heat	49	38
Oven heat seeds at 70ºC for 30 minutes	38	33
Oven heat seeds at 80ºC for 30 minutes	42	40
Oven heat seeds at 90 ºC for 30 minutes	48	41
Control	2.5	0

Table 4: Effect of temperature treatment on seedling length (cm) and seedling vigor of jute mallow seeds

Treatments	Seedling length	Vigour
Soak seeds in water at 21ºC for 15 hours	3.2^{a}	7.2^{a}
Soaking seeds in water at 21ºC + oven heat	3.1^{a}	82.7^{b}
Hot water	2.9^{a}	180.6^{d}
Hot water + oven heat	3.8^{b}	293.2^{e}
Pre-chill seeds at 5ºC for 24 hours	3.1^{a}	22.5^{a}
Pre chilling+ oven heat	3.2^{a}	157.5^{cd}
Oven heat seeds at 70ºC for 30 minutes	4.1^{b}	154^{cd}
Oven heat seeds at 80ºC for 30 minutes	3.1^{a}	135.9^{c}
Oven heat seeds at 90 ºC for 30 minutes	2.7^{a}	134.9^{c}
Control	3.0^{a}	3.0^{a}

Means followed by the same Superscript along the column are not significantly different at 5 % significant level by Duncan Multiple range test. All values in brackets were transformed by Arcsine transformation.

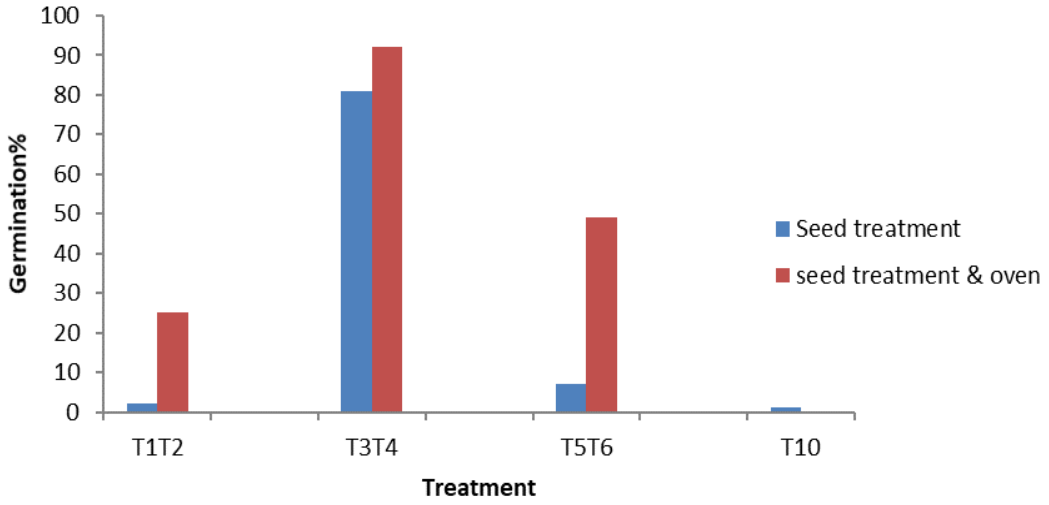

Fig.1: Germination relationship between seeds followed by oven treatments and non-oven treatments

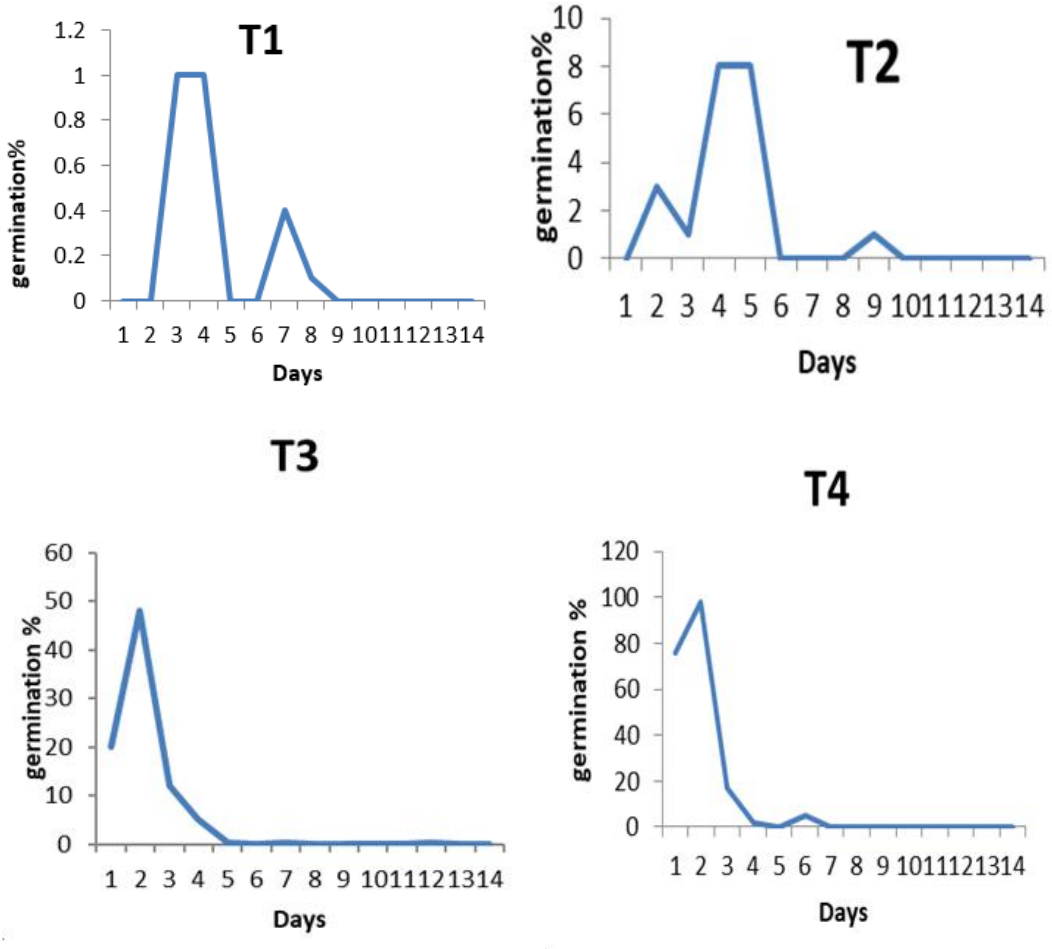

Fig.2: Germination rate of jute mallow following various heat treatments (T1-T4)

T1: soak seeds in water at 21ºC for 15hours, T2: Soak seeds in water at 21ºC for 15 hours followed by oven heat, T3: Hot water at 70ºC, T4: Hot water at 70ºCFollowed by oven heat at 70ºC, T5: Pre chill at 5ºC for 24 hours, T6: Pre-chill at 5ºC for 24 hours followed by oven heat at 70ºC, T10: Control).

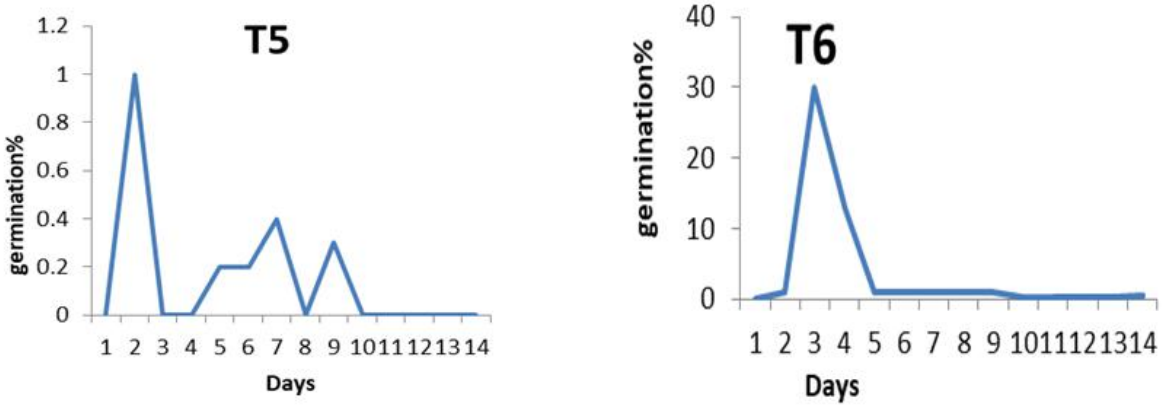

Fig.3: Germination rate of jute mallow following various heat treatments (T5-T6)

(T1: soak seeds in water at 21ºC for 15hours, T2: Soak seeds in water at 21ºC for 15hours followed by oven heat, T3: Hot water at 70ºC, T4: Hot water at 70ºC followed by oven heat at 70ºC, T5: Pre chill at 5ºC for 24 hours, T6: Pre chill at 5ºC for 24 hours followed by oven heat at 70ºC)

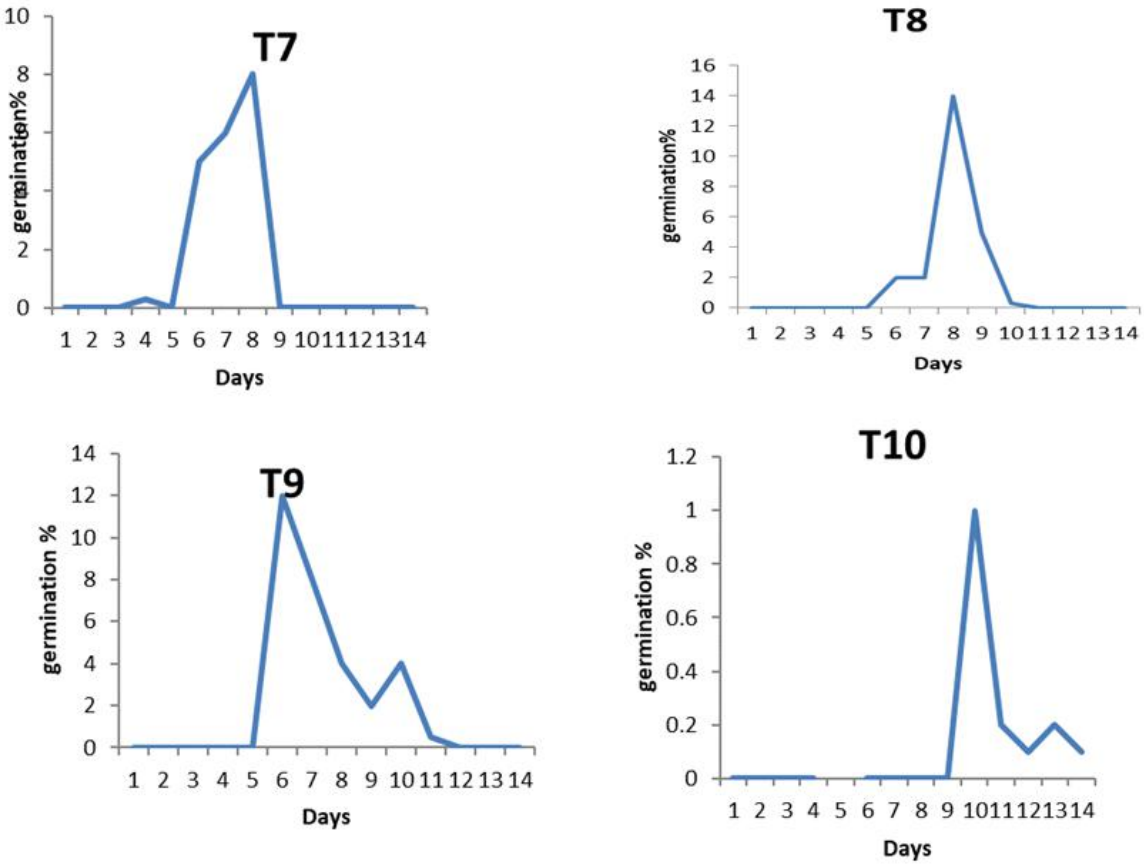

Fig.4: Germination rate of jute mallow following various heat treatments (T7-T10)

(T7: oven heat at 70ºC, T8**:** oven heat at 80ºC, T9: oven heat at 90ºC, T10: Control)

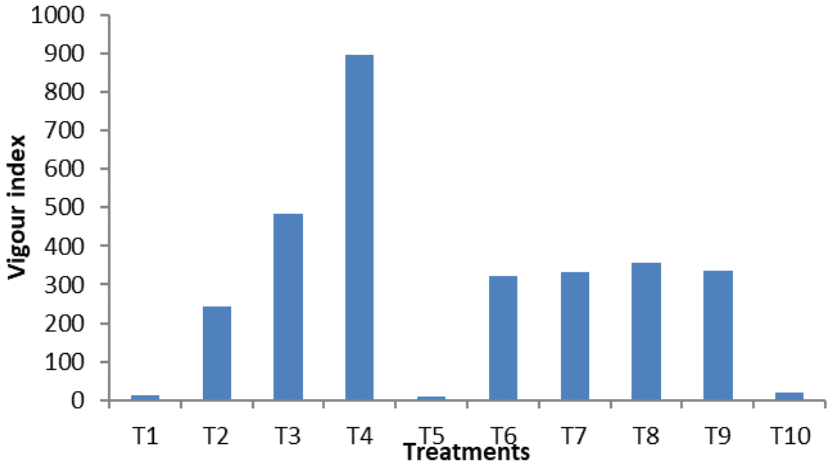

Fig.5: Effect of treatments on seedling vigor of emerged jute mallow seedlings

T1: soak seeds in water at 21ºC for 15hours, T2: Soak seeds in water 21ºC for 15hours followed by oven heat, T3: Hot water at 70ºC, T4: Hot water at 70ºC followed by oven heat at 70ºC, T5: Pre chill at 5ºC for 24 hours, T6: Pre chill at 5ºC for 24 hours followed by oven heat at 70ºC, T7: Oven heat at 70ºC, T8: Oven heat at 80ºC, T9: Oven heat at 90ºC, T10: Control)

IV. DISCUSSION

Health Status and Contributing Factors of Farmer Saved Seeds

African indigenous vegetables are usually cultivated with other crops where the same plot is divided into sub plots and different crops are cultivated in each subplot; this agrees with (Maseko *et al.,* 2018) who reported that African leafy vegetables are cultivated under a mixed cropping system. Farmers with a variety of crops are able to make sales every time compared to farmers who grow single crops because a crop is always available for sale notwithstanding, it also comes along with its challenges. It is however easy for pest and diseases to spread on such farms, especially when crops from the same family are found on the subplots. Pest easily migrate from one crop to another. The presence of fungi on the seed but not within the seed indicated that the seeds may have been kept with other contaminated seeds during storage. Seeds may also have been contaminated during the extraction process or through harvesting equipment or even via storage environments as seeds were not certified. Fungus is usually associated with stored grains and legumes; it also grows well where there is water (moist) and temperature interaction. Fungal infestation of seed coat decreased viability of seeds causing abnormal seedlings.

However, methods of sterilization such as hot water, natural compounds, commercial bleach and ethylene are able to get rid of the seed's infestation. Farmers are able to eradicate the fungal contamination on the seed coat of jute mallow unconsciously during the period of breaking dormancy by steeping the seeds in hot water (Selcuk *et al.*, 2008). The seed is thus sterilized while dormancy is being broken and this reduces the risk of disease infestation in jute mallow. Disease causing bacteria present on the seed coat showed that the farmer saved-seeds did not go through any standard check, therefore, there is potential yield loss as a result of disease infestation in the life of the plant.

Efficient and Effective Methods of Breaking Dormancy on Germination and Seedling Vigor of Jute Mallow

Hot water caused thermal shock to the embryo or leaching of inhibitors to enhance germination, however the embryo may be destroyed as a result of prolong contact with high temperatures which is consistent with (Velempini *et al.*, 2003) who reported that, longer soaking times result in drastic reduction in germination.

Treatments included dipping jute mallow seeds into hot water when it starts to bubble and this caused germination. Based on the observations, the effect of temperature treatments on germination and seedling emergence followed similar trend with seeds dipped into hot water at 70ºC followed by oven heat at 70ºC for 30minutes showing the highest germination and seedling emergence. Seed dormancy in jute mallow is physical dormancy and is usually as a result of hard seed covering which prevent water from entering into the seed (Abukutsa-Onyango, 2005). The hot water thus scarified the seed coat and caused water imbibition hence facilitating germination and emergence. The high temperature also provided good medium for enzymes to catalyze the breakdown of seed coat and this allowed the water imbibition and gaseous exchange thereby enhancing germination and emergence.

Exposing seeds to oven heat at 70ºC showed moderate seedling emergence, which increased with temperature at 80ºC. Dry heat produced may have cracked the hard seed coat making it permeable to water when moistened similar to method of breaking dormancy in some *Acacia* tree species (Walters *et al*., 2004). This explains why seeds in the wild readily germinate and produce seedlings during the rains on farms that were burned during land preparation (Denton *et al.,* 2013). No significant increase in seedling emergence and germination were obtained when oven heat temperature was increased from 80ºC to 90ºC for 30minutes. This could be as a result of embryo damage due to the excessive high temperature and this observation was contrary to Denton *et al., (*2013) who reported that irrespective of how long jute mallow seeds were subjected to bush fire, there were seedling emergence on the field after the first rain. The difference in germination and emergence when temperature increased from 80ºC to 90ºC may also be as a result of embryo damage due to the prolong exposure of the seed to dry heat causing seeds to dehydrate hence increased mortality.

The control treatment and seeds soaked in water at 21ºC for 15 hours did not enhance germination at all. The seed coat could not be modified to imbibe water for germination to occur due to physical dormancy. Pre chilling

seeds at 5ºC for 24 hours resulted in poor germination and emergence which agrees with (Nkomo *et al.*, 2009b) who reported that there was no germination for seeds that were pre-chilled for one(1) day. However, seeds that were pre-chilled with oven heat combination showed significant difference in germination. This finding agrees with (Nkomo & Kambizi, 2009b) who reported that germination occurred when seeds were exposed to temperature of 35ºC and above.

Hot water followed by oven heat treatment showed high seedling vigor for both germination and emergence indicating that, hot water and dry heat enhanced germination, emergence and seedling length. Though the seeds had high viability, the treatments for breaking dormancy favored the plant establishment. The term "seed vigor" has a concept associated with aspects of seed performance which include rate and uniformity of seed germination, seedling growth and emergence. Seeds soaked in water at 21ºC (T1), seeds soaked in water followed with oven heat (T2) and control (T10) produced low seed vigor. This was as a result of poor seedling performance in terms of height and germination which agrees with the International rules for seed testing's explanation of seedling vigor as the total properties that determines the activity and acceptable germination performance of seed (ISTA, 2015).

Germination rate is a necessary parameter in crop establishment on the field. The effect of treatments on the seed varied significantly, seeds dipped into hot water only (T3) and seeds dipped into hot water followed by oven treatments (T4) were the only treatments that started germination from the first day of germination count. This is consistent with other findings that hot water treatments enhance germination (Maina *et al.*, 2011). Germination started on day one and increased by day two but the rate of germination decreased in the subsequent days. About 85% of the total seeds' germinations occurred from day one (1) to two (2) while the remaining treatments started germinating between day two (2) and fourteen (14). The trends of germination rates of the various treatments indicated their effectiveness in breaking dormancy with the control taking the longest time to germinate. A low germination of 2.5% is an indication of the importance of treating seeds of jute mallow prior to planting.

Also soaking seeds in water at 21ºC alone is equally not very effective. Maximum germination rate for treatment (6 and 1) occurred on day three, treatment (2) was on day four, treatment (7and 8) was on day eight, treatment (9) was on day six and treatment (10) started germinating on day fourteen. This revealed that, though the other treatment enhanced germination at some point, there was delay in germination which makes the treatment method ineffective for breaking dormancy.

Treatment 10 which was the control had its maximum germination on day fourteen with germination percentage of 2.5% revealing that jute mallow seeds will not germinate at all or have poor germination and seedling vigor when it is not treated before sowing. Soaking seeds in ordinary water at room temperature (T1) resulted in 5% germination and was not an effective method of breaking dormancy. It agrees with the report by (Maina *et al.*, 2011) that soaking jute mallow seeds in ordinary water will not break dormancy.

V. CONCLUSION

The quality of farmer saved-seeds in terms of purity and viability is adequate as it was above 80% for both 87% and 92% respectively. For seed health quality, no seed borne pathogen were observed. Hot water followed by oven heat treatment can be adopted on large scale production while small scale producers can employ hot water treatment for uniform growth and development.

The best treatment for breaking dormancy in jute mallow from the study was dipping seeds in hot water treatment at 70ºC for five (5) minutes followed by oven heat at temperature of 70ºC for thirty (30) minutes as it gave the highest seedling germination, emergence and vigour. Hot water treatment and hot water combination with oven heat enhanced germination and good germination rate.

Hot water followed by oven heat treatment should be used by large scale producers while small scale producers use only hot water treatment.

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DISCLOSURE

The authors declare that there are no financial supports or relationship that may pose conflicts of interest.

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Appendix

Anova table for percentage germination

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Rep stratum	3	123.28	41.09	1.60	
Treatment	9	23320.62	2591.18	100.60	<.001
Residual	27	695.48	25.76		
Total	39	24139.38			

Anova table for germination vigor

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Rep stratum	3	3787.3	1262.4	2.89	
Treatment	9	286451.0	31827.9	72.93	<.001
Residual	27	11782.5	436.4		
Total	39	302020.9			

Anova table for seedling emergence

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Rep stratum	2	0.012729	0.006365	1.93	0.173
Treatment	9	2.919484	0.324387	98.61	< 0.001
Residual	18	0.059211	0.003289		
Total	29	2.991424	0.103153		