EFFECT OF TEMPERATURE TREATMENTS ON SEED GERMINATION AND SEEDLING GROWTH OF JUTE MALLOW *(Corchorus olitorius)*

BY

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THIS THESIS IS SUBMITTED TO THE UNIVERSITY OF GHANA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF PHILOSOPHY DEGREE IN SEED SCIENCE AND TECHNOLOGY

WEST AFRICA CENTRE FOR CROP IMPROVEMENT

COLLEGEE OF BASIC AND APPLIED SCIENCES

UNIVERSITY OF GHANA, LEGON

JULY, 2019

DECLARATION

I hereby declare that except for the references to works of other researchers, which have been duly cited, this work is my original research and that neither part nor whole has been presented elsewhere for the award of degree.

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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 but efficient production is marred by poor seed germination. This study was undertaken to determine the effect of pre-chill, dry and wet heat on germination, seedling emergence and seedling vigour of jute mallow. The study also examined farmers' practices for seed handling and processing. Hot water at 70ºC, alone or in combination with oven heat of 70^0 produced the best seed germination and emergence. The effect of hot water with oven heat on seedling vigour was also significantly higher than other seed treatments. Farmers' response to seed handling and processing revealed that they did not extract their own seeds because of regular leaf harvesting which is their main reason for production. Also, the farmers preferred seeds from Togo and Benin to seeds from Ghana due to the broader leaf sizes of the Ghanaian cultivars. Different accessions and cultivars have different leaf shapes and sizes, but consumers presume that broader leaves may have received a lot of fertilizer compared to the smaller leaves which looked more organic to them. Jute mallow seed farmers who produce on small scale could use hot water at 70ºC to treat seeds before sowing. Large scale producers, however, should 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.

DEDICATION

This MPhil degree thesis is dedicated to the Almighty God without whom this feat would not have been achieved.

I also dedicate this thesis to my beloved families; Larnyo and Kushiator families.

Thank you

ACKNOWLEDGEMENT

The first thanksgiving goes to the Most High God who made it possible for me to go through this MPhil programme successfully. I also express my heartfelt gratitude to my supervisors during the research studies, Professor Kwadwo Ofori and Dr. Christiana Amoatey. I am very grateful to DAAD for sponsoring my postgraduate studies at WACCI.

My gratitude goes to the coordinator of the program, Dr. Agyemang Danquah and all staffs of WACCI for their assistance.

I am very thankful to Mr. Richard Otoo of pathology laboratory of the Department of Crop Science of University of Ghana and Mr. Charles Appiah Nti of Ghana Seed Inspection Division. I cannot end without expressing my gratitude to Dr. Kwamena Banson of Ghana Atomic Energy and my colleagues at WACCI.

The final thanksgiving goes to my entire family for their support, especially my husband Dr. Ebenezer Larnyo, Fellow at the Institute of Information Systems Engineering, Jiangsu University, China.

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LIST OF ABBREVIATION

ANOVA……………………………………………Analysis of Variance

CSIR ………………………………………………Council for Scientific and Industrial Research

g……………………………………………………grams

GAEC………………………………………………Ghana Atomic Energy Commission

IITA………………………………………………...International Institute of Tropical Agriculture

ISTA………………………………………………..International Seed Testing Association

ml…………………………………………………...Milliliter

PDA…………………………………………………Potato Dextrose Agar

WACCI……………………………………………...West Africa Center for Crop Improvement

CHAPTER ONE

1.0 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 *et al*., 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 very affordable. It is use 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. About 75% of jute mallow farmers deliberately cultivate them across Ghana and it is consumed across all the regions in Ghana except the central region which was not recorded for consumption (Nyadanu *et al*., 2017). The hard seed coat of jute mallow seed causes physical dormancy on seeds hence, it delays seed germination (Tareq *et al*., 2015a). Attempt 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 can break dormancy (Palada *et al*., 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 vigour, the size(small) of the seed makes it is difficult to carry out mechanical scarification on jute mallow seeds (Velempini *et al*., 2003). The use of sulphuric acid to break seed dormancy gave good germination (Palada & Chang, 2003), however chemicals like sulphuric acid do not only over burden small scale farmers with higher production cost but may not be readily available or 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 vigour. Application of heat may be easier than earlier attempt that were more difficult to apply especially by small scale farmers

The objectives of the studies were to:

a) assess seed quality of jute mallow in terms of health, purity and viability
b) assess rate of germination seeds following different method of breaking dormancy using heat treatments
c) determine seedling vigour of jute mallow following different method of breaking dormancy and
d) Identify methods of breaking dormancy for small and large scale production of jute mallow

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 The role of African indigenous leafy vegetables in Africa

African indigenous leafy vegetables have been documented by many researchers as highly nutritious, affordable and medicinal (Irungu *et al*., 2007; Neugart *et al*., 2017). The term African leafy vegetables (ALVs), also called 'traditional leafy vegetables', are defined as plant species which are either genuinely native to a particular region, or which were introduced to that region for long enough to have evolved through natural processes or farmer selection (Maseko *et al*., 2018).

Earlier studies have reported that most African indigenous leafy vegetables have certain properties that has health benefits (Okeno *et al*., 2003). The low cost of production makes it easier for resource poor farmers to cultivate, especially African women involve in agriculture to gain economic empowerment. Good health is not the only benefit derived from indigenous green leafy vegetable, an increase in consumption of African indigenous vegetables will promote crop diversity, alleviate poverty and food insecurity (Irungu *et al*., 2007)

In order to promote sustainability, the United Nations in 1986 established the Institute for Natural Resources in Africa (INRA), an arm of the United Nations University in Accra Ghana, to build endogenous African capacity and strengthen national institutions to promote sustainable use of the continent's natural resources for development. Africa is endowed with lots of indigenous vegetables for food and medicine but African indigenous vegetables have been underutilized over the years and gradually being replaced by exotic vegetables. The frequent release of the improved varieties of the commonly used vegetables replace the indigenous varieties and their wild relatives leading to the scarcity of information on African indigenous leafy vegetables (Adebooye *et al*., 2005). In Ghana, the funding for crop research is almost always towards the staple crops and this do not support the development of these vegetables especially the indigenous vegetables. They are left in the wild and sometimes considered as weed whiles the continent suffers food insecurity and malnutrition. The seed requirement of Africa's Indigenous leafy vegetables (ILVs) depends on informal system of seed production that is from 'on-farm stored seed'. The quality usually falls below the national minimum seed standards. To ensure sustainable production of Africa's ILVs, there is a need of sustainable supply of improved and high-quality seeds (George, 1999) as well as strong market demand for ILV products. Studies shows that some African indigenous leafy vegetables contain higher nutrients as compared to some exotic vegetables however they are left underutilized (Ndlovu *et al*., 2008).

In Ghana, cereals, grains and tubers are considered as the main course of a meal and these starchy staples are usually enjoyed with vegetable sauce, stew or soups. In recent times, indigenous leafy vegetables like cocoyam leaves "kontomire" *Xanthosoma sagittifolia*, water leaf "Bokoboko" *Talinum triangulare*, Amaranth "Aleefu" *Amaranth cruentus*, *Corchorus olitorius* (Ademe/ayoyo), are mostly consumed due to the health consciousness of people. Green leafy vegetables are rich in vitamin A and iron as well as other minerals which the human body needs to maintain good health. When African indigenous vegetables are prepared properly to maintain the nutritional value, micronutrients are released and made available as well as increasing the effective absorption of micronutrients in other staple food crops.

2.2 Importance and production of *Corchorus olitorius (jute mallow)*

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 & Sangodele, 2014). In India, cotton is the first fiber crop followed by Jute mallow and it is mainly grown as cash crop in eastern India (Rahman *et al*., 2010). Though indigenous leafy vegetables are mostly found in the wild, Jute mallow has been cultivated for several years across Africa and Asia (Mathowa *et al*., 2014). The name differs from one country to the other; it is referred to as "Derere" in Zimbabwe, "Tege" in Cameroon, "Otege" in Uganda, "Ewedu" or "Ahuhura" in Nigeria. In Ghana it is popularly referred to as "ayoyo" or "Ademe". Some authors proposed that this species is native to India, Indo-Burma or Sri Lanka but due to the availability of several wild and weedy relatives in Africa there is a widely held assumption that the center of origin of jute mallow is Africa (Loumerem *et al*., 2016). Jute mallow is cultivated across Africa.

Jute mallow crop is from the Tiliaceae family; the crop is an annual herb. Depending on the cultivar, the plant is erect with a height ranging between 20 cm and 150 cm (Nkomo *et al*., 2009a). The stems are angular with simple oblong to lanceolate leaves that have serrated margins and distinct hair-like teeth at the base. Jute mallow is a dicotyledonous self-pollinating crop and is pollinated by insects. Flowers are hermaphrodite with small, yellow-petiole, borne in small clusters in the leaf axils (Loumerem & Alercia, 2016). The cylindrical capsules of 2 cm –5 cm is produced in large numbers, especially during the short days and seeds are dark bluish-green, angular, and about 2 mm long (Loumerem & Alercia, 2016). Jute mallow is one of the leading leaf vegetables in West Africa and is often consumed fresh and stored dry (Palada *et al*., 1999). The plant prefers a fertile, humus rich soil, well-drained alluvial soil but can also do well in non-optimal soil conditions. Seeds can be harvested six (6) weeks after flowering and the plant produces fruits that encapsulate the seed (Ilori *et al.,* 2016). The seeds are threshed from the dried pods by packing it in bags and beaten with stick or trampled by animal. The chaff and straw are removed by winnowing (Ilori *et al*., 2016). Jute mallow is used as medicine for relieving toothaches, abdominal pains and problems related to menstruation and pregnancy

(Ndinya *et al*., 2005). It is also use as an effective alternative drug therapy for the treatments of chronic cystitis, fever, gonorrhea and tumor (Oyedele *et al*., 2006). The nutrition and medicinal value of jute mallow is not the only reason for it gaining attention in crop development but also its economic importance. African leafy vegetables are also sources of income especially for rural women who are involved in vegetable business especially, African indigenous leafy vegetables (Schippers, 2002). The status of jute mallow as a wild vegetable makes it cheap so people of all classes are able to afford and this has contributed to its popularity in both rural and urban areas. Poor households tends to consume more indigenous vegetables as compared to wealthier households, because of low financial resources to purchase vegetables and the wherewithal to cultivate (Vorster *et al*., 2002).

The mucilaginous property is the main reason for consumption because it facilitates swallowing. In rural communities of Botswana where people provide care for relatives who have returned from urban centers because of ailment, jute mallow is mostly used in food preparation for the sick to enhance eating (Velempini *et al*., 2003). The increased utilization of wild vegetables like jute mallow in South Africa has been suggested as one of the ways to alleviate nutritional deficiencies and household food insecurity especially among populations with marginal or no income (Lewu *et al*., 2010).

Recently, jute mallow is cultivated all year round especially in urban centers due to its short life cycle (Schippers, 2002).The mucilaginous nature of jute mallow makes it a substitute for okra, it is use to prepare various delicacies which used to be prepared by okra only or can be mixed with okra during preparation. The seasonal nature of okra makes it unavailable and even if it is available the price is high at certain times of the year, on the other hand Jute mallow is relatively cheaper and available all year round to provide food security.

The health consciousness of many Ghanaians has influenced consumers to eat healthier, especially including fruits and vegetables into one's daily meal. Jute mallow is popular among other indigenous vegetables hence it is important to have a sustainable supply. The sustainability of the crop is dependent on the propagating material which is the seed. One important quality check by farmers is Germination percentage, which gives farmers assurance of good plant population and to estimate the yield potential of the material but seed of jute mallow shows poor germination as a result of physical dormancy imposed by hard seed coat (Velempini *et al*., 2003). The hard seed coat of jute mallow has become a major challenge in its production, for instance, in Botswana; farmers are demotivated to cultivate this plant because of poor germination (Velempini *et al*., 2003).

In Ghana, jute mallow is a household delicacy in many homes especially among the three northern regions and the Volta region where both shoots and leaves are used in food preparation. It also plays an important role in restaurants where is mostly referred to as 'green green'. It is cooked alone or mixed with tomatoes, onion, and pepper with fish or meat. To enhance the mucilaginous property, a bit of sodium bicarbonate is added during the preparation and sometimes okra.

Herbal medicines have been part of the African culture for centuries, herbs are boiled, soaked in water or alcohol, grounded dry or fresh for treatment of various ailments. Jute mallow is one of such significant leaves with medicinal value. Its roots are used for relieving toothaches, treatment of abdominal pains, menstrual and pregnancy problems (Ndinya & Ndinya, 2005). It is also use as an effective alternative drug therapy for the treatments of chronic cystitis, fever, gonorrhea and tumor (Oyedele *et al*., 2006). The demand for herbal products for diseases treatment is on the increase in developing and developed countries due to the minimal side effects of plant products. Jute mallow is among the medicinal crops that is found to be cheap, easy to cultivate and widely consumed around the globe. The crop is said to contain certain properties that relief pain, fever, dysentery and even tumor. It is also use as purgative, treatment of cystitis, gonorrhea, dysuria, and piles. For headaches and liver disorder, the leaves are dried and ground into powder, mixed with water and taken in bits. The Department of Health in the Philippines has advised the citizens to increase their intake of Jute mallow leaf vegetable in addition to 'malunggay' and banana to build resistance against swine flu disease.

In sub-Sahara Africa, food insecurity and malnutrition is high among pregnant women and children under five due to the high intake calories from rice, corn and cassava but lacks micronutrients. Malnutrition result in poor growth and development in children and this affect their academic performance, pregnant women and nursing mothers are at risk and the baby as well because the development of the baby depends on the nutrition of the mother. Jute mallow has been part of the indigenous vegetables in Africa and its consumption needs to be encouraged to provide nutrients to all especially the low income homes. These staple foods need to be taken with enough vegetables to provide the essential nutrients for growth and development. Jute mallow is enriched with nutrients such as protein, iron, carbohydrate, calcium and magnesium which play important role in the household nutrition. According to Ndlovu and Afolayan (2008), jute mallow is of more nutritional quality in terms of crude protein, iron, calcium and magnesium than cabbage and spinach (Ndlovu & Afolayan, 2008). A Proximate analysis by Olayemi and Rahma (2013) shows that jute mallow leaves contain protein; 6.00 ± 0.01%, fat; 1.05 ± 0.05%, ash; 1.81 ± 0.01%, crude fiber; 1.47 ± 0.02%, carbohydrate; 1.05 ± 0.04% and energy 34.27 ± 1.89 k/Cal/10 g (Olayemi *et al*., 2013).

Most indigenous vegetable seeds are acquired through the informal seed system where farmers rely on other farmers' saved seeds or his own save seeds. The cultivation, seed extraction process and storage of seeds are stages that seeds can easily be contaminated with wide range of microorganism which causes plant diseases and eventually crop loss. A seed with high physical, physiological, health and genetic quality has the potential of giving good yield. Among the various diseases that infect the crop is the jute leaf mosaic disease which causes defoliation. This reduce the photosynthetic area of the leaves causing reduction in leaf production and also unattractive for the market. Leaf mosaic disease is a vector borne, the pathogen spreads easily from one place to another through infected seeds and the vector is White fly (*Bemisia tabaci*).

2.3 Description of *Corchorus olitorius* (jute mallow) seed

Species from the Tiliaceae family are part of the 15 plant families with water impermeable seed (or fruits) coats-physical dormancy. This impermeability of the coat is caused by the presence of one or more palisade layers of lignified malphigian cells (macrosclereids) tightly packed together and impregnated with water-repellant chemicals. An anatomical structure in the impermeable layer(s) functions as the 'water gap' which closes at seed maturity and then open in response to an appropriate environmental signal. For germination to occur, the water gap is dislodged, thereby creating an entry point for water into the seed. Once open, water gaps cannot close. Since opening of the water gap is necessary for seeds with physical dormancy to germinate, this event indirectly controls when germination will occur (Baskin, 2003).

Sometimes harvesting is delayed to make the fruit dry on the plants to facilitate seed extraction process, certain varieties shatter and scatter seeds by themselves when fruits are left to dry on the field. Hard seed coat of jute mallow prevent it from germinating however during land preparation when farmers burn their fields, the seeds receive heat to break the dormancy and germination occurs after the first rains (Denton *et al*., 2013) and this the reason for unwanted crop plants or weeds in fields that are cultivated regularly (Copeland *et al*., 2001). The heat from the fire cracks the seed which makes it water permeable and this also occur to seeds of *Acacia* tree species (Walters *et al*., 2004).

There are indications that the position of fruit on the plant affect the germination capacity since seeds extracted from capsules at the top and middle of the stem are better than those from the base. Over ripe, black capsules collected from dry plants at the end of the season are reported to contain more seeds with dormancy symptoms than yellow or brown capsules (Emongor *et al*., 2004).

2.4 Constraints of production of indigenous leafy vegetables

Seed is that basic input required for food production and the quality of the seed affects the total yield. A good quality seed is characterized by its ability to germinate, free from pest and diseases causing pathogens, clean and true to type. Quality seed is one important input that farmers require to ensure food security, however, the seed can be of good or poor quality depending on certain factors. Such factors include time of harvesting the seed, processes that the seed producer adopt for seed extraction, how seeds are stored to ensure that viability is not deteriorated over time.

Indigenous leafy vegetables seeds production is usually under the informal sector where seeds are exchanged among farmers without meeting the minimum standard. Generally, ILVs have not received much study on breeding to get vegetables with qualities that goes beyond just consumption but rather longer shelf life and aesthetic value. Vegetable seeds production has been neglected by local seed producers and left at the mercies of seed importers. Seed producers focus and research more on staple food which is the concern of most investors and donors. Introduction of new technologies to improve crops especially the staple crops like maize, rice, cowpea, etcetera, threatens the vegetable seed production.

Farmers have little information on pest and disease management of ILVs so they tend to use chemical given by agro-chemical dealers to manage pest and disease.

2.5 Factors influencing quality of seeds

When it comes to good quality seed, many factors are considered to influence the seed. A good quality seed must have been produced from a healthy “mother plant”. The environment of the mother plant has a significant role to play in the life of the new seed being borne. When seed formation occurs during drought, seed coat becomes thick or hard which contributes to water impermeability thereby causing hindrance to germination. Some seeds carry seed borne pathogens which affect the germination and seed establishment. Seed borne diseases are usually transmitted from the mother plant to seed during seed formation. The mother plant provides the seed with enough food reserve to enhance energy for the new seed during germination and emergence.

2.5.1 Times of harvesting

Harvesting times affect the performance of the seed. When harvesting is done before seeds reaches physiological maturity, the embryo becomes immature and is not able to provide the required support for seed establishment.

2.5.2 Seed processing

Post-harvest handling and seed processing are usually done manual or mechanical. The manual method of processing mainly depends on human intelligence for selection and sorting which cannot be reliable. During sorting, disease may spread as a result of mixing healthy seeds with diseased ones unconsciously. Mechanical method of processing is solely the use of machine and equipment. When machines and equipment are not cleaned properly, the desired seeds may be mixed with undesired ones. This affects the physical purity of the seed by making the seed lot impure. During seed processing, seeds are dried to an extent that the seed moisture is enough to keep seed viable during storage.

2.5.3 Seed storage

The storage condition of seeds and the period of storage contribute to deterioration of seeds over time. When seeds reach physiological maturity, it has high seed vigour however the vigour deteriorates (Vijayakumar *et al*., 2019). During seed processing, mechanical damage such as broken and bruised seeds may serve as an entry point for disease causing organisms to cause deterioration to the seed. Seeds carrying disease causing pathogens can cause seedling mortality, decrease in germination and vigour. Seed borne diseases have the potential of transmitting disease to the soil thereby causing soil borne diseases (Solorzano *et al*., 2011). Pests like rodents and insects get access to storage rooms and feed on the seeds when storage structure is not properly constructed. This also affects the germination and vigour of the seed.

Factors such as temperature and humidity are important parameters to consider in the life of seed during storage. High humidity and temperature encourage the growth of pathogens that causes deterioration.

2.6 Seedling Vigour

Seed vigour is an important quality parameter that determines the potential for rapid, uniform emergence and development of normal seedlings under a wide range of environment (Geneve, 2005). According to International seed testing association (ISTA, 2015) after germination, the total properties that determines the activity and acceptable germination performance of seed lot on the field is seed vigour.

One of the factors affecting seed vigour is the storage environment and the length of time during storage. A poor storage condition such as moist environment, temperature, humidity and pest infested areas contributes to a drastic reduction in the ability of seeds to carry out all the physiological functions that allow them to perform better on the field. ISTA makes it clear that seed vigour is measured base on multiple concepts which include rate of germination and uniformity, seedling growth; ability of seeds to emerge under unfavourable field conditions as well as performance after storage (Savage and Bassel, 2015). Seed vigour could be related to the complex interaction between the genetic make-up of the seed and the environment.

The size of seed plays significant role in seedling emergence and subsequently in vigour performance. Larger seeds have enough food (carbohydrate) reserve therefore stand a better chance for seed to emerge and establish vigourosly as compared to their smaller counterparts with little food (carbohydrate) reserve.

Utilization of seed vigour is very critical in the life of any seed business because it gives the economic value of the seed even before the harvest time is reached. Commercial seed and crop producers are able to plan for their business base on the seedling vigour. Each seed is expected to establish and thrive well in the environment where it is found to produce high yield.

2.7 Overview of seed systems in Ghana

In Ghana, the formal seed system is headed by the Ministry of Food and Agriculture which is hosting the National Seed Committee and the National Seed Services. Research and development of seeds or varieties is however the mandate of research institutions such as those within the Council for Scientific and Industrial Research (CSIR) and the Universities. When conditions are accepted by the National Variety Release Committee, the variety is released and the research institute is mandated to produce the breeder seed. The Grains and Legumes Development Board (GLDB) then acquires the breeder seed to produce foundation seed. Hitherto, GLDB was the only organization mandated to produce foundation seed, but as a result of increasing demand for foundation seed, research institutions are now also allowed to produce foundation seed. Foundation seeds are then acquired by seed companies and seed growers to produce seeds that are certified for sale to agro-dealers, non-governmental organizations (NGOs) and in some cases directly to farmers or grain producers. The Ghana Seed Inspection Division of Ministry of Food and Agriculture (MoFA) is mandated to inspect and certify the production and distribution of foundation and certified seeds (Etwire *et al*., 2013). The relationship among stakeholders is presented in figure 1.

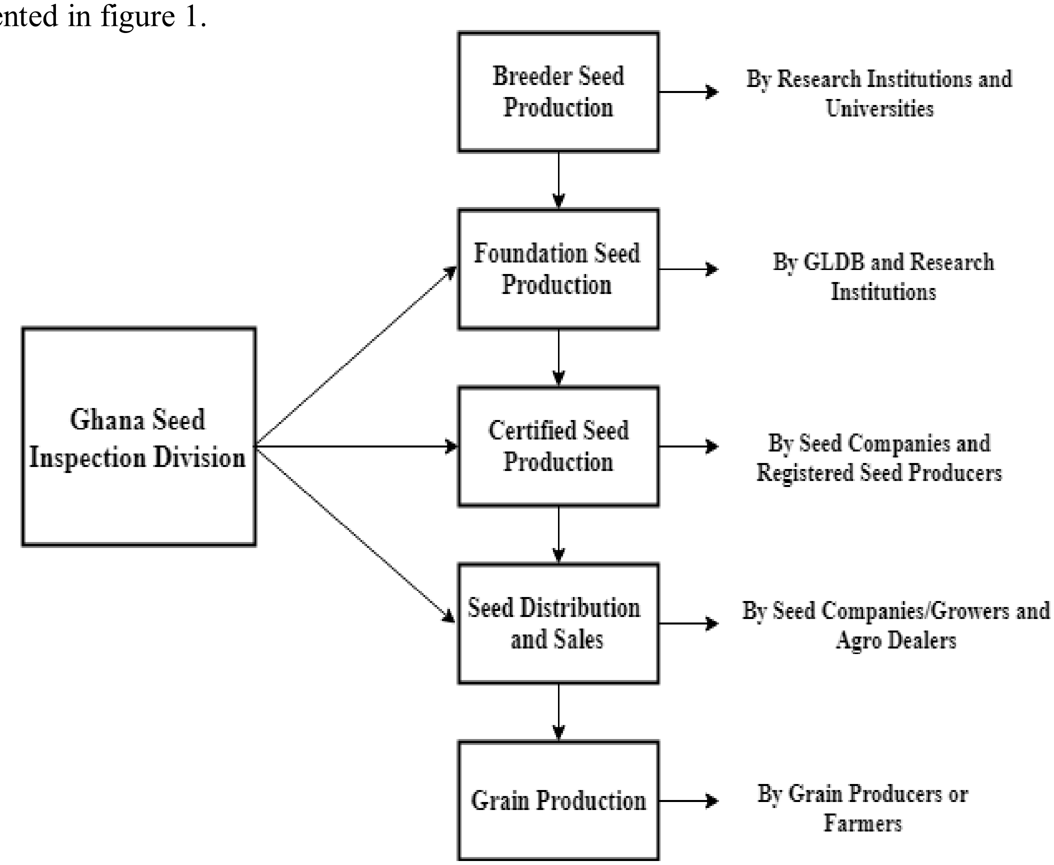

Figure 1: Flow chart of the formal seed sector in Ghana

The yield estimate is usually guaranteed by the formal seed producer however there is certified and improved seeds are inaccessible by small scale farmers in the hinterland and this is where the informal seed system fills in the gap. Farmers in the remote areas do not have the purchasing power to buy high quantities of improved seeds and this do not motivate seed companies to travel long distances to deliver few seeds because as a business profit is important to sustain the business. The standard procedure and regulations makes the formal system capital intensive and eventually make the cost of seeds from the formal seed sector more expensive as compared to the informal seed and small scale farmers do not have the resources to purchase the seeds. Though the quality of the seeds from the formal sector can be assured to be good due to the fact that the seed have gone through various tests by the regulatory bodies before certification, some seeds from the seed companies have poor quality. In most developing countries, certification agencies do not have enough funds and trained personnel to perform to work in the sector thereby reducing productivity in formal seed sector (van Gastel *et al*., 2002). In Ghana, the Ministry of Food and agriculture regulates majority of the formal seed system and this gives them higher workload reducing the timely delivery of services. The registration of seed growers, production, processing, packaging and certification of seeds are usually done at the regional level and in some regions there are no facilities for processing so seed producers transport their seeds to other places for processing which eventually increases their cost of production.

The formal seed system tends to focus on seeds of major crop seeds and sideline minor crops especially vegetables. In Ghana, vegetable seeds are either imported or produced by the farmer. The majority of smallholder farmers in developing countries select seeds from crops that look healthy and high yielding to preserve for the next planting season. The farmers exchange seeds among themselves through barter trade, as a gift, cash or as social obligation. The system has been in existence since man started hunting and gathering food (domestication).

The recycling of seeds reduces the quality of the seed drastically which affect the seedling emergence on the field, as well as vigor and eventually yield. Due to lack of structured regulations and institutions, the quality of the seed is uncertain. The genetic purity of the seed is gradually lost during the recycling as well as the health quality. Seed borne pathogens play very critical role in the performance of the crop, environment, humans and animals safety; seeds infected with mycotoxigenic fungi can initiate mycotoxin contamination, with adverse health effects for the population when affected produce is consumed (Van der Westhuizen *et al*., 2010). The informal system relies on nature hence do not prepare for pest and disease infestations and this brings huge loss when there is an attack. Seed borne pathogens put the soil at risk by transmitting pathogens into the soil which can increase the spread of disease.

The informal system plays very significant role despite its shortcomings, it is receiving support through developmental projects. These projects usually acquire foundation seeds for farmer groups in various communities and also provide inputs such as fertilizers and herbicides as well as technical backstopping with the aim increasing farmer's access to seed (Etwire *et al*., 2013).

One of the important attribute of good quality seed is that, the seed should be healthy seed, thus the seed should be free from any disease causing pathogen. Seed health plays a very key role when it comes to food security and food starts with healthy seeds. Unhealthy seeds do not only increase cost of production but the continuous use of chemicals on the crop to reduce pest and disease can be health threatening to both humans and animals.

During seed processing and storage, seeds are exposed to certain risk factors which could transmit pathogens onto the seed from the air, tools, farm or storage facility.

2.8 Seed dormancy of tropical small-seeded vegetables

Seed dormancy is that condition where seed refuses to germinate irrespective of making all germination conditions available, it is a form of survival mechanism for seeds to keep the crop from being extinct. According to Ndinya (2005), seed dormancy may be good for the seed as it may ensure that seed is kept alive over time, even when there is environmental stress (Ndinya & Ndinya, 2005). Seed dormancy may be exogenous, where the seed goes dormant due to the physical properties of the seed covering or endogenous (physiological) which is as a result of the inherent properties of the seed such as immature embryo. Physical dormancy is mostly as a result of seed coat modification, especially the outer integument layer of the seed that may become hard, fibrous or mucilaginous during dehydration and ripening (Emongor *et al*., 2004). The modification of the seed cover, thus the seed coat makes it impermeable to water thereby making germination difficult unless the seed cover is soften or scarify.

Seed dormancy in jute mallow *is* as a result of the hard seed covering (R Schippers *et al*., 2002). The inability of water getting into the seed due to the hard seed coat delays germination which is an important quality that farmers base on to accept seeds or reject seeds. To overcome poor germination, some farmers sow large quantities of seeds which increase their cost of production. Low seed quality and the high cost of seeds limit the use of seeds in large quantities resulting in the small scale production (Maina *et al*., 2011).

Temperature is considered to be one of the important elements required for seed to germinate. The impermeable seed coat of jute mallow put it in a state of dormancy until there is an environmental disturbance to break dormancy. No matter the amount of heat received by jute mallow seed during bush burning, seedling emergence occur after the first rains on the field (Denton *et al*., 2013). Temperature plays significant role in breaking seed dormancy such as using high temperatures to promote germination in impermeable seed *of Stylosanthes humilis and S. hamata (Fabaceae)*.

When unchill seeds of jute mallow was subjected to a temperature treatment of 25ºC, there was no germination but pre-chilling seeds for three days followed by temperature treatment above 35ºC resulted in 88% seed germination (Nkomo & Kambizi, 2009a). Dry heat treatment may dehydrate seeds causing death of embryo.

Previous studies have introduced several methods of breaking dormancy in jute mallow, they include exposing seeds to temperature above 30ºC after pre chilling enhances dormancy breaking (Nkomo & Kambizi, 2009a). Mechanical scarifications of seeds are able to create holes on hard seed surface which allows water and gaseous exchange within the seed to encourage germination. Mechanical scarification however may be suitable for bigger seeds. Chemical seed treatment such as the use of sulphuric acid, hydrochloric acid in treating some vegetables seeds has been successful in breaking dormancy. Treating jute mallow seeds with 98% sulphuric acid for 10, 20 and 30 minutes) increased germination significantly (Emongor *et al*., 2004). The use of Boiling water (100ºC) for breaking dormancy have been tried for several years however there could be high loss of seeds as a result of high temperature. According to Velempini *et al*., (2003) soaking jute mallow seeds in hot water can enhance germination but prolong soaking will drastically reduce germination to zero (Velempini *et al*., 2003). However, hot water may leach germination inhibitors to enhance germination. Whilst seeds of *Desmathus* spp did not germinate at all when seeds were steeped in boiling water for 15 minutes, on the other hand when fodder legume seeds were steeped in boiling water for 3 minutes there was 100% germination. Dry heat is also another successful method of breaking seed dormancy. For example, there was 70%

germination of sunflower seeds when exposed to dry heat for about 10 minutes at 100ºC (Akinola *et al*., 2000).

CHAPTER THREE

3.0 MATERIALS AND METHODOLOGY

3.1 Experimental sites

The experiment was conducted at the laboratory of Ghana Seed Inspection Division (GSID), (Pokuase-Accra) and the Pathology Laboratory of the department of Crop Science, University of Ghana. Viability, purity, germination and emergence tests were conducted at GSID. The seed health test was conducted at the Department of Crop Science of University of Ghana. Farmers at Ghana Atomic Energy (GAEC) were interviewed on seed handling, processing and production.

3.2 Source of material

Jute mallow seeds used for the study were farmer saved seeds and were purchased from Farmers' Friend, Madina- Accra. The seeds were tested for moisture, health, viability and purity to ensure that good quality seeds were being used for the study.

3.3 Seed viability test

Seed viability test was conducted by using Water floatation method. Two hundred and fifty milliliters (250 ml) of water was measured using measuring cylinder and poured into a beaker. One hundred and fifty grams (150 g) of seed was poured into the beaker containing water. The set up was left for one (1) hour. Base on the principle of specific gravity for separation of good seeds based on seed weight, viable seeds are usually heavier than unviable seeds. The viable seeds settled at the bottom of the glass beaker while the lighter seeds with other impurities floated on the water. The floated seeds were discarded while the whole and viable seeds settled at the bottom of the beaker. The viable seeds were taken out and spread out to dry under room conditions for two days. The viable seeds were weighed and deducted from the 150 g. The weights for the viable and unviable seeds were expressed in percentage (Denton *et al*., 2013).

3.4 Purity test

The aim of the purity test was to determine the percentage composition by weight of the seed being used. Two hundred grams (200 g) 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 few 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 seeds defined as seeds of other plants that may be present. Inert matter was the materials that were neither pure seeds nor other seeds. The various seed components were separated into small containers by using scrapers and weighed.

Purity percentage was calculated by dividing the weight of pure seeds by the total seed weight and multiplied by 100.

3.5 Moisture content test

Seeds were put in a weighing boat and weighed using a scale. One hundred grams (100 g) of seeds were poured into the digital moisture meter and calibrated to shallot seed. The calibration did not have jute mallow on the machine so shallot was used because it has similar seed size.

3.6 Seed health test

3.6.1 Preparation of Potato Dextrose Agar (PDA) medium

Using an electronic weighing scale, PDA powder was fetched with spatula onto a weighing boat and weighed (9.75 g). Two hundred and fifty milliliters (250 ml) of distilled water was measured using a measuring cylinder and transferred into a conical flask containing the PDA powder. The two components were mixed thoroughly by swirling. The conical flask was sealed with cotton and kitchen aluminum foil to prevent contamination. The conical flask was put in an autoclave at 121ºC for 15 minutes to sterilize the mixture. After sterilization the mixture was kept was used to test for the health of the seeds.

3.6.2 Health test

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 on the seed surface.

Two grams (2 g) 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.

3.6.3 Gram stain reaction

Gram stain test was done on to test for the pathogenicity of the bacteria. A drop of sterile water was placed on a microscope slide and the five-day culture was smeared on the slide, air dried and passing underside of the slide over a flame to fix the bacterium on the slide. The slide was then flooded with crystal violet solution and allowed to stand for 60 seconds and washed in a low current tap water for 5 seconds.

3.7 Seed treatments

Seeds were subjected to Ten (10) temperature treatment (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. Twenty grams (20 g) of seeds were placed in a beaker containing two hundred milliliters (200 ml) of twenty one degrees Celsius (21ºC) water for fifteen (15) hours (T1).Twenty grams (20 g) of seeds were place in a beaker containing two hundred milliliters (200 ml) of twenty one degrees (21ºC) water for fifteen (15) hours; after this it was placed in a pre-heated oven at seventy degrees Celsius (70ºC) for thirty(30) minutes (T2). Twenty grams (20 g) of jute mallow seeds were placed in a beaker filled with seventy degrees Celsius (70ºC) water for five (5) minutes (T3). Twenty grams (20 g) of jute mallow seeds were placed in a beaker filled with seventy degrees Celsius (70ºC) water for five (5) minutes after this, it was place in a pre-heated oven at seventy degrees Celsius (70ºC) for thirty (30) minutes (T4). Twenty grams (20 g) of seeds were put in a petri dish and placed in a refrigerator at five degrees Celsius (5ºC) for 24 hours (T5). Twenty grams (20 g) of seeds were put in a plastic bag and placed in a refrigerator at five degrees Celsius (5ºC) for 24 hours; after this, the seeds were put in a pre-heated oven at seventy degrees Celsius (70ºC) for thirty (30) minutes (T6). Twenty grams (20 g) of seeds were put in a pre-heated oven at (70ºC) for thirty (30) minutes (T7). Twenty grams (20 g) of seeds were put in a pre-heated oven at (80ºC) for thirty (30) minutes (T8). Twenty grams (20 g) of seeds were put in a pre-heated oven at (90ºC) for thirty (30) minutes (T9). Twenty grams (20 g) of seeds were not treated with anything (T10). For easy removal of seeds from beaker containing water; seeds were put in clean polyester cloth and seeds that were placed in the oven were put in a covered glass petri dish.

After the required time of each treatment, wet seeds were dried under a fan to remove all surface moisture to facilitate the picking onto filter paper for germination.

To ensure that there was no change in temperature when the oven door was opened, the oven was heated and opened to measure the change in temperature and that was two degrees Celsius (2^oC). Therefore, two degrees Celsius (2^oC) was added to the required temperature of the treatments. Petri dishes were taken out of the oven by using an oven mitt (Denton *et al*., 2013).

3.8 Germination test

Germination was done by using the top of paper method. Two pieces of filter papers were dipped into a beaker filled with two hundred milliliters (200 ml) distilled water. The filter paper was allowed to drip to the last drop and placed on top of 'rings'; a flat and circular plastic with holes to enable a wick through. A wick was passed through the holes of the 'rings' as a medium of moisture transfer to the filter paper. This was replicated four (4) times for each treatment.

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 7º0C 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

The ‘rings’ with the wet filter paper and wink were put onto the Jacobson tray and labelled. Fifty seeds of each treatment were sown on each filter paper and replicated four times making a total of forty (40) set-ups. The set-ups were covered with the bell jar and placed in a germinator. The germinator was switched to allow water to run in the system and ensure the wick was in the water for easy absorption. Germination card was fixed near the set up for easy recording in the germination room and the temperature was 28ºC. A temperature range of (15ºC-41ºC) is tolerable in jute mallow production. Jute mallow germinates 2-3 days after planting hence recording of daily germination counts started on the third day after planting for a total period of fourteen (14) days when most of the seeds had germinated. Radicle (root) emergence was used as the criterion for germination. On the 14th day, data was taken by selecting 10 seedlings randomly from each replicate. A meter rule was used for measuring the length of the seedling. The percentage germination was calculated by dividing the total number of seeds that germinated over the number of seed sown and multiplied by hundred (Denton *et al*., 2013).

3.9 Seedling emergence and seedling vigor index

The experimental design was completely randomized with three (3) replications. Sterilized sand was moistened with enough water but not wet. The moist sand was put in the germination box to about 3 cm thick. The sand was leveled with the long leveler and the excess was removed. Counting board was filled with seeds from each treatment; there were 100 seeds in each counting board. The counting board was put on top of the germination box and gently released to drop the seeds onto the surface of the sand. A handful of sand was sprinkled on the seeds to cover. Each box was labeled with a sticker. Germination box with the seeds were put in a room with ambient temperature. Each treatment was sown separately in the germination box and replicated three times. The set up was **i**rrigated 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 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 a product of seedling length and seedling emergence (Denton *et al*., 2013).

3.10 Survey on farmers' perception of handling jute mallow seeds for production.

Twenty (20) farmers were purposively sampled from the Ghana Atomic Energy Commission (GAEC) farms and interviewed one-on-one using the interview guide designed for this study (see appendix). The farmers were interviewed on the following:

- Source of jute mallow seeds
- How seeds were processed before storage?
- Under what Storage condition were jute mallow seeds stored?
- How long seeds were stored?
- What was done to break dormancy in jute mallow?
- Are seeds treated with anything before sowing?
- How are the seeds sown?
- How long does it take to germinate?
- Are jute mallow cultivated with other crops?
- How large was their field?
- Who were their main buyers?

CHAPTER FOUR

4.0 RESULTS

4.1 Seed viability and health of jute mallow seeds

Based on the principle of density, floatation method of seed viability test resulted in most of the seeds sinking and only a few floating. The viability test revealed that 92% of the jute mallow seeds were viable.

4.1.1 Seed Purity

Figure 2 shows the seeds of jute mallow before the purity test. The test revealed that 87% of the seed samples were pure jute mallow seeds and 13% were inert matter.

Figure 2: Seeds of jute mallow before purity test

4.1.2 Moisture Content

Seeds were tested to determine the moisture content using a digital moisture meter. Result of the meter reading indicated a moisture content of eleven percent (11%).

4.1.3 Health of jute mallow Seed

Out of one hundred (100) unsterilized seeds cultured, 10% were observed to carry fungal pathogens while 5% as shown in table 2 carried bacterial pathogens. However, all the one hundred (100) sterilized seeds carried no contaminants implying there were no seed borne pathogens present. Figure 3 shows the presence of bacteria and fungi growth observed when seeds were cultured in PDA for five (5) days.

Table 2: Presence of seed contaminants

Seeds	Quantity of seeds	Bacteria (%)	Fungi (%)
Sterilized seeds	100	5	10
Unsterilized seeds	100	0	0

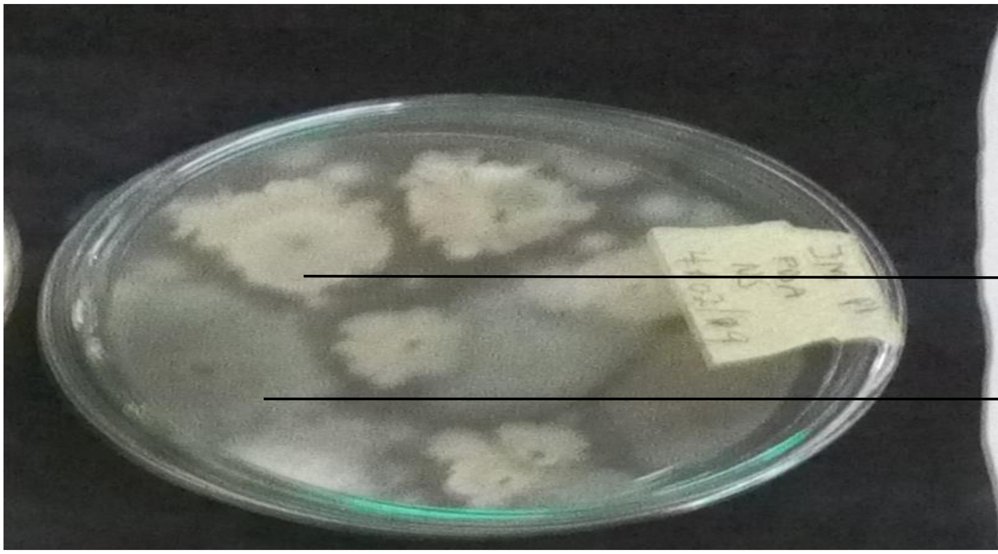

Figure 3: PDA culture of Fungal and bacterial growth on jute mallow seeds

Gram stain reaction of bacterial isolate was gram positive. The bacterial isolate was reddish thick long rod.

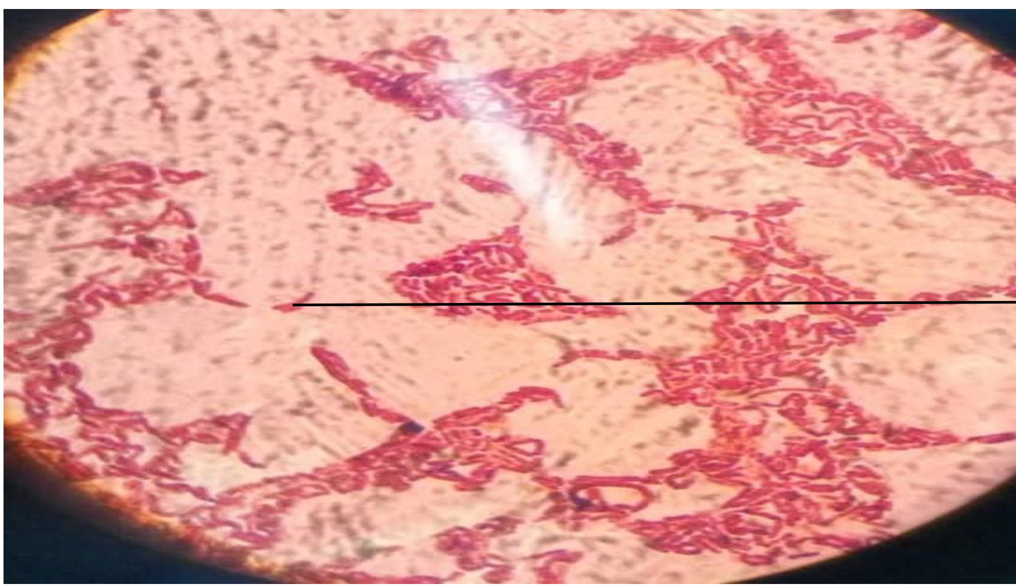

Figure 4: Gram stained isolate from jute mallow seed culture

4.2 Effect of treatments on percentage germination and emergence

Seeds that were treated with hot water and oven combination resulted in the highest percentage of germination of 92%, as well as highest emergence of 87% (Table 3). The control treatment or untreated seeds resulted in the lowest percentage germination of 2.5% and there was no seedling emergence.

Table 3: 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

4.3 Germination of jute mallow seeds as influenced by temperature treatments

Table 3 shows the effect of temperature treatments on seed germination. Some of the treatments evaluated increased germination significantly (P< 0.005) over the control whiles others did not show any significant difference at all. Seeds that were treated with hot water and heat combination (T4) produced the highest germination followed by seeds that were treated with hot water only (T3). Figure 5 shows the performance of hot water and oven heat treatment (T4) on germination. Seeds that were soaked in water at twenty one degrees Celsius (21ºC), that is T1 and the control (T10) produced the least germination.

Figure 6 shows the performance of seeds that were soaked in water at 21ºC (T1).

Table 4: Effect of temperature treatment on germination and seedling length of jute mallow seeds

Treatments	Germination	Seedling length
Soak seeds in at 21ºC water for 15 hours	2^{a} (0.14)	3.2^{a}
Soaking seeds in water at 21ºC + oven heat	26^{b} (0.53)	3.1^{a}
Hot water	61^{e} (0.09)	2.9^{a}
Hot water +oven heat	77^{f} (1.07)	3.8^{b}
Pre-chill seeds at 5ºC for 24 hours	7^{a} (0.23)	3.1^{a}
Pre chilling+ oven heat	49^{d} (0.77)	3.2^{a}
Oven heat seeds at 70ºC for 30 minutes	37^{b} (0.65)	4.1^{b}
Oven heat seeds at 80ºC for 30 minutes	43^{cd} (0.71)	3.1^{a}
Oven heat seeds at 90 ºC for 30 minutes	49^{d} (0.77)	2.7^{a}
Control	1^{a} (0.08)	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.

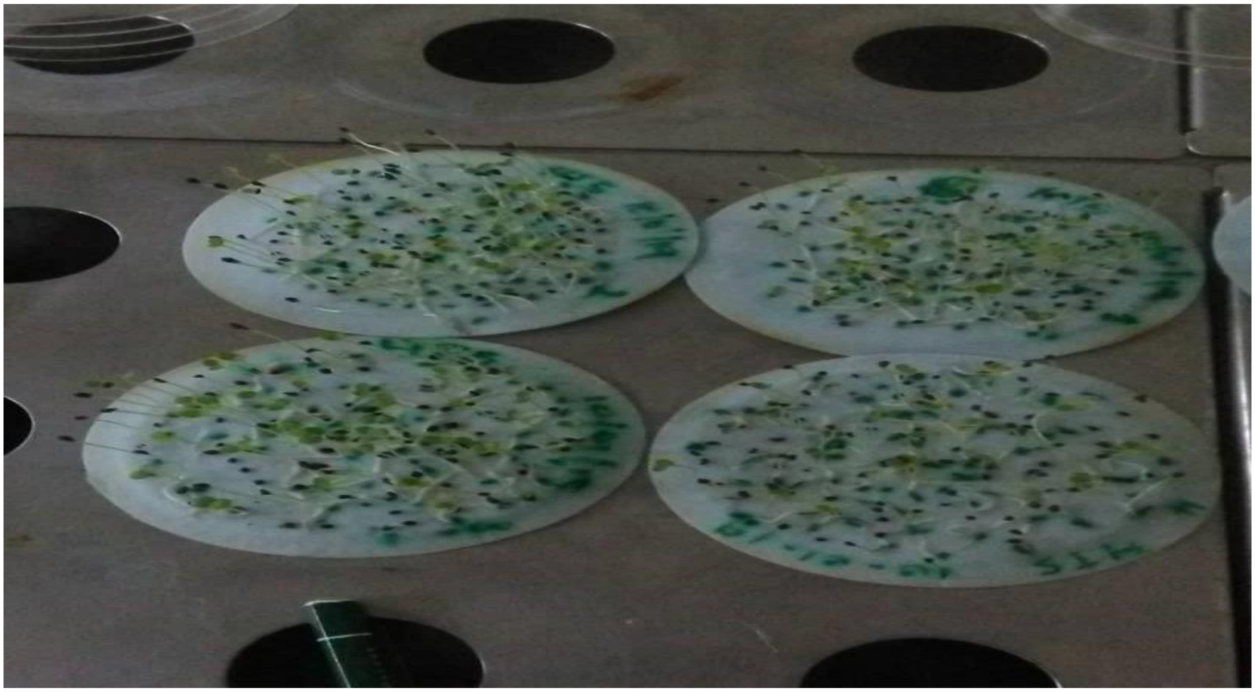

Figure 5: Germination performance of hot water and oven heat treated seeds

Figure 6: Germination performance of water treated seeds

4.4 Relationship between oven treatments and non-oven treatments on germination

Figure 7 shows the effect of oven heat treatment on jute mallow seeds germination. Seeds that were treated with hot water and followed with oven heat had the highest germination percentage as compared to seed that were treated with hot water. Seeds that were pre-chilled followed with oven heat had higher germination percentage as compared to seeds that were pre-chilled. Control produced the least germination percentage.

T1: soak seeds in water at 21^{0}C for 15hours, T2: Soak seeds in water at 21^{0}C for 15 hours followed by oven heat, T3: Hot water at 70^{0}C, T4: Hot water at 70^{0}C followed by oven heat at 70^{0}C, T5: Pre chill at 5^{0}C for 24 hours, T6: Pre-chill at 5^{0}C for 24 hours followed by oven heat at 70^{0}C, T10: Control).

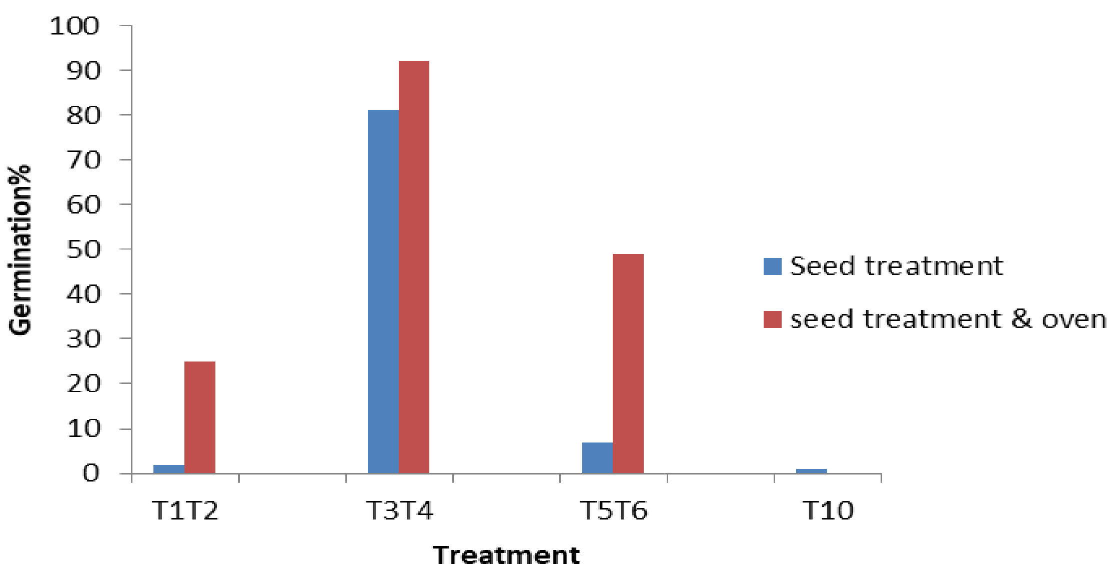

Figure 7: Seed treatment with and without oven heat

Increasing temperature by 10ºC was observed to give a rise in percentage germination. There was a higher increase in germination percentage when temperature was increased from 70ºC to 80ºC. However, the rise in germination percentage when temperature increased from 80ºC to 90ºC was not very high.

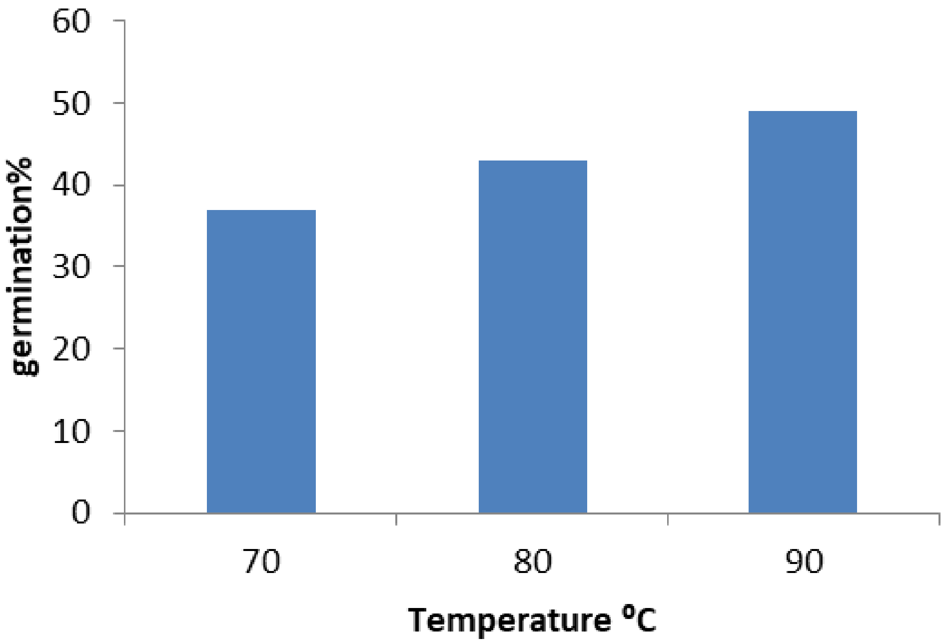

Figure 8: Effect of oven temperature on germination of jute mallow seeds

4.5 Germination rate of *Corchorus olitorius* as influenced by temperature treatments

The rate of germination following the temperature treatments showed that seeds that were dipped into hot water (T3), hot water + oven heat (T4), pre chill, soaked seed in water(T2) and seeds that were pre-chilled (T5) took the shortest days (Figure 9). They all germinated on the first day of germination count. Peak germination for T3, T4 &T5 was day 2 but peak germination for T2 was day 4.

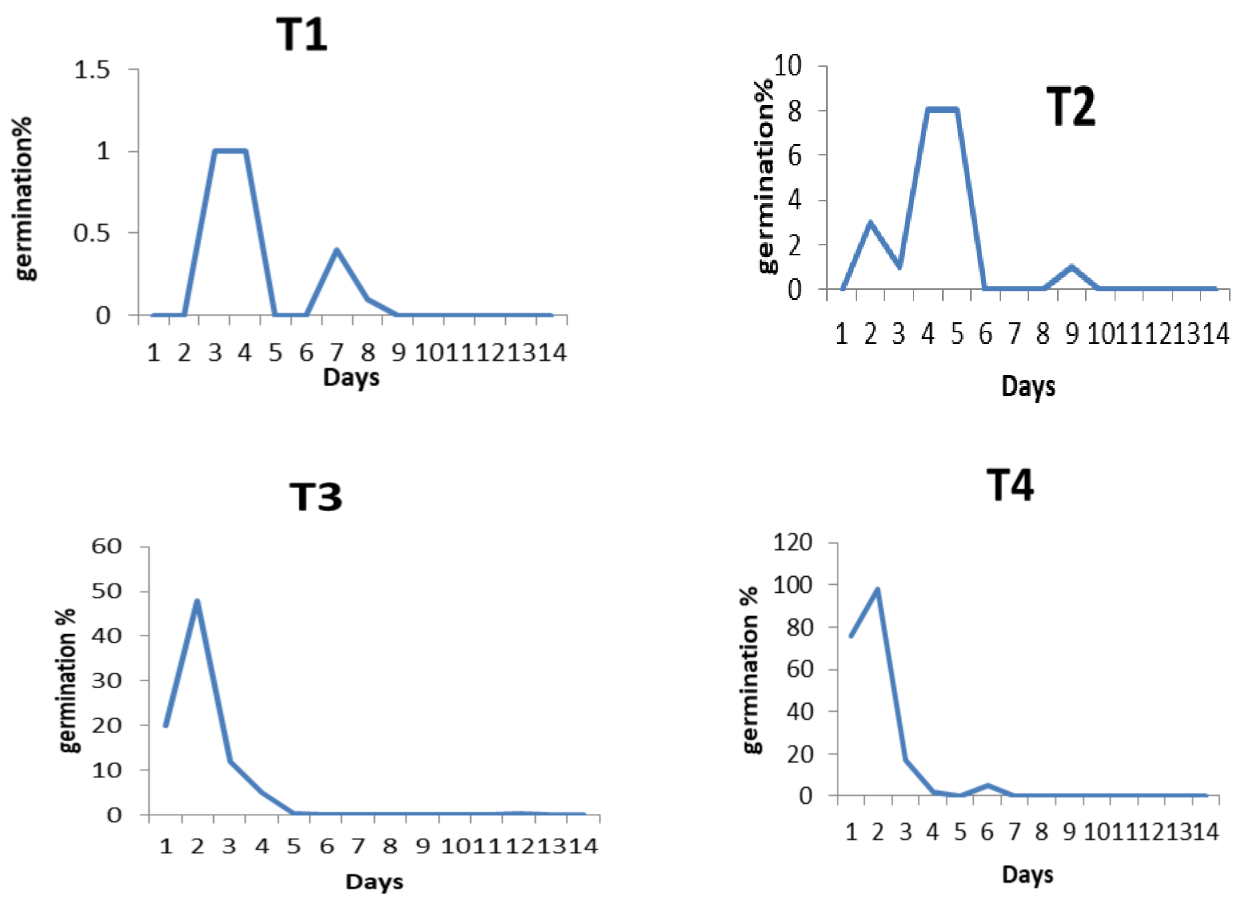

Figure 9: Germination rate of jute mallow following various heat treatments

(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 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).

The rate of germination following temperature treatments figure 9 showed that germination took longer time. Seeds that were oven heated at 70ºC (T7) germinated on day 5 with peak germination on day on day 8. Seeds that were oven heated at 80ºC (T8) germinated on day 6 with peak germination on day 9. Seeds that were oven heated at 90ºC (T9) also germinated on day 6 with peak germination on same day. Control (T10) was the last to germinate on day 10 and germination peak was on same day.

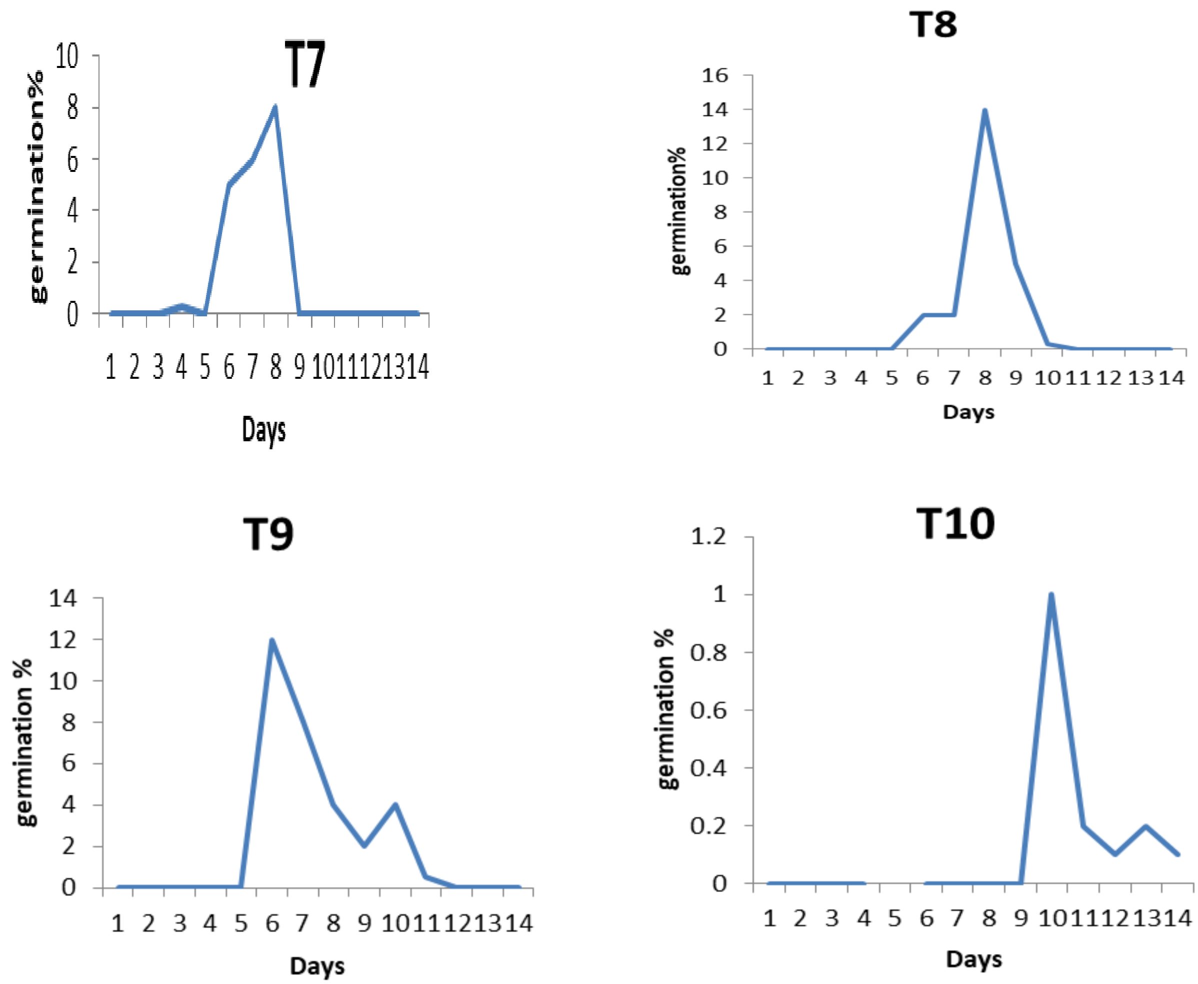

Figure 10: Germination rate of jute mallow following various heat treatments

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

4.6 Jute mallow seedling Vigor under different temperature treatments

Hot water followed by oven heat (T4) showed the highest seedling vigor index. The treatment with the least vigor index was the control (T10). Figure 11 shows the vigor index of germination

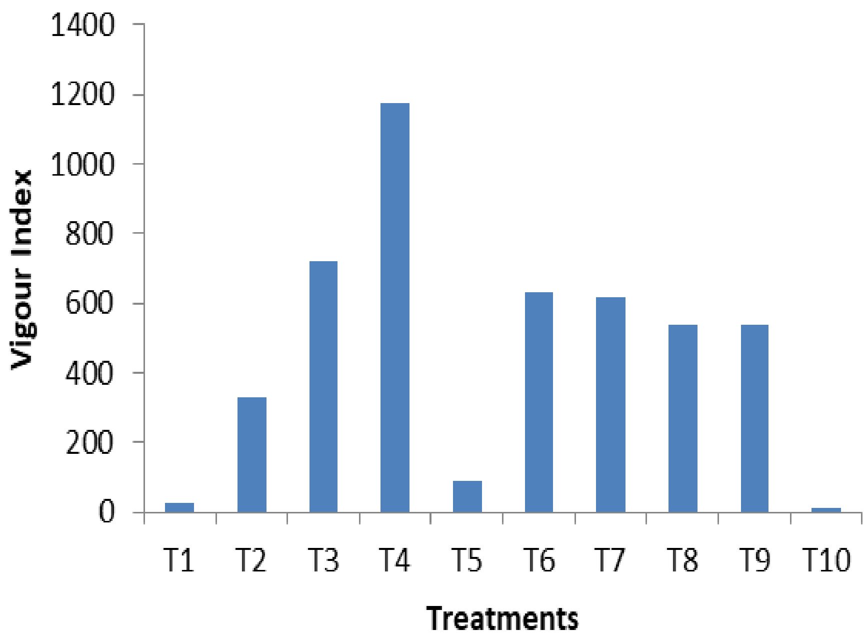

Figure 11: Vigor index of jute mallow germinated seedling as affected by heat treatment

4.7 Effect of temperature treatment on seedling emergence and vigor

The effect of treatments on seedling emergence was significant at ($P \leq 0.001$) (table 3). The effect of hot water and oven heat treatment (T4) was significantly different from all other treatments. Soaked seed in water at 21^{o}C (T1), pre chilled seed (T5) and control (T10) were not significantly different, however (T5) had the least effect on emergence. Treatment effect on seedling vigor was also significant ($P \leq 0.001$).

Hot water followed by oven heat treatment showed significant effect on seed vigour compared to all other treatments. Pre chilled seed treatment gave the least effect on vigor.

Table 5: Effect of temperature treatments on emergence, seedling length and vigor index of jute mallow seeds

Treatments	%Emergence	Seedling length	VI
Soak seeds in water at 21ºC for 15 hours	3[a] (0.17)	1.7 [b]	4 [a]
Soaking in water at 21ºC + oven heat	24[c] (0.51)	3.30 [d]	81[b]
Hot water	66[e] (0.93)	2.45 [b c d]	161[d]
Hot water + oven heat	75[f]	2.6 [b c d]	186[e]
Pre-chill seeds at 5ºC for 24 hours	3 [a](0.15)	0.65 [a]	3[a]
Pre chilling+ oven heat	42 [d](0.77)	2.5 [b c d]	108[c]
Oven heat seeds at 70ºC for 30 minutes	37 [cd](0.63)	2.96 [cd]	111[c]
Oven heat seeds at 80ºC for 30 minutes	36 [c] (0.73)	3.30 [d]	119[c]
Oven heat seeds at 90 ºC for 30 minutes	32[c] (0.76)	3.46 [d]	113[c]
Control	3 [a] (0.17)	1.93 [b c]	7[a]

[a]Means followed by the same Superscript along the column are not significantly different at 5 % significant level by Duncan Multiple range test.

Hot water at 70ºc followed by oven heating at 70ºc treatment (T4) had the highest vigor. Pre chilled seed (T5) had the least effect on seedling vigor. However, seeds soaked in water and control (T1&T10) gave poor seedling vigor. Figure 11 show the effect of treatments seedling vigor.

Results of the effect of treatments on seedling vigour of emerged jute mallow seedlings are represented in figure 12; T1 indicates soak seeds in water at 21⁰C for 15 hours, T2: Soak seeds in water 21⁰C for 15 hours followed by oven heat, T3: Hot water at 70⁰C, T4: Hot water at 70⁰C followed by oven heat at 70⁰C and T5: Pre chill at 5⁰C for 24 hours.

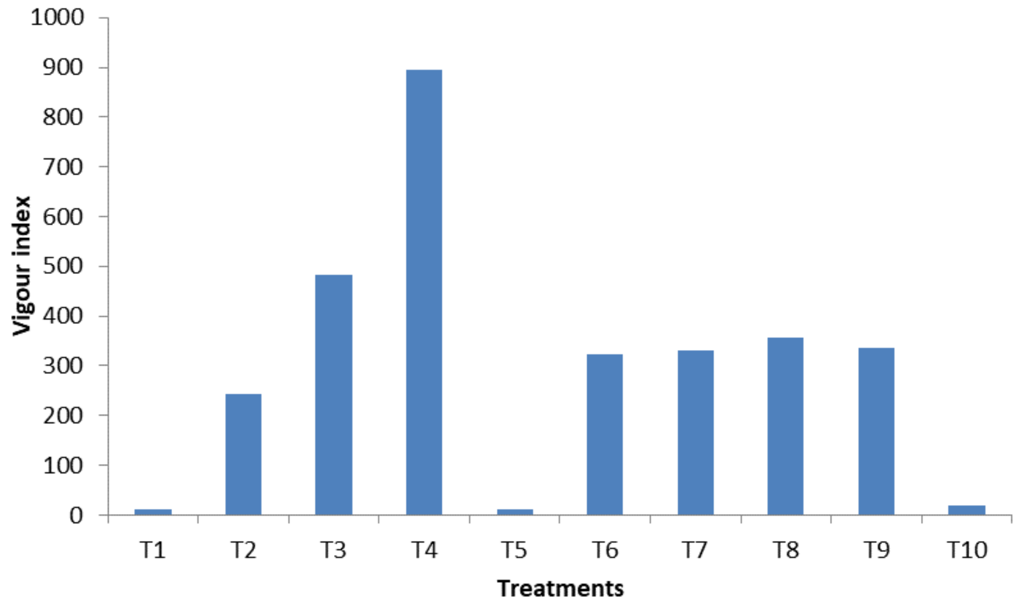

Figure 12: Effect of treatments on seedling vigour of emerged jute mallow seedlings

T6 indicates treatment of pre chill seeds 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 and T10 depicts the control.

4.8 Farmer perception of handling jute mallow seeds for production

4.8.1 Socio- demographic background of farmers

Majority of the farmers interviewed were males (80%) with few females (20%). Farming was not the main occupation of the males, the only used the farming as other source of income to support their primary source of income. The females depended on farming as their primary source of income hence the sell the vegetable at the market sometimes.

4.8.2 Sources of jute mallow seeds for production

Though there is demand for jute mallow all year round and seeds can be extracted and recycled, seed extraction and storage were not done by farmers (Figure 3). Most farmers (90%) acquire jute mallow seeds from the open market. Few (10%) farmers extract seeds but this is not a consistent activity, they do it once in a very long time. Farmers preferred to buy seeds from open market especially from Togo and Benin.

4.8.3 Knowledge of seed dormancy and strategies to enhance germination

All the farmers considered the hard seed coat as a challenge in jute mallow cultivation and concluded that seeds do not readily germinate when the seeds are not treated. Most (90%) of the respondents usually put the seeds in boiling water to enhance germination. Few (10%) respondents put the seeds in the water when it starts bubbling.

CHAPTER FIVE

5.0 DISCUSSION

5.1 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 there is always a crop to sell but it has 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 migrating from one crop to another. The presence of fungi on the seed but not within the seed indicated that the seeds could 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 when 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, ethylene are able to rid of the seeds 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 farmer save seeds did not go through any standard check therefore the potential yield loss as result of disease infestation in the life of the plant.

5.2 Seed moisture content and its effect on seed quality

Jute mallow are usually cultivated by farmer saved seeds which do not go through any standard process for certification therefore the seed quality may vary depending on the seed extraction and storage processes (Maina *et al*., 2017). Seed moisture content was 11 % which falls within the range given by (Tareq *et al*., 2015b) who reported that seed moisture content should be in a range of (11% -12.20%) , anything more than 12.20% will cause seed deterioration which can affect the general performance of the crop.

5.3 Farmers' Perception on small scale production of jute mallow seed

Generally, there is limited information on the seeds production of indigenous vegetables hence farmers recycle their own seeds for planting and this have been indicated in the work of other researchers (Adebooye *et al*., 2005; Maina *et al*., 2017) however, for jute mallow seed production in Greater Accra, the case was different. Farmers were not interested in extracting their own seed but preferred to purchase seeds from the open market specifically cultivars from Togo and Benin. This was because the local cultivars have broad leaves which gives consumers the impression of higher doze of fertilizer application compared with the foreign cultivar which have narrow leaves and looks more organic. This perception by consumers is as a result of the different species of *Corchorus* as reported by (Palada & Chang, 2003) that, the crop has more than fifteen (15) species and these species differ by leaf and fruit shape, stem colour, pubescence and branching and height. Though the seeds from these neighbouring countries may not meet the minimum standard (informal), farmers are willing to purchase them because of consumer preference.(RR Schippers, 2006) reported that absence of or limited research makes production, trade and consumption of indigenous and indigenised African leafy vegetables not to be limited within a nation but among nations in the continent.

Another reason for the farmers refusing to extract seeds locally is the frequent harvesting of the crop for sale which supports their primary income and this agrees with a reported by (Adebooye *et al*., 2005) who said African indigenous leafy vegetables are sources of income, food and traditional medicine. Also, as reported by (Palada & Chang, 2003) during harvesting the whole plant may be uprooted or the shoots are cut off with the leaves and this delays flowering and pod development which eventually makes it difficult for seed development. Since there is demand for the leaves and seeds are available in seed shops, seed production is not a priority to the growers.

Farmers' educational level played a role in understanding the significance of quality seed in their total yield and the overall business. The farmers did some form of record keeping on all expenses incurred during production however they were reluctant to record their income when they made sales. Though they quickly use the money to solve one issue or the other, they confidently, reported that they make profit. The farmers also included in their response that crop is usually not prone to pest and disease infestation thereby making it economically friendly to produce because they do not spend lots of money on disease and pest control; this agrees with Palada & Chang, 2003 who reported that the crop is affected by few diseases which can be controlled by the right cultural practices (Palada & Chang, 2003). The availability of ready market also ensures efficient and effective sales.

5.4 Efficient and effective methods of breaking dormancy on germination and seedling vigour 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 agrees with (Velempini *et al*., 2003); who reported that longer soaking times resulted 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 allows 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 is 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 (Denton *et* *al*., 2013). The difference in germination and emergence when temperature increased from 80⁰C to 90⁰C 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 seed soaked in water at 21⁰C 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 5⁰C 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 seed that were pre chilled with oven heat combination showed significant difference in germination, this agrees with (Nkomo & Kambizi, 2009b) who reported that germination occurred when seeds were exposed to temperature of 35⁰C 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 vigour" 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 21⁰C (T1), seeds soaked in water followed with oven heat (T2) and control (T10) produced low seed vigour. 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 vigour 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 with 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 rate decreased in the subsequent days. About 85% of the total seeds germination 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 21^{0}C 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 ineffective method of 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 (Maina *et al*., 2011).

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusion

Farmers' preferred foreign seeds to local seed of jute mallow, especially jute mallow seeds from Togo and Benin. 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 was 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.

6.2 Recommendations

A study is recommended to evaluate the performance of local jute mallow seeds against seeds from Togo and Benin. Further studies should be carried out to evaluate the leaf yield of seeds sown after hot water treatment and hot water with oven heat. Small scale jute mallow farmers should be encouraged to use hot water at 70ºC to treat seeds and dry prior to sowing while large scale producers could use a combination of hot water at 70ºC and oven heat at 70ºC to treat seeds before sowing. 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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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		

INTERVIEW GUIDE

UNIVERSITY OF GHANA

WEST AFRICA CENTRE FOR CROP IMPROVEMENT

SEED SCIENCE AND TECHONOLOGY

SEED BUSINESS MANAGEMENT

RESEARCH TITLE: Effect of Temperature Treatment on seed Germination and Seedling growth of Jute Mallow

My name is Abigail Kusiator and I am conducting this research as part of Research studies to understand how farmers source, store and treat their jute mallow seed to assure good quality for planting.

I plead for your assistance and cooperation to achieve this task. The study is purely for academic purposes.

SECTION A

DEMOGRAPHIC DATA

1. Name ....
2. Gender: Male ☐ Female ☐
3. Level of education:

   No School ☐ Primary ☐ Secondary/Vocational ☐

   Tertiary ☐ Adult literacy ☐

SECTION B

SEED AND PRODUCTION INFORMATION

4. What types of crops do you cultivate?

5. Do you cultivate *Chorcorus olitorius*?

6. How long have you been farming *Chorcorus olitorius*?

7. Where do you get seeds? a) Seed shop b) Other farmers c) Own seeds.....................................

8. Do you save seeds? a) Yes b) No

If yes, how do you extract your seeds?

9. At what time during the growing cycle do you take your seeds?

10. How long do you dry after extraction?

11. Do you check for seed moisture content? a) Yes b) No

If yes, how do you check for seed moisture content? ………………………………………………

12. How long do you store seeds?

13. What material do you store seeds in?

14. Where do you store your seeds?

15. Do you store *Chorcorus olitorius* seeds with other seeds?

16. Do you do anything to *Chorcorus olitorius* seeds before storing? a) Yes b) No

If yes, then why? ...

17. How do you know the moisture content of the seed is safe for storage? ....

…………………………………………………………………………………………………

…………………………………………………………………………………………………

18. Which planting method do you use? a) Nursery b) Planting at stake

19. Which sowing method do you apply? a) Sowing in drills b) Broadcasting c) Sowing at stake

20. How many seeds do you sow per hole?

21. Do you do anything to the seed before sowing? a) Yes b) No

If yes, what do you do?

....

What is the reason? ....

…………………………………………………………………………………………………

…………………………………………………………………………………………………

22. Do your seeds germinate readily and how many days after planting? a) Yes b) No

If no, why?...

If yes, how do you make them germinate? ………………………..

…………………………………………………………………………………………………

23. Do you know of other methods for breaking seed dormancy?

....

……………………………………………………………………………………………………....

……………………………………………………………………………………………………

24. Do you produce all year?

25. How large is your field?

26. How much do you produce?

SECTION C

MARKETING

27. Who are your main buyers?

28. Do you have demand all year round?

29. How do you market your seed?

Jute Mallow leaves with pods Source:(Palada & Chang, 2003)