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FACULTY OF AGRICULTURE AND ENVIRONMENTAL SCIENCE

Seed Emergence Response of African Horned Melon (*Cucumis metuliferus*) to Pre-Sowing Conditioning treatments.

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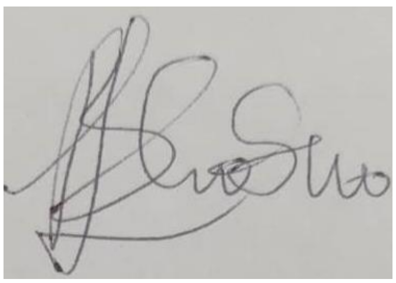
DECLARATION

I Leopold Bhobho, (B221370B) attest that this research report is entirely my own, independent work, and I have fully acknowledged all of the references and mentioned sources that I used. This report has never been turned in for a test or research.

Student's Signature:  Date: 16/09/2025

SUPERVISOR

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ABSTRACT

Because of its high nutritive value, the African horned melon (*Cucumis metuliferus*) is posed as an important crop for nutrition security globally. However, its productivity is constrained by poor and uneven germination. This current study aimed to establishing the optimal soaking and heat treatment pre-sowing seed treatments that can improve germination percentages and to reduce time that is required by the seed to germinate. The objectives of this study were to determine the role of soaking seeds in hot water on germination time and germination percentage and the role of heat treatment on seed germination time and germination percentage. The experiments were laid out in a randomized complete block design (RCBD), with 3 replications, with two factors (white and yellow coat accessions), with eight and sixteen treatments for two experiments. Results of the two experiments revealed significant interactions ($p<0.05$) between the accessions and either, heat and soaking treatment. Yellow accession reduced germination percentages with increased soaking duration and temperature while more-like similar tendencies were observed with the white accession but, both accessions shortened their germination times by a mean of two days. Results showed that pre-sowing treatment in warm water for more minutes and of high temperature not exceeding 60^{o}C, improves germination of *C. metuliferus*. Therefore, if such technologies are adopted by farmers, production of the micronutrient-rich crop can be boosted.

Keywords: *Cucumis metuliferus*, seed dormancy, pre-sowing treatments, thermal scarification, cucurbitacins, food security.

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LIST OF ACRONYMS

ANOVA: Analysis of Variance (statistical method)

DNA: Deoxyribonucleic Acid

DV: Daily Value (nutrition)

ELISA: Enzyme-Linked Immunosorbent Assay

Fe: Iron

HPLC: High-Performance Liquid Chromatography

IPM: Integrated Pest Management

K: Potassium

mg/100g: Milligrams per 100 grams

Na: Sodium

P: Phosphorus

PCR: Polymerase Chain Reaction

RBC: Red Blood Cell

1.0 INTRODUCTION

1.1 Background

Cucumis metuliferus, commonly known as horned melon is a member of the *Cucurbitaceae* family, notable for its adaptability to warm climates and arid conditions. This annual climbing herb grows optimally in subtropical climate (Bhowmick & Jha, 2022; Bock & Norris, 2016). Indigenous to the semi-arid regions of southern and central Africa, particularly Botswana, Zimbabwe, and Namibia, it has historically served as a vital dietary supplement for local communities due to its drought tolerance and nutrient-rich profile (Gwandure & Lukhele-Olorunju, 2023). The plant vigorously grows with habit of smothering or climbing anything near the crop. The vines can grow over 3 meters in length, with hairy leaves and stems, which likely deters herbivores (Macheka et al., 2022). The staminate flower matures about 10 days before the pistils mature, this is likely to promote cross pollination of the crop (Matsumoto et al., 2012). *C. metuliferus* has been proven to show traits which prevent it from hybridizing with other cucurbits of related families, this may likely be to maintain genetic purity (Semenya & Maroyi, 2019).

The horn-melon fruit has a colour range from green to yellow at maturity. It has an ellipsoid shape, covered with numerous horn-like protrusion. The fruits length ranges between 10-20 cm. the mesocarp contains a gelatinous, lime-green pulp housing numerous flat, cream-colored seeds. The sweet-tart blunt taste of the fruit has largely been the contributing factor governing its limited commercial appeal (Semenya & Maroyi, 2019). However, the crop has good storability characteristics, reaching up to 8 months with an intact physical and nutritional profile (Gwandure & Lukhele-Olorunju, 2023). The crop has been largely used for ornamental and decorative purposes due to its appearance (Kumari et al., 2022).

The horned melon is a source of a wide range of vital nutrients to human, among them vitamin C, vitamin A, dietary fiber, magnesium, iron and calcium (Kumari et al., 2022). The seeds are rich in lipids and proteins, 25–30% lipids and 12-10% respectively. The horned melon seeds has unsaturated fatty acids, which makes them a candidate for functional foods ingredient (Mallick & Masui, 1986). The pulp has antioxidants and phenolic compounds, useful for their anti-inflammatory and antimicrobial properties in vitro (Swaruparani & Shanmugam, 2024). The fruit has been traditionally consumed raw with its juice important for rehydrating the consumers, the pulp has been known to help with wounds and burns (Shopo et al., 2022). However, a trend of health consciousness has opened a whole range of applications of horned melon in this era, with the fruits being used in smoothies, salads, and cocktails. Further research has been exploring the fruit's applications as a natural thickener and colorant in dairy alternatives as well as its prebiotic potentials (Barin et al., 2023).

C. metuliferus has its seeds sheathed in a gelatinous pulp containing germination inhibitors, including cucurbitacins and phenolic compounds (Aparicio et al., 2021). Traditionally, the seeds were fermented in water for 48-72 hours, after which they are washed and dried. The method leverages microbial degradation of the inhibitors, and studies have noted a 20% to 65% boost in germination when the fermentation method is used (Bhowmick & Jha, 2022). Recently, some studies aimed at synchronizing horn melon germination used 0.2% potassium nitrate or gibberellic acid (Bock & Norris, 2016). To optimizing yields for *C. metuliferus*, nursery propagation is a viable option with the notion of transplanting seedlings guaranteeing a better field establishment (Ibrahim et al., 2014). However, it is labour intensive and unsustainable considering the crop is grown under rain fed conditions, this prompts the need for innovation and more sustainable options to overcome the barrier posed by poor germination characteristic of the crop.

1.2 Research problem

The African horned melon (*Cucumis metuliferus*), with its drought tolerance and high nutritional values, is constrained from widespread adoption by poor seed germination due to the presence of inhibitory substances in its gelatinous fruit pulp (Shopo et al., 2022). Although traditional methods of fermentation, which last 48 to 72 hours, enhance germination percentage (20-65%), their labor intensity restricts scalability and realize only modest gains in germination (Sharma et al., 2012). Contemporary chemical treatments, e.g., potassium nitrate, impart efficiency but pose economic and access constraints for smallholder farmers. It is necessary to enhance low-cost, farmer-friendly pre-sowing treatments that balance between effectiveness, scalability, and biotic stress tolerance, so this climate-smart crop can reach its potential in the food systems of sub-Saharan Africa.

1.3 Justification

Establishing optimal pre-sowing temperature and soaking treatments will be important for recommendation purposes to farmers, as short germination time helps in avoiding attack on the seed by soil microorganisms that courses plant diseases and high germination percentage is an important index for high yields. Optimal yields can only be realized if plant density is at optimal levels in the field. Besides, if seeds have lower germination percentages, usually farmers solve this by increasing sowing rates, which results in a negative bearing on production costs, as seed is expensive to buy.

1.4 Aim and Objective

1.4.1 Aim of research

To evaluate the effect of pre-sowing treatments on the germination of the African Horned Melon (*Cucumis Metuliferus*) seeds.

1.4.2 Objectives

i. To identify an optimal pre-sowing temperature treatment that promotes high germination percentages on *C. metuliferus* seeds.

ii. To identify an optimal pre-sowing water soaking treatment that promotes high germination percentages on *C. metuliferus* seeds.

1.4.3 Hypothesis

H_1: There is an optimal pre-sowing temperature treatment that promotes high germination percentages on *C. metuliferus* seeds.

H_1: There is an optimal pre-sowing water soaking treatment that promotes high germination percentages on *C. metuliferus* seeds.

2.0 LITERATURE REVIEW

2.1 History and distribution of Cucumis metuliferus

Cucumis metuliferus, widely known as the horned melon, belongs to the Cucurbitaceae family. This annual vine has a distinctive fruit, characterized by horn-like protrusions and has a hue between green and yellow at maturity. The fruit's gelatinous flesh has a lime-green colour with a tangy-sweet flavor evocative of passion fruit (Bogopa, 2017; Dane, 1983). Although some botanical literature claims that this species can be found south of a line extending from Nigeria to Sudan and Ethiopia, the primary diversity is far south (Maluleke et al., 2021). According to the South African Biodiversity Institute, the crop is native to sub-Saharan (Sibiya et al., 2020). In Zimbabwe, the fruit is traditionally harvested from wild or semi-cultivated stands, particularly in arid regions like Matabeleland, where it thrives in sandy soils (Chanza & Musakwa, 2022).

Globally, the horned melon has established itself as a nutritious fruit and an ornamental crop. Its commercialization was pioneered by New Zealand in the 1980s, with exports to Europe and North America (Jimam et al., 2010). Production had, by 2023, been expanded to Kenya, Israel, Australia, and the U.S. (particularly California), driven by the market for exotic fruits (Zhao et al., 2025). In Zimbabwe, the crop is not fully utilized but is increasingly popular due to its drought tolerance. A 2022 Zimbabwe Agricultural Growth Programme (ZAGP) report cited pilot schemes in Masvingo Province pinpointing horned melon as a climate-resilient crop for smallholder farmers (Gwandure & Lukhele-Olorunju, 2023). The fruit's high shelf life about six months at room temperature and ornamental value make it amenable to export markets, although infrastructure limitations hinder scale-up.

Fig 2.1 Shows the Cucumis metuliferus plant and fruit

2.2 Botanical Description of Horned Melon.

Horned melon (*Cucumis metuliferus*) is a vigorous annual trailing vine, often climbing over natural supports like bushes and trees in its native habitat. Its stems are notably thin, elongated, and covered in fine hairs, contributing to a rough texture (Awasthi, 2020; Bhowmick & Jha, 2022). These stems, radiating from a persistent woody rootstock, can extend up to 5 meters. The plant's vegetative structures exhibit a characteristic covering of stiff, spreading hairs that range from white to brown (Sibiya et al., 2020). Under cultivation, providing support is beneficial due to the vine's relatively weak tendrils. Leaves are dark green, heart-shaped, and feature shallow lobes on extended stalks. Unbranched, curling tendrils emerge from the leaf axils (Bhowmick & Jha, 2022; Zhu et al., 2021).

This monoecious species produces distinct male and female flowers. Bright yellow, funnel-shaped blossoms appear in the leaf axils, opening into five distinct lobes (Bhowmick & Jha, 2022). Female flowers possess a yellow corolla (typically 8–15 mm by 4–12 mm) and a distinctive green ovary approximately 20 mm long (Awasthi, 2020). This ovary is densely covered with dark green, fleshy spines tipped by stiff bristles and ultimately develops into the fruit. Male (staminate) flowers, often appearing slightly before the female flowers, form in small clusters usually with 1-4 flowers (Bhowmick & Jha, 2022; Ye et al., 2020). They feature a short, green to pale yellow corolla (5-13 mm by 2-8 mm), fused at the base, and are borne on stalks (Bhowmick & Jha, 2022; Ye et al., 2020).

The mature fruit is ellipsoid-cylindrical in form, reaching dimensions of 60-130 mm long by 28-94 mm wide (Jorge et al., 2022). Initially light green, the fruit undergoes a striking color change to bright orange upon ripening. Its outer surface presents a unique pattern of light, scribbly interlacing lines and is densely studded with stout, broad-based spines (6-14 mm by 2-5 mm) (Bizuneh et al., 2023). These fleshy spines terminate in sharp white or brown bristles. Internally, the ripe fruit contains translucent green, jelly-like flesh filled with numerous whitish seeds. This pulp offers a refreshingly fruity flavor, often compared to passion fruit (Cáceres et al., 2024). Unripe fruits remain dark green. The seeds are flattened and ellipsoid, generally remaining true to the parent plant unless cross-pollination occurs (Olennikov & Kashchenko, 2025).

2.3 Uses of Horned Melon

Horned melon fruit exists in distinct wild variants: notably bitter and non-bitter forms. The bitter type contains significant cucurbitacins – toxic triterpenoids rendering it unsafe for consumption (Olennikov & Kashchenko, 2025; Zhao et al., 2025). On the other hand, the non-bitter variant exhibits substantially lower toxicity and is cultivated globally. Despite cultivation, its inherent flavor is often described as mild or bland compared to popular cucurbits (Ye et al., 2024). However, selective breeding efforts, particularly in African nations like Botswana, Zimbabwe, and South Africa, are successfully developing sweeter cultivars (Gwandure & Lukhele-Olorunju, 2023).

This fruit holds considerable, yet underutilized, economic promise. Both the gelatinous pulp and edible seeds are consumed raw. Young, immature fruits can be prepared similarly to cucumbers, offering roughly double the nutritional value. To enhance its subtle taste when eaten fresh, the pulp is commonly sprinkled with sugar or salt and scooped directly. It also serves as a vibrant addition to tropical fruit salads (Chanza & Musakwa, 2022).

Beyond culinary applications, the fruit's high water content provides a valuable hydration source for humans and animals in arid regions (Mukherjee et al., 2022). Its striking bright orange appearance and prominent spines make ripe horned melon popular for ornamental decoration. The pulp and seeds are frequently blended into refreshing beverages (Shopo et al., 2022). This jelly-like flesh also functions as a flavorful topping for desserts like sorbet, yogurt, or ice cream. Interestingly, the pulp can even substitute for vinegar in salad dressings. All components – seeds, skin, and pulp – are edible (Jorge et al., 2022).

Traditional preparation methods include baking wild fruits whole (practiced in the Kalahari) or slicing and drying them for preservation (Zhu et al., 2021). Young leaves are also consumed, typically boiled and eaten like spinach. Critically, the presence of diverse amino acids, fatty acids, and volatile compounds in *C. metuliferus* positions it as a potential resource for combating malnutrition (Kumari et al., 2022).

Beyond its nutritional role, horned melon (*Cucumis metuliferus*) demonstrates significant potential within pharmaceutical applications (Kumari et al., 2022; Ye et al., 2020). This therapeutic value stems primarily from its diverse array of bioactive phytochemical constituents. The fruit synthesizes numerous secondary metabolites, underpinning its traditional use both as food and in managing various health conditions (Omokhua-Uyi & Van Staden, 2020; Sibiya et al., 2020). Key compounds identified include alkaloids, carbohydrates, cardiac glycosides, flavonoids, saponins, tannins, steroids, and terpenoids.

The pulp's richness in beta-carotene and vitamin A contributes critically to immune function support, maintenance of healthy vision (particularly night vision), and skin integrity (Aparicio et al., 2021; Jorge et al., 2022). Research indicates regular consumption elevates key hematological markers, including packed cell volume, haemoglobin concentration, and red and white blood cell counts (Rajaković et al., 2025). Seeds are notable sources of linoleic and oleic acids, associated with blood pressure regulation. They also contain potent antioxidants γ-tocopherol and α-tocopherol (vitamin E isomers). These compounds protect cellular structures; including red blood cells, skin, muscle tissue, nerves, and the heart-by neutralizing damaging free radicals implicated in cancer development and cardiovascular pathologies (Olennikov & Kashchenko, 2025; Ye et al., 2024).Extracts from the fruit pulp, particularly glycosides, exhibit anti-diabetic properties relevant to diabetes mellitus management. Isolated alkaloids demonstrate both antiviral activity and anti-ulcer effects (Mukherjee et al., 2022). The fruit's high zinc content may positively influence male fertility parameters, such as sperm count and motility.

2.4 Food Security and Nutritional Benefits.

The horned melon is a significant source of micronutrients such as vitamin C (5.3 mg/100g), magnesium (40 mg), and iron (1.13 mg) that are essential in the war against malnutrition in drought-prone regions (Olennikov & Kashchenko, 2025; Zhao et al., 2025). Recent research by the University of Zimbabwe has also shown high antioxidant content (lycopene and β-carotene), hence establishing a connection between its consumption and lowered vitamin A deficiency risks (Chanza & Musakwa, 2022). The fruit's high moisture content (89%) also assists with hydration in arid regions. NGOs like Nutrition Action Zimbabwe in 2020 introduced horned melon into school feeding to combat stunting and observed improved dietary diversity in children (Shopo et al., 2022).

Horned melon exists in two primary variants: a bitter wild type containing toxic cucurbitacins (triterpenoids), and a cultivated non-bitter form with significantly reduced toxicity (Lai et al., 2022). The edible non-bitter fruit exhibits a subtle flavor profile, occasionally noted as reminiscent of pineapple or banana. Nutritionally, it delivers substantial iron (32.88% DV), magnesium (22.14% DV), vitamin C (13.67% DV), phosphorus (12.29% DV), and vitamin B6 (11.31% DV) (Mukherjee et al., 2022). Secondary nutrients include vitamin A, B vitamins (B2, B3, B5), and beta-carotene. Bioactive compounds such as alkaloids, flavonoids, saponins, cardiac glycosides, and volatile oils occur in both seeds and leaves (Jorge et al., 2022).

The fruit's composition is dominated by high moisture content (≈90%), alongside moderate protein (≈10%), lipids (≈6%), and carbohydrates (≈45%) (Kumari et al., 2022). This elevated hydration level aligns with other cucurbits like cucumber (96%), melon (90.15%), and watermelon (92.6%), positioning horned melon as a critical water source in arid regions (Mukherjee et al., 2022).

Moisture percentage directly influences fruit shelf life, with levels typical of fresh produce at maturity. Despite its mild sweetness (sugars: 7.86g/100g), the fruit's vitamin C content surpasses cucumbers by 100%, though it provides only 30–50% of the vitamin C in fresh oranges (Umer et al., 2022). Pre- and post-harvest conditions significantly influence this nutrient's retention.

Mineral analysis reveals notable sodium (2mg/100g) and potassium (123mg/100g) levels. While sodium supports cellular water balance and nerve function, horned melon's low-sodium/high-potassium profile may aid hypertension prevention (Barin et al., 2023). Potassium further enhances fruit quality (color, size, drought resistance) and human health (stroke and heart disease mitigation) (Barin et al., 2023; López-Martínez et al., 2023). Phosphorus (37mg/100g) supports bone health and cellular regulation, with daily requirements achievable through moderate consumption. Most strikingly, iron content (1.13mg/100g) exceeds other cucurbits by 120–430%, making it a potent ally against anemia. A positive correlation between iron and potassium levels aligns with findings in other crops (Mukherjee et al., 2022).

Table 1 Shows nutritional Composition of *Cucumis metuliferus*/100g raw fruit (Šeregelj et al., 2022)

Nutrient	Amount	% Daily Value*
Macronutrients		
Carbohydrates	7.56 g	3%
Fat	1.26 g	2%
Protein	1.78 g	4%
Water	88.97 g	–
Vitamins		
Vitamin A (equiv.)	7 µg	1%
Beta-carotene	88 µg	–
Thiamine (B1)	0.025 mg	2%
Riboflavin (B2)	0.015 mg	1%
Niacin (B3)	0.565 mg	4%
Pantothenic Acid (B5)	0.183 mg	4%
Vitamin B6	0.063 mg	5%
Folate (B9)	3 µg	1%
Vitamin C	5.3 mg	6%
Minerals		
Calcium	13 mg	1%
Iron	1.13 mg	9%
Magnesium	40 mg	11%

Manganese	0.039 mg	2%
Phosphorus	37 mg	5%
Potassium	123 mg	3%
Sodium	2 mg	0%
Zinc	0.48 mg	5%

2.5 Challenges to Large-Scale Production

Field productivity remains comparatively low, particularly in wild populations. Like most cucurbits, yield and fruit quality respond acutely to irrigation schedules, planting dates, fertilizer regimes, and planting density (Lai et al., 2022). Pollination dynamics further constrain output. While honeybees serve as efficient pollinators, they exhibit low innate attraction to horned melon blossoms—visiting primarily when alternative floral resources are scarce (Kumari et al., 2022).

Disease resistance stands as a notable strength; the species demonstrates robust immunity against viral pathogens, wilts, and root diseases, making it commercially valuable as a cucumber rootstock (Kumari et al., 2022; Lai et al., 2022). Nevertheless, pest vulnerability persists. Whiteflies, spider mites, and aphids readily infest crops in warm, high-nutrient environments that promote succulent growth (Macheka et al., 2022). Agronomic limitations include its aggressive vining habit, which precludes intercropping, and fruit spines that necessitate protective gloves during harvest. Consumer acceptance faces hurdles due to the fruit's intimidating appearance, though sweeter cultivars in Zimbabwe, Botswana, and South Africa show market promise (Van Wyk, 2011).

Despite its hardness, horned melon is faced with agronomic constraints. Susceptibility to squash mosaic virus (SqMV) and fusarium wilt persists, and there have been outbreaks in Israel (Achikanu et al., 2020). Seed germination remains problematic due to inhibitory substances in the fruit mucilage. A 2021 Harare Institute of Technology study demonstrated that pre-soaking seeds in water for 48 hours before drying increases germination by 70% (Gwandure & Lukhele-Olorunju, 2023). Temperature sensitivity also limits farming to regions above 15°C, though Beitbridge greenhouse experiments suggest promise for extended growing seasons in 2020 (Chanza & Musakwa, 2022)

2.6 Strategies to Improve Germination.

2.6.1 Soaking Treatments.

Soaking of seeds is an ancient practice to rehydrate seed coats and break dormancy through the enhancement of water absorption and the leaching out of chemical inhibitors (Jorge et al., 2022). Farmers in Zimbabwe, particularly in arid regions like Matabeleland, have practiced soaking in water overnight to improve the germination of drought-tolerant crops like *Cucumis metuliferus* (Mutetwa et al., 2023). Recent studies emphasize the utilization of running water or boiling water for optimally enhancing the process. Boiling water treatments, like those the for *Prosopis* species, involve immersing seeds in boiling water and then cooling them slowly (Jorge et al., 2022). Effectiveness varies across species; a study contacted at Chinhoyi University of Technology found that soaking seeds for 24-hours in boiled water increased *C. metuliferus* germination by 40% in semi-arid Zimbabwean soils, while longer exposure reduced viability (Muthoni, 2024).

Research on litchi seeds in China demonstrated that soaking duration is an important consideration for germination. 54-hour soaks achieved full germination in some cultivars (Zhao et al., 2025). Similarly, trials in South Africa on marula (*Sclerocarya birrea*), a regionally significant tree, showed that 12-hour soaks improved germination by 60% (Maluleke et al., 2020). These findings demonstrate the need for species-specific protocols. For Zimbabwe, the Department of Research and Specialist Services (DRSS) now recommends varied soaking times (12–36 hours) for *C. metuliferus* depending on seed origin and prevailing regional climatic conditions (Sebati et al., 2024).

2.6.2 Temperature Scarification.

Heat scarification, which damages seed coats or deactivates inhibitors, is a low-cost method to enhance germination and destroy pathogens. In Nigeria, it noted that *C. metuliferus* seeds treated at 60°C for 30 minutes improved germination by 65%, but higher temperatures (120°C) were lethal to seeds (Usman et al., 2015). Similar results were achieved in Zimbabwean trials, where treatments at 60°C for 20–30 minutes enhanced germination by 50% in communal area farming fields (Mutetwa et al., 2020).

Heat treatments also reduce fungal seed-borne diseases. In recent studies it was demonstrated that treatment at 70°C for 15 minutes eliminated fungal pathogens in *C. metuliferus* seeds without impacting viability (Usman et al., 2015). Excessive heating (>80°C) will, however, embrittle seeds and particularly in those with low initial viability. Local studies on African acacias, such as *A. sieberiana*, have indicated species-specific limits; in *C. metuliferus*, the optimum temperature range is 50–70°C (Owino & Gichimu, 2020).

2.6.3 Physical Scarification.

Physical scarification is the mechanical breaking or weakening of seed coats to allow water absorption, usually applied to hard-coated seeds like *Acacia, Cassia, and Sesbania* (Olarewaju et al., 2021). Nicking by hand with tools like nail clippers is effective for large seeds but time-consuming, requiring precision to avoid injury to the embryo. Smaller seeds, such as sedge seeds, are often bulk scarified using sandpaper, a technique susceptible to uneven results (Mutetwa et al., 2023). While untested in *C. metuliferus*, recent studies explored sandpaper scarification in indigenous cucurbits. Muthoni (2024), found light sanding seed coats of *C. metuliferus* enhanced germination by 35% compared to non-treated seeds. Another success in South Africa was with *Citrullus lanatus* (wild watermelon), where sandpaper scarification reduced germination by 10 days (Diouf, S, 2023).

2.6.4 Chemical Scarification.

Chemical scarification using reagents like sulfuric acid (H_2SO_4) is used for species that have impermeable seed coats or stony endocarps. Acacia and Leucaena are frequently treated this way, with treatment duration varying with species and seed origin (Usman et al., 2015). Safer alternatives are now emphasized in the literature, such as citric acid or hydrogen peroxide, particularly for small-scale farmers. The Scientific and Industrial Research and Development Centre (SIRDC) in Zimbabwe experimented with 10% H_2SO_4 on *C. metuliferus* seeds in 2018, with 80% germination in 14 days (Mutetwa et al., 2023). Nevertheless, longer exposure (>15 minutes) destroyed embryos, revealing the requirement for accuracy. A Kenyan study of *Vigna unguiculata* (cowpea) in 2021 concluded that 5% acetic acid for 20 minutes was as effective as H_2SO_4 without the risk of toxicity (Mali & Chavan, 2016). For *C. metuliferus*, pilot studies are recommended for calibration of concentrations since seed coat thickness varies for African accessions (Omokhua-Uyi & Van Staden, 2020).

3.0 CHAPTER THREE: MATERIALS AND METHODS

3.1 Experimental site

The experiment was conducted in the Biological Sciences laboratory of Bindura University of Science Education, Astra Campus. It lies at an altitude of 1109.35m above sea level and latitude of 17°18.1152´ South, and longitude of 31°19.8336´ East. The area is on a transitional zone Natural Region IIb and it receives an average annual rainfall of 700mm/annum. The area also experiences some high temperatures of about 28°C during the cropping season and low temperatures of about 5.5°C.

3.2 Design

The research was done in two separate experiments: (i) testing the effect of soaking seeds in warm water on germination time and germination percentage; and, (ii) testing the effect of heat treatment on seed germination time and percentage. Both experiments used same plant material, thus two accessions of horned-lemon, yellow coated seed and white coated seed.

3.2.1 Experiment 1

To evaluate the effects of genotype and hydro-thermal priming on germination physiology a factorial approach was used. The experimental matrix assessed two principal variables: (1) *C. metuliferus* accession identity (two phenotypically distinct seed lineages), and (2) hydration exposure intervals (four precisely timed soaking durations in heated aqueous medium). Their full combinations gave 8 treatments, as shown in Table 3.1. Each treatment group comprised seeds placed on moisture-saturated cotton wool within petri dishes. To minimize spatial heterogeneity, a randomized complete block design (RCBD) with 3replications was used. Germination was tracked through daily observation, with two parameters assessed: temporal germination efficiency, recorded at daily interval until radical emergence ceased within each replicate (Days to Complete Germination/DCG), and reproductive viability, calculated at the 18th day as the proportion of viable seeds achieving successful emergence relative to initial population density (Final Germination Percentage/GP).

Table 2 Shows treatment structure for the soaking pre-sowing treatment

Treatments	Factor A (accessions)	Factor B time for soaking(Minutes)
1	a	0
2	a	20
3	a	40
4	a	60
5	b	0
6	b	20
7	b	40
8	b	60

3.2.2 Experiment 2

This investigation employed a factorial experiment to evaluate two critical biological variables influencing *C. metuliferus* germination dynamics. The primary experimental factors comprised: 1) seed coat pigmentation (Accession A: yellow-coated seeds versus Accession B: white-coated seeds), representing distinct phenotypic expressions within the species, and 2) thermal environment (six temperature regimes). Their interaction gave 12 treatment groups, as shown Table 3.2. A randomized complete block design (RCBD) with 3 replications for every treatment was done. Two germination response parameters were recorded: Days to Complete Germination (DCG), defined as the elapsed duration until no further radicle emergence occurred within a replicate, and Final Germination Percentage (GP), calculated at the 18th day as the proportion of viable seeds exhibiting radical protrusion relative to the initial population of seed.

Table 3 Shows treatment structure for the heat treatment pre-sowing treatment

Treatments	Factor A (accessions)	Factor B (Temperature and time of exposure)
1	a	30 degrees for 30 mins
2	a	30 degrees for 60 mins
3	a	60 degrees for 30 mins
4	a	60 degrees for 60 mins
5	a	90 degrees for 30 mins
6	a	90 degrees for 60 mins
7	b	30 degrees for 30 mins
8	b	30 degrees for 60 mins

9	b	60 degrees for 30 mins
10	b	60 degrees for 60 mins
11	b	90 degrees for 30 mins
12	B	90 degrees for 60 mins

3.3 Procedure

Following soaking and heat applications, seeds were positioned on moist cotton wool. For each pretreatment, fifteen seeds per accession germinated under light conditions (10 seeds/dish) while five seeds per accession germinated in darkness (5 seeds/dish). A single control group served both experimental sets. Table 4 details the complete factorial design: Experiment 1 tested soaking durations (0/20/40/60 minutes) with 30 seeds per treatment across two accessions. Experiment 2 evaluated thermal exposures (30°C/60°C/90°C at 30/60-minute intervals) with 30 seeds per treatment combination. Total n=120 (Exp1) and n=180 (Exp2) seeds.

Table 4 Shows seed Treatment Plan for C. metuliferus Germination Experiment

Experiment	**Treatment**	**Number of Seeds per Accession**	**Total Seeds (2 Accessions)**
Experiment 1: Soaking Treatment	Control (No Treatment)	15	30
	Soaked for 20 minutes	15	30
	Soaked for 40 minutes	15	30
	Soaked for 60 minutes	15	30
Total (Exp. 1)		**60**	**120**
Experiment 2: Heat Treatment	30°C for 30 minutes	15	30
	30°C for 60 minutes	15	30
	60°C for 30 minutes	15	30
	60°C for 60 minutes	15	30
	90°C for 30 minutes	15	30
	90°C for 60 minutes	15	30
Total (Exp. 2)		**90**	**180**

3.4 Data collection

Radicle emergence was documented at critical developmental intervals, specifically on days 6, 9, 10, 11, 12, 15, and 18 post-treatment initiation. Germination success was operationally defined as the visible protrusion of a radicle exceeding 2 mm in length, consistent with standardized viability metrics established in foundational literature (Aliero & Gumi, 2012). Daily inspections used magnifying lenses to verify morphological thresholds, with ambiguous cases subjected to triplicate verification by independent technicians. This phased monitoring strategy captured nonlinear germination kinetics while minimizing observational bias during rapid growth phases.

3.5 Data analysis

Analysis of variance was done using R studio version 4.1.0. Least Significance Difference (LSD) at $P<0.05$ will be used to separate means. Bar and line graphs showing interaction between treatments and seed germination will be plotted using Microsoft Excel 2010 Edition.

4.0 CHAPTER FOUR: RESULTS

4.1 Effect of soaking on days taken to complete germination and germination percentage

Soaking in hot water had significant effect ($P<0.05$) on the germination rate of *Cucumis metuliferus* with treated seeds germinating, on average, two days earlier than controls (Tables 4.1, 4.2; Figure 4.1). Control seeds germinated as long as 14 days, while 20, 40, and 60-minute soaked seeds germinated within 12, 11, and 10 days, respectively. However, germination percentage varied between accessions: the yellow accession had higher viability in non-treated seeds (70%), decreasing to 60% (20 and 40 minutes) and 50% (60 minutes) with increased soaking time. In contrast, the white accession had increased germination after soaking, from 40% in non-treated seeds to 55%, 70%, and 75% after 20, 40, and 60 minutes soaking, respectively (Figure 4.2). These results highlight accession-specific responses to hydration, since the yellow seeds were more prone to prolonged soaking, while the white seeds enjoyed increased exposure to water.

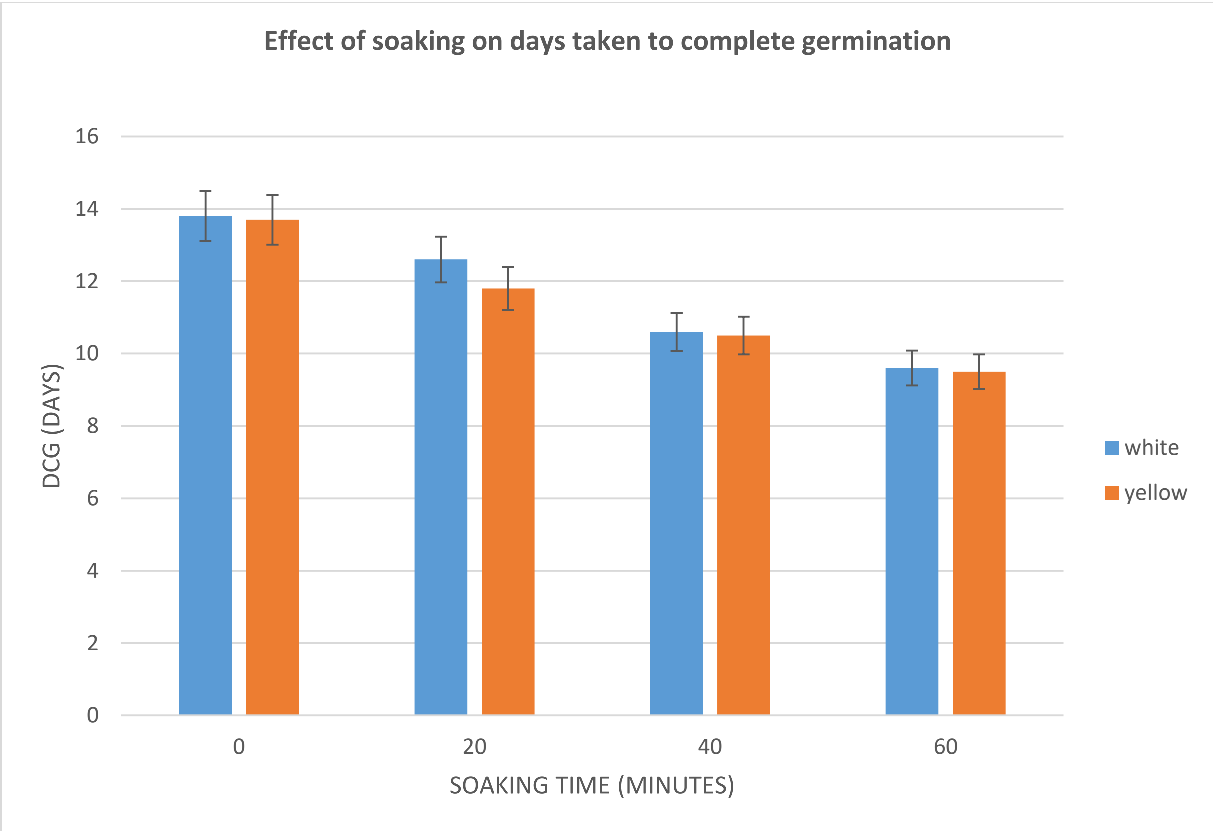

Fig 4 1: Shows effect of soaking on days taken to complete germination. DCG = days to complete germination. Blue represents white-colored accessions while brown represent the yellow-colored accessions

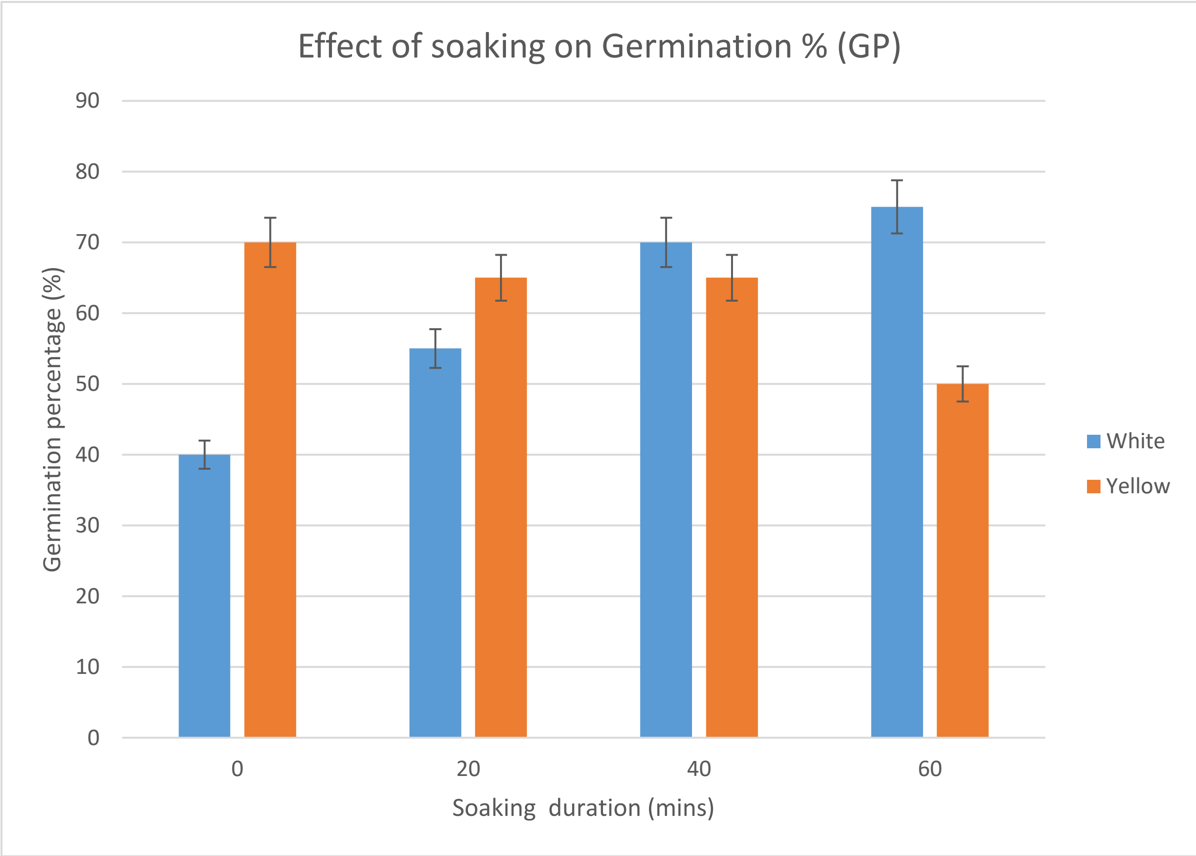

Fig 4 2 Shows effect of soaking on germination percentages. GP = Germination percentage. Blue represents white-coloured accessions while brown represent the yellow-colored accessions

4.2 Effect of heat treatment on days taken to complete germination and germination percentage

Heat treatment showed a significant effect ($P<0.05$) on seed germination of *C. metuliferus*, bringing the germination period two days closer than non-treated controls for both yellow and white accessions (Figure 4.3). However, the asymmetry in percentage germination reflects differences between accessions: untreated yellow seeds and seeds heated to 30°C, for 30 minutes exhibited the greatest germination at 70%, while prolonged or higher temperatures (e.g., 90°C for 60 minutes) resulted in 0% germination. By contrast, the maximum germination for white seeds reached 80% (30°C, 30 minutes) and 70% (60°C, 30 minutes) but remained at 40% in controls.

Extreme heat (90°C) drastically compromised the germination of both accessions, with the white seeds exhibiting 20% (30 minutes) and 0% (60 minutes) germination, corresponding with a decline for yellow seeds (Figure 4.4). Accession-dependent responses to thermal stress were therefore observed, balancing enhanced germination and low viability at elevated temperatures.

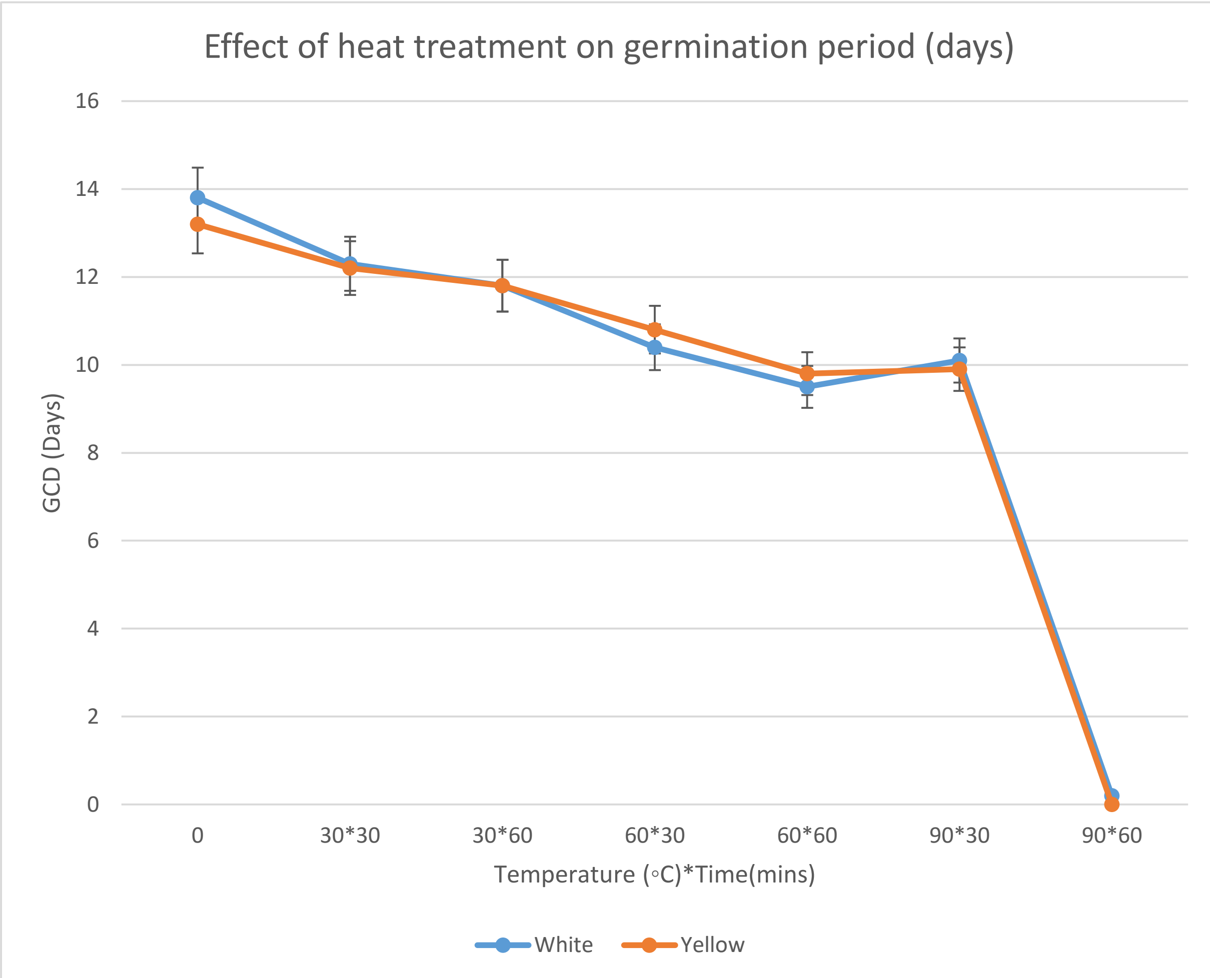

Fig 4 3 Shows effects of heat treatment on germination period. DCG=Days to complete germination

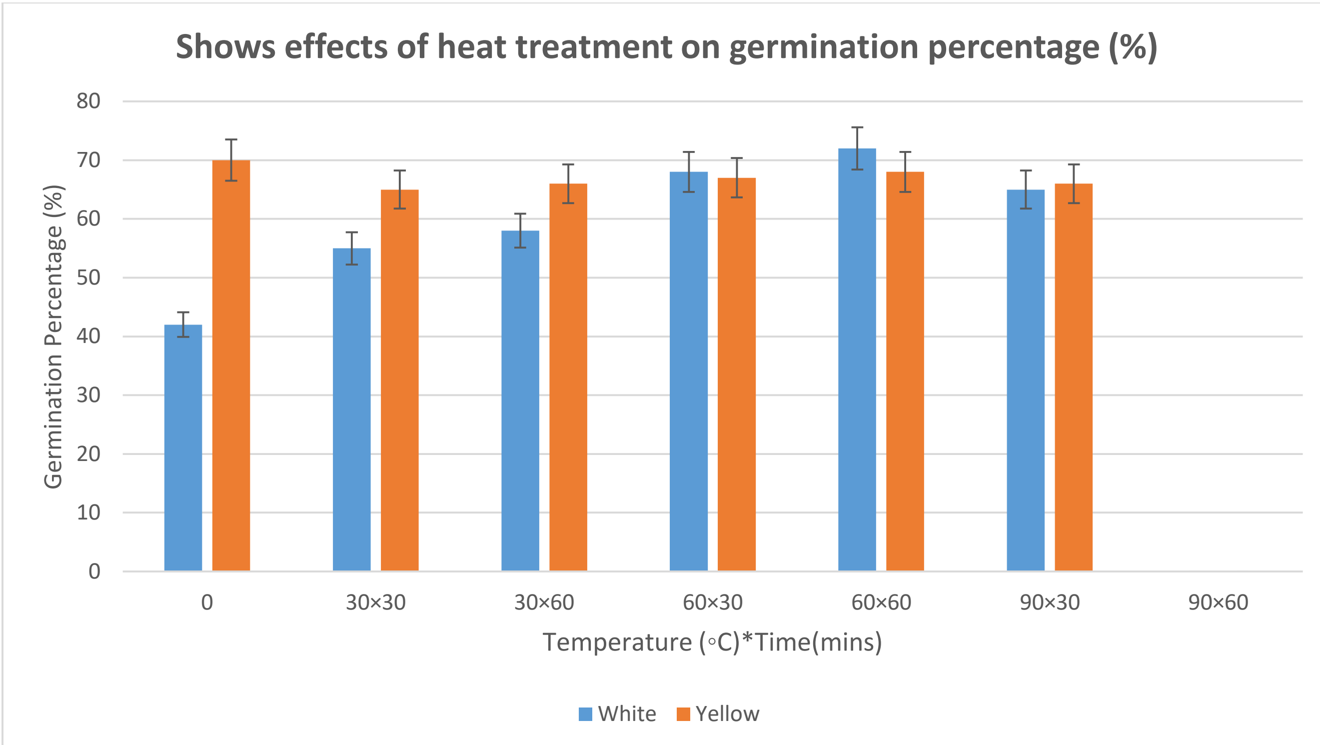

Fig 4 4 Shows effects of heat treatment on germination percentage. GP= germination percentage.

5.0 CHAPTER FIVE: DISCUSSION

5.1 Soaking treatment

These findings indicate that *Cucumis metuliferus* seeds were quite responsive to presowing treatments, with soaking duration and temperature of heat treatment established for the two accessions tried. Careful soaking period in warm water for 30 to 60 minutes and heating treatments at temperatures not exceeding 60 degrees Celsius were successful for both yellow-colored and white-colored accessions. These corroborate previous studies on the role of moisture and temperature in breaking seed dormancy and improving germination (Ye et al., 2020).

The soaking experiment demonstrated the fact that warm water soaking interacted to seed germination significantly ($p < 0.05$), as indicated in Figures 4.1 and 4.2. The processing duration for germination occurred between the two accessions similarly responding to soaking. The treated seeds germinated much earlier than those controls in one particular category. Seeds soaked for 60 min had the shortest period of germination: 10 days. This coincides with the finding of Mutetwa et al (2020), that indicated moisture softening the seed coats so as to allow for mucilage radicle emergence and hastened germination. Also, the blocking effect by light exposure had the difference in germination timing. Seeds germinated under light conditions (on the laboratory table) germinated one to two days earlier than those germinated in darkness (inside the laboratory beaker board), which, in turn, emphasizes the role of light as a germination trigger for *C. metuliferus*.

The germination of both accessions had different germination responses to soaking; however, they had different germination percentages. Germination percentage kept decreasing with increasing soaking time for this accession with yellow color; untreated seeds recorded the highest germination percentage (70%), which fell to 50% when the seeds were soaked for 60 minutes. This implies either inherently low viability of this yellow accession or loss of seed viability because of prolonged soaking, usually associated with either damage of seed coats or microbial activity (Bogopa, 2017; N. Maluleke & Koopa, 2021). This did induce in the white accession the opposite direction, as the germination percentages increased from 40% in untreated seeds to 75% soaking for 60 minutes. This, therefore, means, that much moisture content actually is further beneficial for optimal metabolic activities and probably radicle emergence.

The moisture and light roles of germination of seeds. Water is the most important requisite for seed germination because it facilitates the diffusion of oxygen through the softened seed coats, a process which is less effective in dry seeds (Ali, 2020; Zhu et al., 2021). But somehow, too much of it is not healthy to moisture-sensitive accessions as it leads to seed rot and, thus, its viability is reduced. Light was also found to be an important factor as seeds germinated under light conditions showed much higher germination percentages (as high as 90% germination) than those germinated in darkness. This implies that *C. metuliferus* seeds are positively photoblastic, which means that light needs to be applied before successful germination occurs. These results are comparable to findings from other light-sensitive species in which light acts as a signal to indicate the probability of favorable environmental conditions for germination (Ghoreyshi et al., 2023; Muthoni, 2024).

5.2 Heat Treatment Experiment and Germination Response

The experiment on heat treatment showed a highly significant interaction ($p < 0.05$) between heating and germination of *Cucumis metuliferus* seeds, as shown by Tables 4.3 and 4.4. Both accessions had similar reactions to heat treatment, with seeds treated at moderate temperatures (30–60°C) germinating sooner than the untreated ones. However, no germination was noted when seeds were exposed to high temperatures of 90°C, thus suggesting that high temperatures negatively impact seed viability. As noted by Maluleke et al., (2021); Mutetwa et al., (2023), the seed coat is a critical component of the germination process since it controls the entry of water and gases. Heat treatment damages or weakens the seed coat, hence promoting increased water uptake and gas exchange, which subsequently hastens radicle emergence and reduces the time of germination. This is the reason why treated seeds germinated quicker than untreated ones.

The two accessions responded differently to heat treatment as far as germination percentages are concerned. For the yellow-colored accession, the highest germination percentages were obtained in untreated seeds and seeds heated at 30°C for 30 minutes. The germination percentages reduced slightly upon heating the seeds at 30°C for 60 minutes or 60°C for 30 minutes, but no germination was observed at 90°C. This suggests that the yellow accession seed possesses a naturally high seed viability that is interfered with by long or intense heat treatments. The complete inhibition of germination at 90°C is an indication that seeds are killed by extreme temperatures through protein denaturation or permanent structural damage to cells (Ghoreyshi et al., 2023).

Contrarily, the white accession exhibited low germination percentages in the untreated seeds but increased viability when seeds were subjected to moderate heat treatments. The highest germination percentage of up to 80% was attained when seeds were subjected to 30°C for 30 minutes. Similar to the yellow-colored accession, there was no germination at 90°C, hence confirming high temperature to be detrimental to *C. metuliferus* seeds. Improved germination by moderate heat treatment shows that there is a more recalcitrant seed coat in the white-colored accession with some germination inhibitors that were alleviated by the weakening effect of heat on the seed coat (Jimam et al., 2010; Matsumoto et al., 2012).

The results indicate that the optimal temperature range for breaking seed dormancy in *C. metuliferus* is between 30°C and 60°C, with an exposure time of 30–60 minutes. Lower temperatures require longer exposure times to achieve the same effect, while higher temperatures necessitate shorter durations. This aligns with the principle that moderate heat treatments enhance seed coat permeability without causing irreversible damage, thereby promoting germination (Lee et al., 2010; Matsumoto et al., 2012).

The findings suggest that the white-colored accession has a harder seed coat, which may explain its lower germination percentages in untreated seeds. The presence of germination inhibitors on the seed coat is also plausible, as these inhibitors can be removed or neutralized through presowing treatments such as heat or soaking. Conversely, the yellow-colored accession appears to have a softer seed coat, making it more sensitive to presowing treatments. Its high germination percentages in untreated seeds suggest that excessive or prolonged treatments may damage the seed coat or disrupt internal metabolic processes, reducing viability.

6.0 CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The results of this research demonstrate that presowing treatment has a remarkable increase in germination rate of *Cucumis metuliferus* and enhances germination percentages of the white-color accession. But presowing treatment does not lead to enhanced germination percentages of the yellow-color accession even though it possesses more viability than control seeds. This situation evinces that the effect of presowing treatment is accession-specific because of seed coat characteristics and their response to exogenous stimuli. The research stresses that germination protocols must be customized to deal with every accession's special requirements to maximize seedling emergence and increase yield capacity.

6.2 Recommendations

Farmers are recommended to subject *Cucumis metuliferus* seeds to presowing treatment in conditions that have a risk of attack by soil microorganisms since presowing treatment allows germination at a previous time compared to nontreated seeds. In particular, presowing treatment is greatly recommended for the white accession to increase seed viability and germination percent. In contrast to that, presowing treatment can be avoided in the case of the yellow accession because it has higher viability in nontreated conditions. These suggestions highlight the importance of applying accession-specific management to improve germination and obtain effective crop establishment.

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Appendix

Appendix 1: Means for the effect of soaking on germination of *C. metuliferus*

Soaking Duration (min)	Yellow - GP (%)	White - GP (%)	Yellow - DCG	White - DCG
0	70	40	13.5	13.5
20	65	55	11.5	12.5
40	65	70	10.5	10.5
60	50	75	9.5	9.5

GP = germination percentage; DSG = days to complete germination Appendix 2: Means for the effect of heat treatment on germination of C. metuliferus

Appendix 2: Means for the effect of heat treatment on germination of *C. metuliferus*

Accession	Measure	30°C × 30min	30°C × 60min	60°C × 30min	60°C × 60min	90°C × 30min	90°C × 60min
Yellow	GP (%)	70	70	60	60	40	30
	DCG	13	12	12	10.5	10.5	9.5
White	GP (%)	40	80	60	70	50	20
	DCG	13.5	11.5	11.5	10.5	9.5	10

Key: GP (germination percentage); DCG (days to complete germination)

Table 3.1: Effect of soaking on days to complete germination

Source of Variation	d.f.	S.S.	M.S.	V.R.	F pr.	Significance
Blocks	1	20.25	20.25	37.8	<0.001	***
Accessions	1	0.25	0.25	0.47	0.516	ns
Soaking Duration	3	36.75	12.25	22.87	<0.001	***
Accessions × Soaking Duration	3	0.75	0.25	0.47	0.715	ns
Residual	7	3.75	0.5357	—	—	—
Total	15	61.75	—	—	—	—

Table 4.2: Effect of soaking on germination percentage

Source of Variation	d.f.	S.S.	M.S.	V.R.	F pr.	Significance
Blocks	1	1225	1225	7.3	0.031	*
Accessions	1	25	25	0.15	0.711	ns
Soaking Duration	3	325	108.3	0.65	0.61	ns
Accessions × Soaking Duration	3	1625	541.7	3.23	0.091	ns (†)
Residual	7	1175	167.9	—	—	—
Total	15	4375	—	—	—	—

Table 4.3: Effect of heat treatment on days to complete germination

Source of Variation	d.f.	S.S.	M.S.	V.R.	F pr.	Sig
Block	1	12.4529	12.4529	41.09	<0.001	***
Accessions	1	0.1429	0.1429	0.47	0.507	ns
Temperature (Temp)	3	44.2321	14.744	48.66	<0.001	***
Time	2	0.375	0.1875	0.62	0.556	ns
Accessions × Temp	3	1.2321	0.4107	1.36	0.307	ns
Accessions × Time	2	0.375	0.1875	0.62	0.556	ns
Temp × Time	0	0.25	—	—	—	
Accessions × Temp × Time	0	0.25	—	—	—	
Residual	11	3.3333	0.303	—	—	—
Total	23	51.3333	—	—	—	—

Table 4.4: Effect of heat treatment on germination percentage

Source of Variation	d.f.	S.S.	M.S.	V.R.	F pr.	Significance
Block	1	1157.1	1157.1	10.43	0.007	**
Accessions	1	14.3	14.3	0.13	0.726	ns
Temperature (Temp)	3	13642.9	4547.6	40.97	<0.001	***
Time	2	2400	1200	10.81	0.002	**
Accessions × Temp	3	1185.7	395.2	3.56	0.045	*
Accessions × Time	2	0	0	0	1	ns
Temp × Time	1	100	100	0.9	0.36	ns
Accessions × Temp × Time	1	100	100	0.9	0.36	ns
Residual	13	1442.9	111	—	—	—
Total	27	20042.9	—	—	—	—