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Germination Performance of Cacao *(Theobroma cacao L.)* Seed: A Basis for Seed Storage Prototype

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Abstract:- The main objective of the study was to determine the germination performance while it was exposed to forced environmental condition and [1] To describe the physiological characteristics characteristics in recalcitrant of Cacao (Theobroma cacao L.) Seed [2] to determine the tolerable limits and germination performance if it is still viable and [3] to evaluate the seedling physiological response while on its individual treatments as cited under methodology. From the study conducted, it was revealed that for those seeds exposed to Moist saw dust showed control to maintain germination performance even the period of time as it was observed during 10 days after set-up. The germination performance of the cacao seed exposed to moist saw dust found out to have similar output performance with control treatment, indicating that the seed exposing the seed to moist saw dust has an influence to preserve the seeds and extend life-span and remain viable in due time. With the result, concluded that cacao seeds were wet seeds because it does not give good germination performance for the rest of the treatments during 10 days after exposure except to treatment 4 and 8. On the other hand for those seeds that were exposed to refrigeration, germination performance was not comparable to treatment 8, but the highest quantity of abnormal seedlings was observed in this treatment.

Keywords:- *Germination Performance, Seed Storage, Cacao (Theobroma Cacao L.)*

I. INTRODUCTION

In the Philippines, Tablea is a traditional product from Cacao (Theobroma cacao L.) it is indigenously prepared through fermentation process of dried cocoa beans. Tablea is prepared in various ways and is produced in numerous parts in the Philippines specifically some areas of Mindanao regions. Presently, Cacao production is a significant re-promising industry in the country today, Fruit production generally follow through the pattern of seasonal in each individual country were production is located, with this ecological phenomenon by which naturally occurring limits the supply of planting materials and fruit supply to coup up the gap of consumption requirements.

Primarily, reliable supply of planting materials relay on sexually propagated nursery stocks by which in order to provide the demand requirements it needs to prepare the planting materials before the season it will be end, but due to some problem naturally occurring while on storage period the Cacao seeds cannot be preserved in a long period of time in order to coup up the requirement during lien season.

At present, the technical research conducted related to Cacao that will enhance cacao seed storability, in the future is limited and it is not in the attention of the researchers to be undertaken in the field in order to resolve some related technical issue that requires specific recommendation to address the problem.

Seed germination performance of Cacao (Theobroma cacao L.) After fresh from harvest gradually reduce naturally, as to the extent to know the maximum peak of its germination performance still on a limited information and somehow this fruit have high and low season per year, with this situation seed preservation is yet in optimum research attention, thus limited sexually produce planting materials is not available throughout the year.

➢ *Research Objectives*

The main objective of the study is to know the germination performance of Cacao (Thoebroma cacao L.) while expose to forced environmental conditions; specifically, this research study aims to:

- To described the physiological characteristics in recalcitrant of Cacao (Theobroma cacao L.) Seed.
- To determined the tolerable limits and germination performance if it is still viable.

- To evaluate the seedling physiological response while on its individual treatments.

➢ *Scope and Delimitation of the Study*

This study focused only on the germination performance of Cacao (Theobroma cacao L.)While exposed to different treatments and longevity period. Seedling growth performance after the study was not included and not part of the study.

➢ *Significance*

This study will provide information particularly technical knowledge in Cacao (Theobroma cacao L.) characteristics in terms of germination performance while it is exposed to controlled environmental situation and possibly know the tolerability germination performance within longevity period while the seed subjected to treatment.

II. LITERATURE REVIEW

➢ *Soil Requirement*

The presence of confounding variables, such as variations in farm management, may be attributed to variances in soil type and local microclimate (Godfray et al., 2010; Blaser et al., 2018). Important considerations include the soil requirements, which consist of a mixture of clay and sandy soil with approximately 50% sand, 30-40% clay, and 10-20% silt. The pH level should range from 5.0 to 6.5, with higher values being more favorable for cacao growth. The soil should be deep, reaching a depth of about 150 cm. In terms of climate, ideal rainfall for cacao cultivation falls within the range of 1250 to 3000 mm per year, preferably around 1500-2000 mm. The dry season should not exceed three months. The temperature range suitable for cacao lies between a mean maximum of 30-32 degrees Celsius and a mean minimum of 18 degrees Celsius. The altitude of the cultivation area should be between 300-1200 meters above sea level. The most suitable temperature conditions for cacao are generally found at altitudes of 700 meters and above. It is beneficial for cacao to have evenly distributed rainfall throughout the year. (Nietzel et al., et al. 2019) provide further details on these factors.

➢ *Propagation, Nursery Establishment of the Seeds, and Establishment of Shade Crops*

The seeds needed only ripe, healthy pods that were uniform in size (Babadele et al.; S., 2019), not swollen and different shapes; rubbing the seeds with sawdust or sand, then washing to remove the mucilage (Castro et al., P. A. O., 2015); spreading the seeds on wet sacks and covering them with wet newspaper for 24 hours to keep them moist and well-drained. For seed propagation, immerse cleaned seeds in a fungicide solution for 10 minutes, then scatter them on damp sacks and cover them with wet newspaper for 24 hours. To prevent fungus, keep it wet and aired (Alverson et al., 1999). Some seeds germinated (a pigtail-like root emerged). Sow pre-germinated seeds (Robertson et al., D., 2006) not more than 1 cm deep in prepared polybags with the pigtail-root pointed downwards in select 8" x 10" polybags and fill with a mixture of loamy to sandy loam soil and completely composted organic materials. Germination usually begins after two days.

Nurseries are established and managed after seed propagation: [a] Choose a flat, road-close location with water (Valle et al., 2007). [b] Choose a well-drained, water-free spot. Shade material must provide 70–80% shade for cocoa seedlings. To prepare seedlings for field planting, Niemenak et al. (2010) advocate progressive shade removal. Twin rows of polybags with a 45-cm-wide alternative route are advised. [e] Weeding: Weeds growing between blocks may be chopped down with scythes (herbicide is not suggested); consequently, manual or mulching (Ingram et al.; H., 2018) with rice husk, Incorporate 15–35 grams of ammonium phosphate per bag when fertilizing after the first leaf hardens. Culling/Selection: remove nursery seedlings that are underperforming. To decrease seedling stress during transplanting (Babadele F. et al., 2019), rotate the polybag a few degrees one week before field planting. It is also done for seedlings with rigid leaves (Robertson et al., D., 2006) and those with roots that have entered the earth, which must be watered a few days later (Tacio, 2011).

Vegetative propagation reproduces true-to-type trees, uniform growth, and early-to-bear flowers, and the clone retains most, if not all, of the seedling mother tree's essential traits, such as pod value, bean size, fruit wall thickness, and others. For cacao, employ patch budding, nodal grafting, or standard cleft grafting (Tacio, 2011).Establishment of shade crops seedlings must be shaded from direct sunlight during the first few years, as newly planted cocoa trees need 75% shade (25% direct sunlight overall) during their first year, which can be reduced to a 50% level of overall shade in their second year (Tacio, 2011).After that, the pod-bearing cocoa trees must be shaded with only about 25% density of direct sunlight for the rest of their life span. However, older cocoa trees can survive the sun's direct rays because permanent shade trees should be planted 6 to 9 months before the cacao seedlings will be planted (Tacio, 2011). Relative to the permanent shade, crops that have a thin canopy, tall trunks, and do not defoliate seasonally are ideal for intercropping with cocoa trees for extended periods; some suitable crop-bearing varieties are coconut, cashew, longan, durian, mango, and mangosteen. Moreover, both cacao and shade trees can be planted at 6 x 3 m. See Figure 1 below.

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Fig 1 Cacao and Shade Trees can be Planted at 6 x 3 meter

The most typical distances to consider when planting shade crops, propagating plants, or establishing a nursery are: A double hedge row with a density of 1.5 to 2.0 x 6.0 m = 2,300 trees/ha is shown in A; a density of 3 x 2 m = 1666 plants/ha or 2.5 x 2.5 m = 1600 plants/ha is shown in B. Soil fertility, tree crop coverage, and existing tree shade determine the optimal planting density for cocoa, which ranges from 400 to 1100 plants/ha. On average, there are 600 cocoa plants per hectare when cashew and coconut are intercropped. As a result, planting should begin in the middle of the rainy season to provide sufficient time for establishment before the next dry season: In order to ensure that your seedlings are protected from sunburn, planting shocks, and stress, it is best to plant them in the early morning or late afternoon. Additionally, make sure that the hole is large enough to hold the soil mass ball. A standard hole dimensions are 30 cm in width, 30 cm in length, and 30 cm in depth.

Moreover, figure 2 below are the list of some common and suitable plants to intercrops with cacao:

Table 1. ***Name***	**Filipino common Name**
	Permanent Shade Plants
Leuceana	Ipil-ipil
Gliricidia	Madre de cacao (suitable pepper production)
Jackfruit	Langka
Lansones	Lansones
Marang	Marang
Durian	Durian
Cashew	Kasoy
Mango	Mangga
Longan	Longgan
Pomelo	Pomelo
Coconut	Niyog
Gliricidia	Madre de cacao (suitable pepper production)
Jackfruit	Langka
Lansones	Lansones
	Temporary Shade Plants (fast growing)
Sesbania	Sesbania
Crotalaria	Crotalaria
Flemingia	Flemingia
Cassava	Kamoteng kahoy or Balanghoy
Maize	Mais
Ginger	Luya
Abaca	Abaca
Papaya	Papaya
Sesbania	Sesbania
Crotalaria	Crotalaria
Flemingia	Flemingia
	Vines
Pepper –black	Paminta
Dragon fruit	Dragon fruit
Vanilla	Vanilla
Pepper –black	Paminta
Dragon fruit	Dragon fruit
	Ground Covers and Manure Crops
Lemon grass	Tanglad
Peanut	Mani
Sweet potato	Kamote

Fig 2 Suitable Plants to Intercrops with Cacao

➢ *Care-Maintenance and Pest Management*

Care, maintenance, and pest control had to seek to guarantee production after the installation of the nursery shade crops and propagation had taken place, and they had pleaded for the following: [A] Manual ring weeding: a one-meter radius around the stem is cut off with a sickle for weeding. Brush cutters, contact spraying, and systemic herbicides are further options for weed management among trees (Tacio, 2011). [B] Pruning aims to accomplish: Reduce pest and disease infestations.

- Control the shape and height of the tree.
- Control the shape and height of the tree to ensure easy access for harvesting.

A brief outline of how to apply to prune is as follows: First Step: Upkeep Regular removal of branches that hang low or develop downward is the first step in pruning. Step 2: Consistently tend to the stem's freshly sprouting chupons; Thirdly, cut off any branches or shoots that are within 60 centimeters of the jorquette. Step 4: Consistently prune out any branches that are unhealthy, dead, or severely damaged. In order to make regular harvesting and maintenance easier, step 5 is to prune the tree's highest branches (up to 4 meters). Step 6 is to open up the tree's center by cutting off branches in the canopy. This will increase sunshine and wind, which the cocoa pod borer does not like, and it will also increase flowering.

The most damaging cacao pest in the Philippines, according to pest control, was the cacao pod borer (Conopomorpha cramerella). In addition, the pod is invaded by larvae. Throughout the year, young stink bugs (Pentatomidae) may feed on a wide variety of agricultural and wild plant species, causing harm to the tissue around developing seeds (Koch et al., 2017). According to South Dakota State University (2010) and CIRAD (2008), in order to manage the borer, the following steps should be taken: 1) harvest all ripe pods; 2) bury all empty cacao pod husks; and 3) remove all contaminated pods. 4) Pruning overgrown branches will let more light in, which will keep pests at bay. 5) To prevent eggs from being laid on the immature pods, wrap them in plastic or bag them tightly. Apply fertilizer to the tree to make it healthier and more resistant to pests. Nevertheless, this has the potential to improve the local climate (Lin et al., 2007).

[B] Helopeltis prefers sunny spots with open canopies. However, in order to better see the illness and use management strategies, it is important to cut the trees with care and remove excessive shadow if present. One place Helopeltis may get food is in newly formed chupons. [C] Infested branches should be chopped off forty centimeters below the larval hole by Stem Borer (Zeuzera).

The larva can't feed, hatch, or breathe if you poke it out with a wire and then spritz some soap solution into its exit hole; to stop it, you may seal or plug the entrance with dirt or wood once you've killed the branches. Because the soap fume is so unpleasant, the larva will likely be forced out of the hole after some time has passed. Disease control includes sanitation pruning for vascular streak dieback (VSD), which is caused by Oncobasidium theobroma: Remove diseased branches 30 cm below the affected area and burn any infected cuttings (Lin et al., 2007). To prevent spores from landing on seedlings, cover the cacao trees with polyethylene roofing (Goodall et al., 1949). Varieties tolerant of vascular streak dieback (VSD) should be planted in areas with low humidity. [D]Frequent harvesting is essential for preventing pathogen sporulation from Black Pod Rot, which is caused by Phytophthora palmivora. This means that any pods that are sick, dead, or mummified should be disposed of or buried. Next, cut down on shade trees and cacao plants to lower humidity levels; make sure there's good drainage to prevent spores from floating about in pools of water.

➢ *Rehabilitation of old Cacao Trees by Side Grafting*

Removal (Babadele F. et al., 2019) or side or bark grafting (Bogdan et al., 2016) are two methods for rehabilitating trees that are no longer productive. Utilizing scions from plants that are recognized for high-yield and quality beans and side-grafting them onto existing unproductive trees in the plantation is called side-grafting (Goodall et al., 1949; Ingram V. et al., 2018).

➢ *Harvest Management*

For practical use in the field, six(6) fundamental ideas may be outlined under harvest management. [1] Pod harvesting: Fertilization to harvesting takes around 5 to 6 months. Approximately five months constitute the harvest season. Picking mature cocoa pods from trees is the process of harvesting cocoa. Pick ripe pods on a regular basis. The quantity and quality of the beans will be diminished if you pick green pods or pods that are overripe. To avoid damaging blossoming cushions, carefully harvest with a sharp knife.

Second, you may improve the taste of your cocoa beans and speed up the fermentation process by storing your harvested pods for a few days. Before opening the pods and removing the beans, step three is to collect and prepare the pod husks. Keep the pod husks off the ground to prevent the spread of insects and infections. To get the beans out of the pod, shatter it with a non-sharpened steel blade and twist it open (Sriwati et al.; B. A., 2015). A wooden hammer is another option for breaking apart the pods. Remove any organs, soft or empty beans, broken beans, or beans that have germinated from the bean bulk.

[4] Fermentation of beans: Chocolate's fragrance and taste are created during the fermentation of cacao beans. In addition, the following are some reasons to promote bean fermentation: [a] Place the damp beans in woven baskets or wooden boxes; [b] Place a layer of banana leaves on top of the bean mass; [c] Rotate the bean mass once a day; [d] Let the liquid (sweat) drain off the beans; [e] Continue as before. It will take around seven or eight days for the fermentation to finish. The bean with good fermentation is round and has brownish cotyledons.

[5]. Drying beans: After fermentation is complete, they need to be dried in the sun on drying racks or baskets that are rotated often. During rainy weather, be sure to cover the beans with plastic or relocate them to a dry place. Before drying, remove any damaged or germinated beans, remove the pod placentas, and separate the bean clusters.

[6] Yield: Cacao trees reach maturity 24 months after planting, however it takes about five years after planting for them to reach peak productivity. Good yields are generated over decades, with a peak in the eighth or tenth year. Typical annual yields from conventional trees range from 300 to 500 kg/h. Generated at quantities over 1000 kg/h, hybrids are superior.

➢ *Seedling Evaluation*

At each checkpoint before the last check, only the healthy seedlings are taken out of the germination media; this process is repeated throughout the whole testing time. Standard, abnormal, ungerminated, fresh, and dead seedlings are examined and recorded after the test (Goodall, D., 1950; Pancaningtyas et al., 2014; ISTA, 1985; Manual in Seed Technology). Ungerminated seeds are further classified as hard, fresh, and discarded. According to Tabora, R.S. (1998) in the Manual in Seed Technology, "normal" seedlings are those that, when planted in high-quality soil and subjected to ideal circumstances of moisture, temperature, and light, have the ability to mature into typical plants. If they fit into one of these groups, we may call them typical seedlings: Depending on the species being evaluated, seedlings that have all of their basic features well-developed are considered complete, proportionate, and healthy (Cicek et al.,2011).Their extensive root system includes [a] main roots that are long and thin, [b] secondary roots that could be visible, and [c] several seminal roots rather than a single primary root (in certain Gramineae and Cyclamen species). In addition to a well-developed shoot axis that includes [d] hypocotyls that are straight and slender and elongated in seedlings that show epigeal germination (Pancaningtyas, S., et. al. 2014); [e] hypocotyls that are short and barely distinguishable in seedlings that show hypogeal germination (e.g., Pisum Asparagus); [f] hypocotyls and epicotyls that are both elongated in certain genera that exhibit epigeal germination (e.g., Phaseolus); and [g] a mesocotyl that is more or less elongated in certain Gramineae family members (e.g., Sorghum).

Additionally, in relation to it, a certain quantity of cotyledons was present: With very few exceptions among dicotyledons (e.g., Cyclamen), monocotyledons (e.g., Allium) and certain modified cotyledons (e.g., Asparagus and Gramineae) may have a single, green, leaf-like cotyledon. dicotyledons have two sets of cotyledons. When examined under a microscope, seedlings that germinate epigeally have two verdant cotyledons and, when fully grown, resemble leaves in size, shape, and form. At first, they may be plump and shriveled, but that all changes when the seeds germinate.

The cotyledons of plants that germinate hypogeally are often spherical or oval, have a fleshy texture, and stay in the soil within the seed coat (e.g., Pisum). In terms of the green, developing main leaves: [j] seedlings with alternate leaves (like Pisum) may have one main leaf followed by a few scale leaves; [k] seedlings with opposite leaves (like Phaseolus) may have two main leaves. The development of the terminal buds at the shoot apex differs throughout the examined species. In addition, a Gramineae plant with a fully grown straight coleoptile will have a green leaf that grows within the structure, all the way to the tip, and then passes through it.

Section 1.2 Young plants with minor flaws: According to Michael et al. T. (2017), these seedlings have a few minor flaws in their main structures, but they don't allow any other unsatisfactory or imbalanced growth to occur. Some of the minor flaws that are present include: [a] Despite the main root's defect, there is an insufficient number of secondary roots; the root shows little alteration, such as repaired fractures or splits, discolored or necrotic areas, or both. Zea oryza, sorghum, malvaceae, cucurbitaceae, and large-seeded legume seedlings are the only ones that need this special treatment.

[b] There is minimal damage to the hypocotyls or epicotyl, including discolored or necrotic spots, healed cracks and splits of limited depth, and loose twists. [c] The cotyledons also have minimal damage, including deformed or damaged cotyledons and discolored or necrotic spots. However, normal function is retained by half or more of the total tissue. The 50% rule describes this overarching concept. At the site of connection, there shouldn't be any harm.

The shoot apex and surrounding tissue show no signs of injury or decay in dicotyledons, which have one typical cotyledon. On the other hand, tricotyledons, instead of two, are acceptable as long as they meet the 50% criterion.

[d] The primary leaves have limited damage, such as a discolored or necrotic spot or deformed or damaged leaves, but half or more of the total tissue functions normally; [d.1] There is only one regular leaf (e.g., in Phaseolus), but there is no evidence of decay or damage to the terminal bud; [d.2] three primary leaves instead of two (e.g., Phaseolus), provided they comply with the 50% rule; [e] The coleoptile has limited damage, such as discolored or necrotic spots; [e.1] the coleoptile has limited damage, such as discolored or necrotic spots; [e.2] the coleoptile is loosely twisted or forming a loop because it is trapped under the glumes or coat; [e.3] the coleoptiles with a green leaf that does not extend to the tip but reaches at least one halfway up to the coleoptiles.

Section 1.3. Secondary fungal infection in seedlings. Here we have seedlings that have begun to exhibit signs of deterioration or discolouration. All the important structures are deemed normal, and it is evident that the degradation has originated from somewhere else (e.g., another seedling) (Laloi et al., 2002; Traore et al., 2003).

Half-Batch Rule. If at least 50% of the cotyledon tissue is functional, the seedling is regarded normal; however, if more than 50% of the cotyledon tissue is dysfunctional (e.g., missing, necrotic, discolored, or decaying), the seedling is termed abnormal. When there is damage or degradation to the tissue surrounding the cotyledons' connection to the hypocotyls, the 50% rule is also applied. When evaluating primary leaves that are faulty (like Phaseolus), the 50% rule is also used. Despite their diminutive size, it is not used if the leaves retain their typical form (Bogdan et al., 2016).

- *Abnormal Seedlings*

According to Tabora, R.S. (1998) (Manual in Seed Technology), these are seedlings that, even when grown in ideal soil circumstances, would not mature into typical plants due to a permanent flaw in one or more of its vital components (ISTA, 1985). There are three main categories of aberrant seedlings that may arise from different sources:[1] Seedlings suffered damage. A lack of balanced growth in seedlings caused by the absence or significant damage to any necessary structures (Bailey et al., 2006). Mechanical handling, extreme heat or drought, or insect damage are some of the extrinsic factors that might cause harm. For instance, [1.1] cotyledons or shoots that are cracked or fully detached from the rest of the seedling; [1.2] hypocotyls, epicotyls, or cotyledons that are cracked or split; [1.3] coleoptiles that have broken or damaged tips; and [1.4] mission, split, or tilted main roots.[2]. Seedlings that have An uneven or deformed shape. They are young plants whose growth is stunted or uneven due to physiological or biological issues inside the plant. However, these disruptions are usually the result of earlier outside forces, such as unsuitable parent plant growth, seed ripening conditions, early harvesting, herbicide or pesticide effects, improper cleaning, or storage conditions (Laloi M. et al., 2002). Genetic predisposition or the seed's inherent aging process are two potential causes (Michael et al., 2017). Symptoms that indicate that a seedling is not typical include: [2.1] A primary root that is delayed or spindly; [2.2] Hypocotyls and epicotyls that are short and thick, looping, twisted, or spiraled; [2.3] Cotyledons that are curled, discolored, or necrotic; [2.4] A growth direction that is inverted (shoots bending downward, roots with negative geotropism); [2.5] Seedlings that are yellow or white due to chlorophyll deficiency; and [2.6] Seedlings that are spindly or glassy. 3. Seedlings That Have Declined. According to H. et al. Stanwood (1989), these seedlings are unable to grow normally because any vital structures have been infected or degraded. Fungi or bacteria may have attacked, either outside or within, leading to the deterioration.

- *Abnormalities of Specific Seedling Parts*

A combination of the following problems, as listed by ISTA (1985), [1], are present in abnormal seedlings. The main root may be stunted, restricted, stubby, spindly, retarded, caught on the seed coat, absent, infected with negative geotropism, fractured, glassy, or have one or more seminal roots.You may anticipate the presence of one or more faults in secondary or seminal roots. In situations where the seedling's value is determined by the existence of several secondary roots (e.g., Cucumis) or seminal roots (e.g., Triticum), it cannot substitute an aberrant primary root. [2]. the lower stem, the upper stem, and the mesophyllum: [2.1] not developing a tuber (apart from cyclamen), [2.2] being short and thick, [2.3] being twisted into a loop or spiral, [2.4] being flipped upside down [2.5] severely fractured or shattered, [2.6] slender, split through to the end, 2–8 crystalline lacking [2.9], deteriorated [2.10] due to primary infection, restricted [2.11], and firmly twisted [2.12].

The Cotyledons (using the 50% Rule): [3] (1) Inflamed or twisted, (2) Discolored, (3) Deformed, (4) Necrotic, and (5) Broken or otherwise Regardless of the 50% criterion, a seedling is considered abnormal if its cotyledons are glassy, detached or absent, or rotted due to primary infection. Additionally, injury or decay at the site of attachment to the seedling axis or near to the shoot apex is also grounds for abnormality.

The main leaves (using the 50% rule): The following conditions may be present: [4.1] deformity, [4.2] necrosis, [4.3] damage, [4.4] decay due to primary infection, [4.5] absence, [4.6] normal shape but less than half of the usual size. Also discolored [4.7]. Terminal Bud and Surrounding Tissues: [5.1] Missing, [5.2] Damaged, and [5.3] Deformed [5] [5.4] deteriorated due to first infection. Also, keep in mind that even if a seedling has formed one or two auxiliary buds (like Phaseolus) or shoots (like Pisum), it is still considered abnormal if the terminal bud is flawed or absent.

Gramineae's coleoptiles and first leaf [6]: There are a number of issues with the coleoptile, including deformities, splits, missing parts, base splitting, damaged or missing tips, spindly growth, strong bending over, decay from primary infection, tightly twisted growth, first leaf extending less than halfway up the coleoptile, and missing, shredded, or otherwise deformed parts. All things considered, the seedlings were: [7.1] misshapen, [7.2] broken, [7.3] cotyledons erupting before the root, [7.4] two fused, [7.5] an endosperm collar that lingered, [7.6] pale or yellow, [7.7] slender, [7.8] translucent, and [7.9] diseased due to primary infection.

- *Ungerminated Seeds*

Other hard seeds that remain fresh (Babadele F. et al., 2019) and viable after appropriate treatment for dormancy breaking are classified as fresh, ungerminated seeds (Ingram, V. et al., 2018). Imbibition occurs, but development never occurs (physiological dormancy) (Bogdan et al.; D. et al., 2016).

III. OPERATIONAL DEFINITION OF TERMS

This study used the definitions by terms of Copeland (1976), Bewley and Black (1985), ISTA (1985), Tabora (1998), Guariño (2000), and Code practice for Cacao:

- *Coleoptile -*

Refers to a transitory membrane covering the shoot apex of certain species that protects the plumule as it emerges through the soil. The coleoptiles are photosensitive and stops growth when exposed to light, allowing the plumule to break through and continue to growth.

- *Cotyledon -*
The first (non-foliage) leaf or pair of leaves of an embryo and seedling and serve as the storage food of a seed.

- *Dicotyledons –*
A group of plants so classified because the embryo normally has two cotyledons.

- *Germination –*
Refers to the resumption of active growth of embryo that results to in the rupture of the seed coat and the emergence of the young plant.

- *Recalcitrant* **(***Wet***)** *Seed –*
Refers to the seed that must maintain its moisture content in order to remain viable. Ungerminated seeds- refer to the seeds with live and or dead embryo.

- *Bean Cracking –*
Process of cracking cocoa beans using a mechanical grinder, a special roller or wooden pounder to separate the cocoa shell/husk from the nib.

- *Filled Tablea –*
Tablea with the addition of other ingredients such as sugar, peanuts, milk or rice

This study composed of three phases: **Phase I** – Gathering of materials to be used and Preparation of the Treatments of the study. **Phase II** – Preparation of Germination Medium and Experimental Layout. **Phase III** – Data Collection and Analysis.

- *Grinding –*
Process of crushing or pulverizing the roasted nib into powder form to make it smooth and easy to melt

- *Molding –*
Process of creating different shapes and forms of the ground cacao using a cast or a mold.

- *Tablea –*
Roasted, ground and molded cacao nibs

- *Roasting –*
Cooking by dry heat (between 120 to 180oC) using an oven, pot or pan to separate the cocoa bean shell (outer husk) from the cocoa nib (inner bean) and facilitate easy cracking and winnowing.

- *Winnowing –*
Process of removing the shell/husk from the cocoa bean using a mechanical winnower, a large winnowing pan or "bilao" or by putting on a fan/blower to blow away the shells/husk.

IV. METHODOLOGY

- *Phase I – Gathering of materials to be used and Preparation of the Treatments of the study*

- *Gathering of Materials to be used.*

The following materials were gathered in establishing the germination performance experiment.

Table 2 List of Materials Needed.

Item	Materials	Quantity
1	Germination boxes.	9 pcs
2	Fine river sand.	2 sacks
3	Thermometer.	1pc
4	Matured Cacao Seeds.	2 sacks/1000 pcs seeds
5	Plastic container(s)	9 pcs
6	Plastic cabinet.	3 pcs/Set
7	Weighing Scale.	1Unit/Set
8	Refrigerator	1Unit

- *Preparation of the Treatments of the study.*

The following treatment were gathered in establishing the experimental set-up of the study. Refer to table 3 and Figure 2.

Table 3 *Treatment of the Study and Description.*

Treatment of the study	Description
Treatment 1	Control Fresh harvested seeds (just remove mucilage)
Treatment 2	Exposed the seed to open field/ just on Top of the Table for 5 days).
Treatment 3	Cabinet storage (Store the seed to cabinet-controlled environment for 5 days).
Treatment 4	Moist Saw dust (Gmelina sawdust from Saw mill + Water for 5 days).
Treatment 5	Plastic Container (exposed to refrigeration for 5 days).
Treatment 6	Exposed the seed to open field/ just on Top of the Table for 10 days).
Treatment 7	Cabinet storage (Store the seed to cabinet-controlled environment for 10 days).
Treatment 8	Moist Saw dust (Gmelina sawdust from Saw mill + Water for 10 days).
Treatment 9	Plastic Container (exposed to refrigeration for 10 days).

Fig 3 Flow of the Preparation of the Treatments of the study and its seed storage of the Study.

➢ *Phase II – Preparation of Germination Medium and Experimental Layout of the study.*

- *Preparation of Germination Medium.*

The following steps were required in establishing the experiment germination medium.

✓ **Steps:**

- Use fine river sand. Used sieve (strainer) to maintain uniformity of sand particles.
- Weight (2000 grams) and place fine sand in germination box and sterilized with hot water (90-100°C).
- Put water to the germination box on the sand. Drain the excess water and leave it moist.
- Put the seeds in rows on the Sand. Take note that in putting seeds in a sand make sure It was based from the treatments experiment number of days (either 5 days and 10 days after) in sowing especially the treatment number 1, you have to sowed it after removing the mucilage. Refer to table 3 and Figure 3.

Fig 4 Flow of the Preparation of the Germination of the study.

➢ *Preparation of Experimental Layout of the study.*

The following were layout and set-up of the germination performance experiment template from box 1 to box 9 considering the number of replication in every treatment. Refer to experimental layout and figure 4.

- *Experimental Layout of the study:*

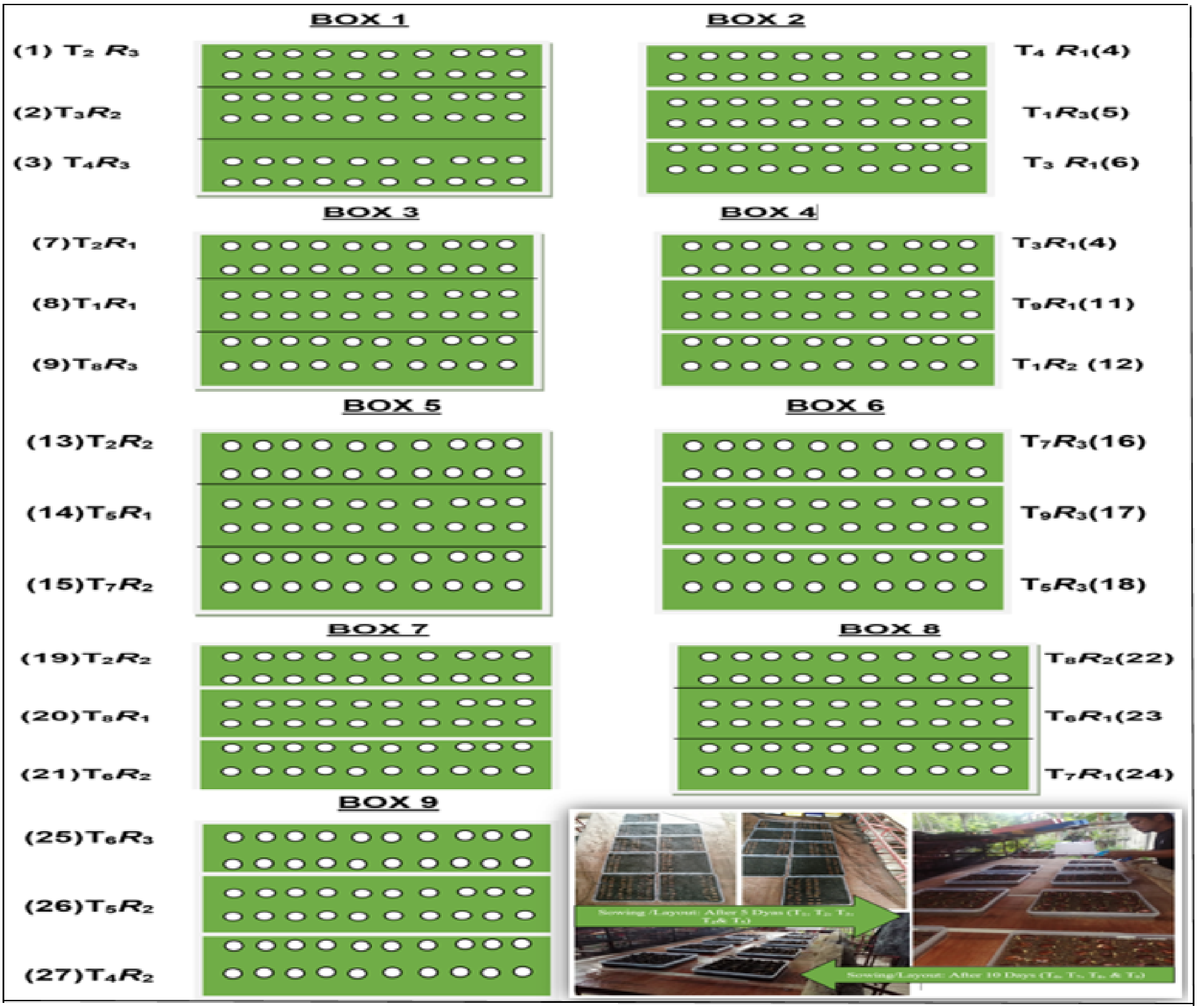

Fig 5 Experimental Layout and Sowing (5 Days and 10 Days After).

- *Phase III – Data Collection and Analysis.*
- *Data Collection.*

In data collection, seed germination and seedling evaluation were considered in establishing experimental data collection as follows:

- *Seed germination.*

The percentage of germination was taken 5 days after seed sowing and so on to every other 5 days interval until 10 days (2times data gathering).

- *Percentage of germination =*

No. of seedlings/No. of seeds sown X 100

- *Seedling evaluation.*

The normal seedling, abnormal seedling, and ungerminated seeds were evaluated based on standard evaluation.

- *Normal seedling*:

base on standard evaluation (ISTA, 1985, TABORA, R.S. 1998)

- *Abnormal seedling*:

base on standard evaluation (ISTA, 1985, TABORA, R.S. 1998)

- *Ungerminated seeds*:

base on standard evaluation (ISTA, 1985, TABORA, R.S. 1998)

- *Data Analysis.*

The analysis of variance (ANOVA) for single factor of CRD by Gomes and Gomes (1986) was used to analyze the data on germination percentage of: Normal seedlings, Abnormal seedlings and Ungerminated seeds. Significant results were compared further using Duncan's Multiple Range Test (DMRT).

Fig 6 Care-Maintenance and Pest Management to Data Collection. The data collection done right after five (5) days of sowing under treatment (T1, T2, T3, T4, and T5). And After ten (10) days of sowing under treatment (T6, T7, T8, and T9).

V. RESULT AND DISCUSSIONS

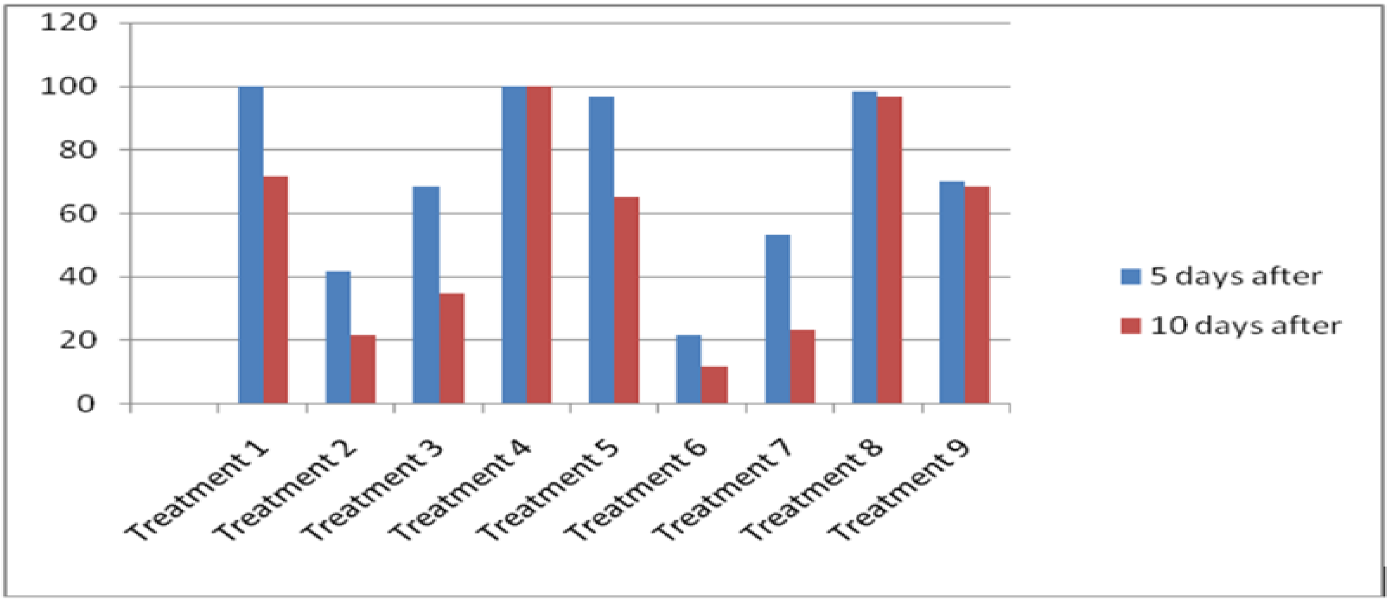

Fig 7 Seed Germination 5 and 10 Days After Sowing.

Figure 6, Treatments 4 and 8 (exposed moist saw dust) showed control in influencing the germination performance and remain to its ideal germination which is show in control treatment even during 5 and 10 days after sowing. Treatment 5 shows only control potential during 5 days after sowing, but 10 days after, there was a reduction of germination performance. All the remaining treatments the response during 10 days was ranging from 60-70% germination performance. Analysis of variance revealed a significant difference among treatments as shown in Appendix 1.

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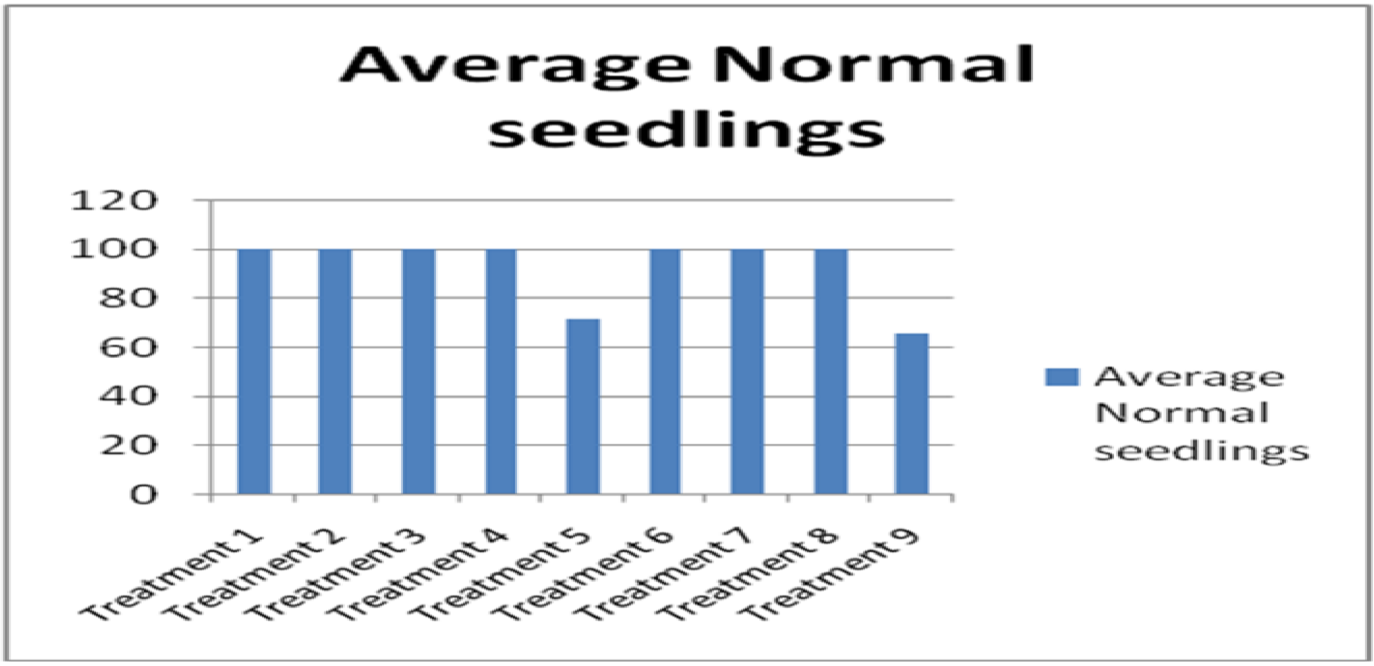

Fig 8 Normal Seedling.

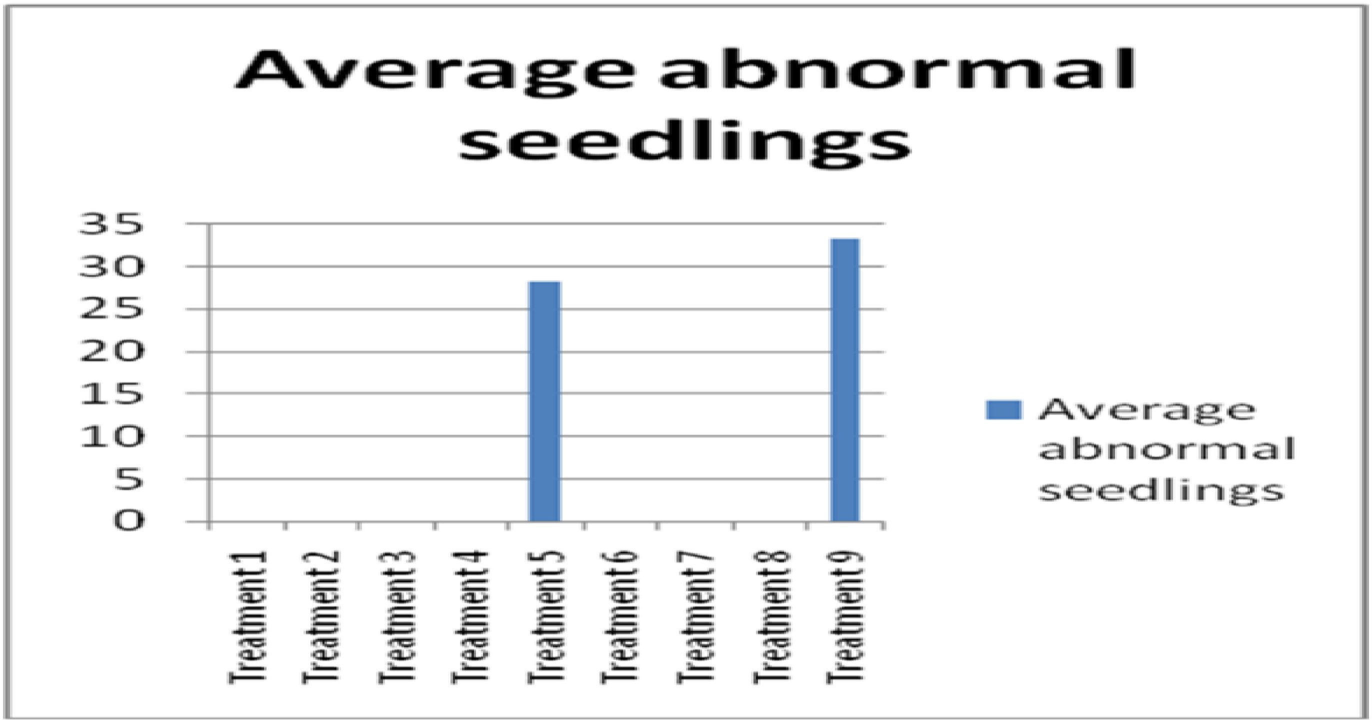

Fig 9 Abnormal Seedling.

The Normal seedlings result showed that all of the treatments showed no influence because the reduction of performance was not observed except treatments 5 and 9 revealed that normal seedlings were range only to 65-70% to be normal seedling as shown in figure 7. Appendix 2, showed the analysis of variance showing no significant difference among treatment except for treatments 5 and 9. This observation was also observed in figure 8.

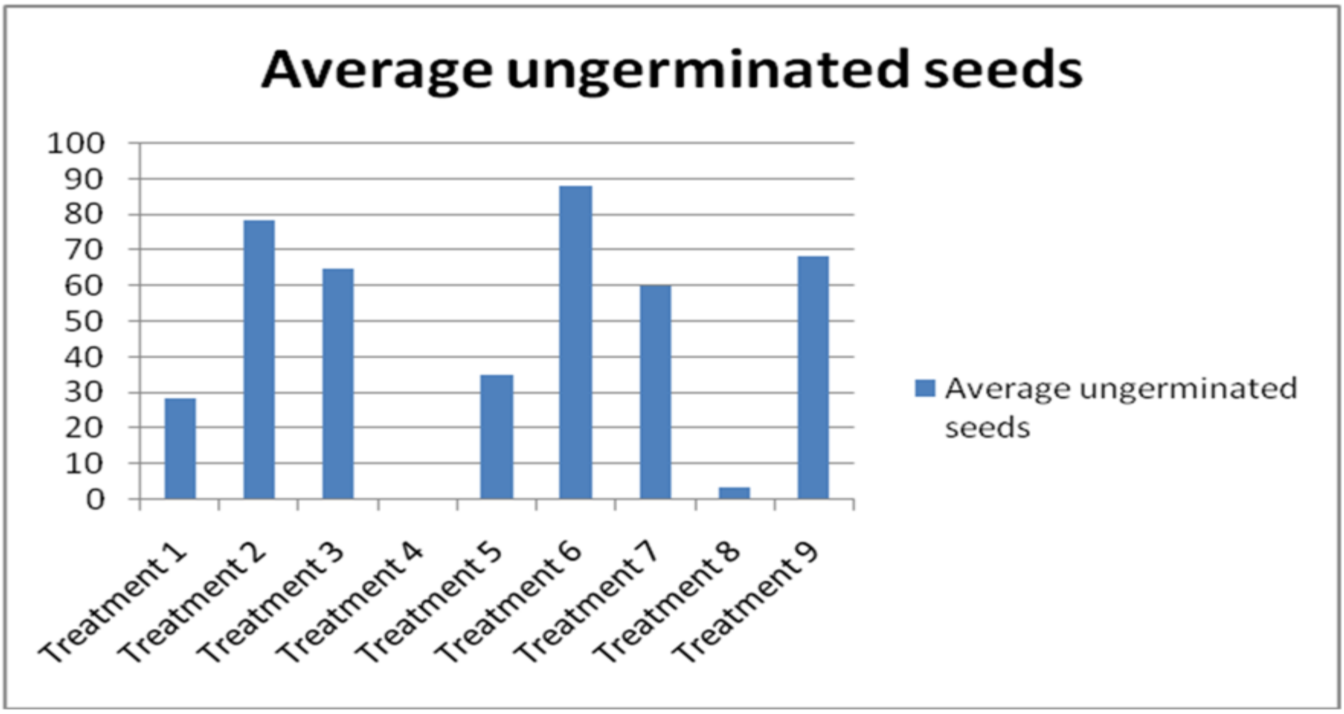

Fig 10 Ungerminated Seeds.

Ungerminated seeds were observed to all treatments except treatments 4 and 8(exposed to moist saw dust) considering that cacao seeds are wet seeds that are not favored to germinate when the moisture content reduces no within tolerable limits. Wet seeds normally failed to germinate when the moisture content of the seeds gradually reduced due to some factors either environmental or with human intervention. This observation showed that moist saw dust can control the moisture loss from the seed and will result to germination performance and remained viable even after 10 days. This was observed in treatments 4 and 8.

VI. SUMMARY, CONLUSION, RECOMMENDATION

➢ *Summary*

The main objective of the study was to know the germination performance while it was exposed to forced environmental condition. This main objective was attained by considering the specific objectives: [1] To describe the physiological characteristics characteristics in recalcitrant of Cacao *(Theobroma cacao L.)* Seed, [2] to determine the tolerable limits and germination performance if it is still viable and [3] to evaluate the seedling physiological response while on its individual treatments as cited in the methodology. This study was led out by a single factor of CRD by Gomes and Gomes (1986) to analyze the data on germination percentage of: normal seedlings, abnormal seedlings, and ungerminated seeds. Significant results were compared further using Duncan's Multiple Range Test (DMRT).

➢ *Conclusion*

The result of the study revealed that for those seeds exposed to Moist saw dust showed control to maintain germination performance even the period of time as it was observed during 10 days after set up. The germination performance of the cacao seed exposed to moist saw dust found out to have similar output performance with control treatment (treatment 1), indicating that the seed exposing the seed to moist saw dust has an influence to preserve the seeds and extend life span and remain viable in due time. With the result, concluded that cacao seeds were wet (recalcitrant) seeds because it does not give good germination performance for the rest of the treatments during 10 days after exposure except to treatment 4 and 8. On the other hand for those seeds that were exposed to refrigeration, the germination performance was not comparable to treatment 8, but the highest quantity of abnormal seedlings was observed in this treatment.

➢ *Recommendation*

With this result, in order to let cacao seeds, remain viable in due time, the use of moist saw dust as a storage preservation chamber was recommended. Further, research studies be conducted on the following treatments and set-up. Combination of Cacao seeds + Moist saw dust and exposed refrigeration, Cacao seeds + Moist saw dust and store at cabinet temperature, Prolong the germination period in the box until such germination stop so that viability performance will be measured, consider also the used of many varieties.

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APPENDICES

- *Appendix 1: Table 4 Preliminary Counting of Germination 5 Days after Sowing.*
  Lambino Village, Poblacion, Sta. Maria, Davao Occidental, Philippines, December 2020

Table 4 Preliminary Counting of Germination 5 Days after Sowing

Treatment	**% Age of Germination**				**Treatment**	
	I	**II**	**III**	Total	Mean	**Comparison of Results**
Treatment 1	100	100	100	300	100	*A*
Treatment 2	40	45	40	125	41.66667	*C*
Treatment 3	70	70	65	205	68.33333	*B*
Treatment 4	100	100	100	300	100	*A*
Treatment 5	100	95	95	290	96.66667	*A*
Treatment 6	20	25	20	65	21.66667	*D*
Treatment 7	55	50	55	160	53.33333	*C*
Treatment 8	95	100	100	295	98.3333	*A*
Treatment 9	70	75	65	210	70	*B*

Table 5 Means of common letter superscripts are not significantly different.

Analysis of Variance						
SV	**df**	**SS**	**MS**	**Fc**	**Ft**	
					5%	1%
Treatment	8	20066.7	2508	301**	3.71	2.51
Error	18	150	8.333			
Total	26	20216.7				

CV 4% ** highly significant

- *Appendix 2: Table 6 Second Counting of Germination 10 Days after Sowing.*
  Lambino Village, Poblacion, Sta. Maria, Davao Occidental, Philippines, December 2020.

Table 6 Second Counting of Germination 10 days after Sowing

Treatment	**% Age of Germination**				**Treatment**	
	I	**II**	**III**	Total	Mean	**Comparison of Results**
Treatment 1	75	70	70	215	71.66667	*B*
Treatment 2	20	20	25	65	21.66667	*D*
Treatment 3	35	40	30	105	35	*C*
Treatment 4	100	100	100	300	100	*A*
Treatment 5	70	60	65	195	65	*BC*
Treatment 6	10	15	10	35	11.66667	*E*
Treatment 7	20	25	25	70	23.33333	*D*
Treatment 8	95	100	95	290	96.66667	*A*
Treatment 9	70	65	70	205	68.33333	*B*

Table 7 Means of common letter superscript are not significantly different.

Analysis of Variance						
SV	df	SS	MS	Fc	Ft	
					5%	1%
Treatment	8	26124.1	3266	294**	3.71	2.51
Error	18	200	11.11			
Total	26	26324.1				

CV 6.08%**highly significant

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- *Appendix 3: Table 8 Analysis of Variance on Normal Seedlings.*
  Lambino Village, Poblacion, Sta. Maria, Davao Occidental, Philippines, December 2020.

Table 8 Analysis of Variance on Normal Seedlings.

Normal Seedlings						
Treatment	**% Age of Germination**			**Treatment**		
	I	**II**	**III**	Total	Mean	**Comparison of Results**
Treatment 1	100	100	100	300	100	A
Treatment 2	100	100	100	300	100	A
Treatment 3	100	100	100	300	100	A
Treatment 4	100	100	100	300	100	A
Treatment 5	70	75	70	215	71.66667	B
Treatment 6	100	100	100	300	100	A
Treatment 7	100	100	100	300	100	A
Treatment 8	100	100	100	300	100	A
Treatment 9	66	65	66	197	65.66667	C

Table 9 Means of common letter superscript are not significantly different.

Analysis of Variance						
SV	**df**	**SS**	**MS**	**Fc**	**Ft**	
					5%	1%
Treatment	8	4635.63	579.5	602**	3.71	2.51
Error	18	17.3333	0.963			
Total	26	4652.96				

CV 1.05%**highly significant

- *Appendix 4: Table 10 Analysis of Variance on Abnormal Seedlings.*
  Lambino Village, Poblacion, Sta. Maria, Davao Occidental, Philippines, December 2020.

Table 10 Analysis of Variance on Abnormal Seedlings.

Abnormal Seedlings.						
Treatment	**% Age of Germination**			**Treatment**		
	I	**II**	**III**	Total	Mean	Comparison of Results
Treatment 1	0	0	0	0	0	B
Treatment 2	0	0	0	0	0	B
Treatment 3	0	0	0	0	0	B
Treatment 4	0	0	0	0	0	B
Treatment 5	30	25	30	85	28.33333	A
Treatment 6	0	0	0	0	0	B
Treatment 7	0	0	0	0	0	B
Treatment 8	0	0	0	0	0	B
Treatment 9	30	35	35	100	33.33333	A

Table 11 Means of common letter superscript are not significantly different.

Analysis of Variance						
SV	df	SS	MS	Fc	Ft	
					5%	1%
Treatment	8	111.522	13.94	911**	3.71	2.51
Error	18	0.27555	0.015			
Total	26	111.798				

CV 6.9%**highly significant

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- *Appendix 5: Table 12 Ungerminated Seed 10 Days After.*
  Lambino Village, Poblacion, Sta. Maria, Davao Occidental, Philippines, December 2020.

Table 12 Ungerminated Seed 10 Days After.

Ungerminated Seed 10 Days After						
Treatment	**% Age of Germination**			**Treatment**		
	I	**II**	**III**	Total	Mean	Comparison of Results
Treatment 1	25	30	30	85	28.33333	*B*
Treatment 2	80	80	75	235	78.33333	*B*
Treatment 3	65	60	70	195	65	*B*
Treatment 4	0	0	0	0	0	*B*
Treatment 5	30	40	35	105	35	*A*
Treatment 6	90	85	90	265	88.33333	*B*
Treatment 7	80	75	25	180	60	*B*
Treatment 8	5	0	5	10	3.333333	*B*
Treatment 9	70	65	70	205	68.33333	*A*

Table 13 Means of common letter superscript are not significantly different.

Analysis of Variance						
SV	df	SS	MS	Fc	Ft	
					5%	1%
Treatment	8	4635.63	579.5	602**	3.71	2.51
Error	18	17.3333	0.963			
Total	26	4652.96				

CV 13.221%**highly significant

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➢ *Appendix 6: Documentation and Short Description.*
Lambino Village, Poblacion, Sta. Maria, Davao Occidental, Philippines, December 2020.

Documentation:	Short Description:
 	Harvesting and Preparation of the Matured Cacao Seeds from The Field.
 	Removal of Mucilage "Lamug-Lamug", Using Fined river Sand.
 	Removal of Mucilage With Water and Strainer.
 	Preparation of Treatment Number 2 and Treatment Number 6.
 	Preparation of Treatment Number 3 and Treatment Number 7.
 	Preparation of Treatment Number 4 and Treatment Number 8.
 	Preparation of Treatment Number 5 and Treatment Number 9.

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Preparation of Germination Medium Using Strainer.

Preparation of Germination Medium with Weighing Scale of 2000 Grams or 2 Kilograms.

Preparation of Germination Medium and Distribution to the Treatment Box 1 to 9 with Hot water. (Refer to Methodology).

Preparation and Sowing of Treatment 1, 2,3,4, and 5 After 5 Days.

Box Number 1 and 2. And Germination Performance of Cacao Seeds.

Box Number 3 and 4. And Germination Performance of Cacao Seeds.

Box Number 5 and 6. And Germination Performance of Cacao Seeds.

Box Number 7 and 8. And Germination Performance of Cacao Seeds.

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Box Number 9. And Germination Performance of Cacao Seeds.

Preliminary Data Gathering Under 5 Days (Treatment 1, 2, 3, 4, and 5) Germination Performance.

Preparation and Sowing of Treatment 6,7,8, and 9 After 10 Days.

Caring and Maintenance from the Start of 5 and 10 Days After of Sowing.

Caring and Maintenance from 10 Days Onwards.

Secondary Data Gathering Under 10 Days Germination Performance and Beyond.

Secondary Data Gathering Under 10 Days Germination Performance and Beyond.

Seedlings.

Seedlings.

Extra Cacao Seeds From Treatment 4 And 8.