The Germination-Maturity Correlation in Edible Plants: A 22-Year Observational Study in Western Uganda

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Abstract: Understanding the relationship between seed germination time and plant maturity is essential for agricultural planning and crop management. This study presents a 22-year observational analysis conducted in western Uganda, examining a diverse range of edible plants to determine whether germination duration (measured in days or weeks) corresponds proportionally to the time taken for the plant to reach harvestable maturity (measured in months or years). The findings reveal a strict correlation where plants with short germination periods consistently reach maturity within a shorter timeframe, while those with prolonged germination exhibit extended growth cycles. These results suggest that germination time can serve as a predictive indicator of crop maturity, offering practical applications for farmers, agronomists, and plant scientists. The study further explores potential biological explanations for this trend, including the allocation growth rates, resource efficiency, and environmental adaptations. These insights contribute to a deeper understanding of plant development timelines and may aid in optimizing crop selection and yield forecasting. Future research should focus on experimental validation and genetic factors influencing this correlation.

Keywords: *Seed Germination, Imbibition, Germination Time, Plant Maturity, Edible Crops, Agricultural Planning, Growth Cycle Prediction, Harvestable Time.*

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I. INTRODUCTION

➢ *Study Background*

Understanding plant growth cycles is fundamental to agriculture, crop management, and food security. One of the key challenges in agronomy is predicting the time it takes for a plant to reach maturity after germination, as this influences planting schedules, harvesting periods, and overall agricultural productivity. While many studies, such as those about the quality of soil, climate, and genetic traits, have explored factors affecting plant growth, there has been limited focus on whether seed germination time serves as a reliable predictor of plant maturity.

This study presents a 22-year observational analysis conducted in western Uganda, systematically examining various edible plants to determine whether the duration of seed germination corresponds proportionally to the time taken for the plant to reach harvestable maturity. The findings reveal a consistent correlation across multiple species, suggesting a fundamental biological principle that could enhance agricultural forecasting and planning.

The researcher was motivated by what he observed when he was a practicing teacher of primary five, where he had planted a seedbed in one corner of the classroom to help teach students about hypogeal and epigeal germination types. This was in June 1998 while carrying out school practice, part of his training as a teacher at Bwera Primary Teachers’ College in western Uganda, close to the border with DRC.

The study revealed that different seeds germinate at differing lengths of time, but also grow and develop differently and at different rates and times. The plants studied first were the annual edible plants, which take a short time (2.5 – 4 months) to provide conclusive results and appropriate inferences. After the annual plants, perennial food crops were also studied, and then non-edible seed-bearing plants such as the eucalyptus were added. Annual crops such as beans, maize, groundnuts, sorghum, rice, which took days to germinate, also took months to become ready for harvest. Perennial crops such as mangoes, jack fruits, and guava, which took many weeks (months) to germinate, were ready for harvest after some years. This corresponded to the number of weeks they took to germinate. These scientific observations were repeated

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several times, where different seeds were sown in one seed bed, while noting the variations in the germination time, and later transplanted as their growth patterns were being watched. Rice, grown in a seed-bed first, then later transplanted, bloomed so well, and looked healthier than that which was planted directly. However, the time both spent to mature for harvest was the same.

Using the readily available seeds of the beans, ground nuts, and maize, the researcher was surprised to see the seeds sprouting up after 2.5, 3, 4, and 5 days, yet he was preparing for a lesson that would be conducted some 8 days ahead. By the time of the lesson, the evidence of epigeal would be very remote. The cotyledons that come from the soil with the growing shoot would have fallen off. This compelled the teacher to repeat the experiment, sowing some other seeds again. Similar results were found, compelling him to find out more and more about other seeds of different plants, how long each species takes, and how each of them grows to maturity.

- *Objectives of the Study*

The Purpose of the study, therefore, was to find out how long different seeds take to germinate and the relationship between the time taken to germinate and plant maturity. The study was carried out:

- To investigate whether the time taken for seed germination correlates proportionally with the plant's maturity and harvest readiness.
- To examine the factors that favor seed germination and plant potency.

- *Significance of the Study*

This principle has potential implications for Agricultural planning, allowing farmers to estimate harvest periods based on germination time, Crop selection, and breeding, enabling agronomists to optimize crop varieties for different climates and growing seasons, and scientific understanding of plant development, contributing to theories of resource allocation and growth efficiency.

- *Scope of the Study*

This research focuses on edible plants, including both annuals and perennials, to assess whether the germination-maturity correlation holds across diverse plant types. The study was conducted over two decades in western Uganda, a region with diverse agro-ecological conditions, providing a robust dataset for analysis. The methodology used involves direct observation of germination and maturity periods, ensuring that conclusions are based on long-term empirical evidence.

- *Research Questions and Hypothesis*

This study seeks to answer the following questions:

- Is there a proportional relationship between germination time and plant maturity in edible plants?
- Are there exceptions to this correlation, and what factors might influence deviations?
- How can this principle be applied to improve agricultural decision-making?

The research is guided by the hypothesis that plants with shorter germination times mature and produce harvestable yields more quickly, whereas those with longer germination periods require extended time to reach full maturity.

II. LITERATURE REVIEW

- *Introduction*

Understanding the relationship between seed germination and plant maturity is critical in agronomy and plant developmental biology. Existing literature offers valuable insights into the physiological, genetic, and environmental factors that underlie plant growth cycles, leaving the predictive value of germination time in estimating crop maturity underexplored. This study summarizes key findings regarding the time relationship between seed germination and plant or fruit harvest readiness.

- *Relationship Between Seed Germination and Plant Maturity*

Seed germination has long been studied as the initial and often decisive phase of a plant's life cycle. Bewley and Black (1994) provide an extensive analysis of germination physiology, describing it as a complex process regulated by water uptake (imbibition), enzymatic activation, and hormonal signaling. Their work suggests that the speed and uniformity of germination can influence seedling vigor and early growth performance, which may have downstream implications for plant maturity.

Complementing this, Finch-Savage, and Leubner-Metzger (2006) emphasized the role of dormancy- breaking mechanisms and hormonal control in initiating germination. They suggest that variability in germination timing across species could be evolutionarily linked to life cycle strategies, implying a potential correlation with developmental durations.

The idea of temporal predictability in plant development has also been explored through phenological modeling. Erickson and Michelini (1957) introduced the plastochron index, a concept for quantifying plant development based on the timing of morphological events. This approach supports the hypothesis that early growth cues, such as germination rate, may forecast later developmental milestones. McMaster and Wilhelm (1997) further advanced this framework with the growing degree-day (GDD) model, which uses thermal time accumulation to predict crop stages. These models reinforce the notion that germination time, which is often influenced by temperature and moisture, can be a useful parameter in forecasting maturity periods, especially when applied across multiple crop species.

Genetic and environmental factors also play a crucial role in shaping the duration between germination and

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maturity. Wilczek et al. (2009) demonstrated how genetic perturbations in Arabidopsis thaliana affected flowering time and developmental plasticity under seasonal changes. Their findings underscore the interplay between genetic programming and environmental stimuli in determining growth duration. Similarly, Koornneef and Meinke (2010) highlighted how model organisms have been instrumental in uncovering genetic loci associated with growth timing, lending credence to the potential for genetic markers to predict crop cycles based on early developmental traits.

In applied agricultural contexts, early vigor, stemming from rapid germination, has been linked to improved yield outcomes in challenging environments. Blum (2011) posited that in water-limited systems, early-developing crops have a selective advantage, suggesting that breeding for faster germination may indirectly select for shorter maturation periods. Sadras and Calderini (2015) supported this by advocating for the integration of physiological modeling into agronomic decision making, particularly in aligning cultivar selection with environmental conditions and crop calendars.

Studies focusing on specific crops further demonstrate the practical correlation between germination and maturity. Rehman and Harris (2000), for example, found that salinity-induced delays in barley germination also resulted in extended time to maturity, indicating a mechanistic link between early and later stages of development. Similarly, Ellis and Roberts (1981) showed that seed aging and vigor significantly affect germination rate and, by extension, the uniformity and timing of maturity in many orthodox seeds.

- *Seed Germination and Plant Potency*

A study by Abdul-Baki and Anderson examined the relationship between the decarboxylation of glutamic acid and seed vigor in soybeans. The study, which specifically investigates the impact of glutamic acid decarboxylation on seed germination, seedling growth, and overall seed quality, found that decarboxylation is a key factor influencing seed vigor, with higher levels of decarboxylation correlating to improved seed performance (Abdul-Baki & Anderson 1973). This study confirms the fact that seed vigor as well as seed germination can be influenced by many factors beyond the commonly known water, air (oxygen in the soil), and temperature/warmth as key influencers. The study further provided valuable insights into the biochemical processes that are fundamental to seed vigor in soybeans. Such findings are key to the way seed quality can be assessed and improved in order to ensure successful crop production.

Carlos Alberto Busso (2013), in his book ‘From Seed Germination to Young Plants’, makes it clear regarding ecological and environmental Influences on seed germination and plant growth. Even when the book establishes more information, the writer does not hint at the relationship between these influencers or how growth rates relate or correspond to plant maturity. This is what this study has established.

Carol (2000) provides a working hypothesis of the ecological and environmental conditions under which various kinds of seed dormancy have developed. Seed predation and dispersal, environmental stress, light and temperature, and resource availability are some of the factors that he lists in his work.

Taken together, this body of literature affirms that seed germination is not merely an isolated phase but an integral component of the broader plant growth cycle. The convergence of physiological, environmental, and genetic research supports the hypothesis that germination time can serve as a practical predictor of plant maturity. These insights provide a conceptual basis for your study and highlight the potential applications in crop planning, breeding, and yield forecasting.

III. METHODOLOGY

This chapter presents the research design, study area, study design, sample crops, how data was collected and methods used, data analysis and data quality control.

- *Study Area*

This study was conducted in western Uganda, a region characterized by diverse agro-ecological zones, including tropical rainforests, savannah, and highland areas. These varied conditions provided an ideal environment for observing different edible plant species under natural growth conditions. The study area experiences two main rainy seasons (March–May and September– November) and an annual temperature range of 15–30°C. These conditions favor seed germination and plant development.

- *Study Duration*

The research was carried out over 22 years, from 1998 to 2020. After 5 years of repeated observations, the researcher was about to conclude the findings about the germination-maturity correlation in annual plants. However, he felt he was not yet done because there were more plants that he needed to observe as well. The extended timeframe allowed the researcher to observe multiple plant species repeatedly and across different climatic conditions, reducing the impact of seasonal variability on the findings. Perennial plants required the researcher’s patience to collect the right data.

During the study period, patience is key. For example, the soil should not be removed to find out whether the seed or seeds are still in the soil, as this may hurt the epicotyl and, in turn, affect the process of germination. The epicotyl should itself crack the soil. For perennials such as coffee, checking was done daily, but after the first two weeks. For jack fruit seeds that take a little longer to appear, checking was done every two days after the first 5 weeks, but within the 6th week, checking was also done daily to note the particular day the epicotyl fissured the soil to allow the shoot to sprout. Here, it took a full week after the soil was opened to fully see the shoot. What appears first is the spine of the sprouting seedling. The leaf structure appearance delays a little longer, but actually, the seed has germinated.

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To determine how many years this plant will take to bear fruits, the sowing date records can be used in juxtaposition with the day and time the spine of the epicotyl springs up. The epicotyl usually appears pointed in form of a goad / spine that fissures the soil; and then the leaf structure will follow.

Over the years, the researcher has been testing and retesting to affirm his findings. This is what has extended the publication of results.

- *Selection of Plant Species*

The study focused on a diverse set of edible plants, including annuals, biennials, and perennials, to assess the consistency of the Germination-Maturity Principle across different growth habits. Selected species included:

- Fast-germinating, short-maturity plants such as Beans (*Phaseolus vulgaris*), Maize (*Zea mays*), soya beans (Glycine max), sim-sim (sesame/sesamum), ground nuts (Arachis hypogaea)
- Slow-germinating, long-maturity plants: Mangoes (*Mangifera indica*), Avocadoes (*Persea americana*), Jackfruit (*Artocarpus heterophyllus*), Soursop (*Annona muricata*)

- *Data Collection Methods*

- *Recording Germination Time*

For each plant species, seeds were sown in natural field conditions and also in a seed-bed and germination time was recorded in terms of the number of days or weeks that passed for each seedling to emerge from the soil after planting. Observations were repeated across multiple planting cycles to ensure consistency.

- *Recording Maturity and Harvest Time*

The time taken from sowing through germination to the first harvestable yield was recorded in weeks, months and years. The harvestable time was determined based on the plant's standard maturity indicators, such as pod hardening and fruit ripening and fruit or pod color changes.

- *Data Verification and Cross-Checking*

Observations were cross-checked with agronomic records and existing agricultural literature. Local farmers and agricultural experts were consulted to confirm plant-specific maturity timelines. Data inconsistencies (e.g., delays due to weather, pest attacks) were noted to minimize bias.

- *Data Analysis*

A correlation analysis was performed to assess the relationship between germination duration and plant maturity, where data were categorized into short, medium, and long-term germination groups, and corresponding maturity times were compared.

- *Limitations of the Study*

Some plants exhibited environmental variability affecting germination and maturity (e.g., drought conditions). Only naturally grown plants were studied, meaning results may differ for genetically modified or selectively bred crops. The researcher concentrated on edible plants whose maturity was easy to determine.

- *Study Results*

Different plant species takes different times to germinate or emerge from the soil. For example, most beans took between 3 to 4 days to fissure the soil as shown hereafter.

- *General Observations of Results*

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Fig 1 Observing the Sprouting Bean Seeds

- *NB*

Simple variations were also observed. Not all seeds planted at the same time, on the same seedbed under the same conditions cracked the soil at the same time. While the researcher attributed that kind of variation to the seed's rate of imbibition while in the soil, it was also observed that even mangoes, bananas, guava, jackfruits… growing on the same cluster or sharing one stem, one receptacle or growing on the same vine did not ripen at the same time.

While in A, the two seeds had spent 72 hours in the soil, in photograph (B), the same seed in A on the right was re-observed 8 hours later. This implies that it was 80 hours old.

In beans, the changes are easy to notice in the first week. This was within day 4.

It must be made clear that there are simple variations in germination and growth due to several factors such as seed health, soil type, amount of water in the soil and many other factors that will be explained later.

The ground nuts and the maize took between 4 and 4.5 days to break the soil or appear on the surface.

Fig 2 Observing the Germination of Groundnuts

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This photo was taken 4 days after the sowing time 18 hours later, another photo was taken for the same seed bed and some other seed had also sprouted. These variations will always be occurring but they depend on many factors highlighted in this study.

Hour after another, there are observable changes on the germinating shoot. Leaf size, leaf length and as well as number of leaves keep changing with time.

Fig 3 Observing the Germination of Maize Seeds

The maize seedling was observed and the photo above was taken after four days. On the sixth day (that is, 2 days later), it was further observed and results were different as shown above.

The Avocados and Mangoes took between 5 to 6 weeks, while the jack seed took up to seven weeks. Under certain circumstances, these perennial plants may also exceed the well-established length of time in terms of days or weeks to germinate. Other examples among the many seeds and seedlings studied are shown hereafter.


Fig 4 Observing the Germination of Mango Seeds

In this photograph, two mango seeds from the same tree were sown in the same soil on the same day.

During the first four weeks, there was no sign that something was planted in this soil.

After five weeks, the soil showed some crack. Two days later, a pointed whitish tip showed up and kept increasing day after day. 4 days later, another one appeared.

This photo was taken at the end of week 6. The soil was the same, the ecological conditions were the same, the seeds were from one tree but the rate of germination was not the same. These variations cannot miss but there is always an average time if you repeat the experiment severally in different environments. This too is the same mystery that science should explain regarding fruits, such as mangoes on the same stalk won't ripen at the same time.

At $5^1/2$ years, both of them flowered in the same month. Although the first season was very poor, the 2nd became better.

For every seed studied, there was a very close relationship between that seed's length of time to germinate and the time its plant took to bear mature or harvestable fruits. For example, for the beans whose seeds took 3 days to germinate, their fruits (pods) matured after three months and were ready for harvest. For the ground nuts that germinated after 4 days, they took four months to have mature pods ready for harvest.

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Fig 5 Observing the Germination of Jack Fruit Seeds

In the above photograph, the researcher decided to open the soil trying to see if the seed was still there. This hurt the seed which had started germinating inside. However, it did not hurt the growing shoot (plumule / embryo) in the soil. So, germination continued. The seed (right) had not started germinating and it never germinated at all.

The jack fruit seeds that took 7 weeks in the soil, also took seven years to produce mature fruits. After six years, some fruits began to appear but they eventually withered off. This happened to 99.7% of all jack fruit trees that were under study. However, 0.3% of the plants under study behaved differently.

Example, one of the plants was sown on Feb. 3. 2002. It took similar time like the others to germinate but up to March 2025, it had not had mature fruits. They appear and eventually wither off year in, year out. However, something to note is that, the first fruits began to appear towards the end 2008, just about 7 years later, although they kept falling off. Further observation of the same plant was made in February 2025 when the plant was 23 years old. I had not had any mature fruit. The fruits were still falling off before they mature. The area which was found in the copper drain valley seems not to be good for jack fruit production. This is another area of investigation.

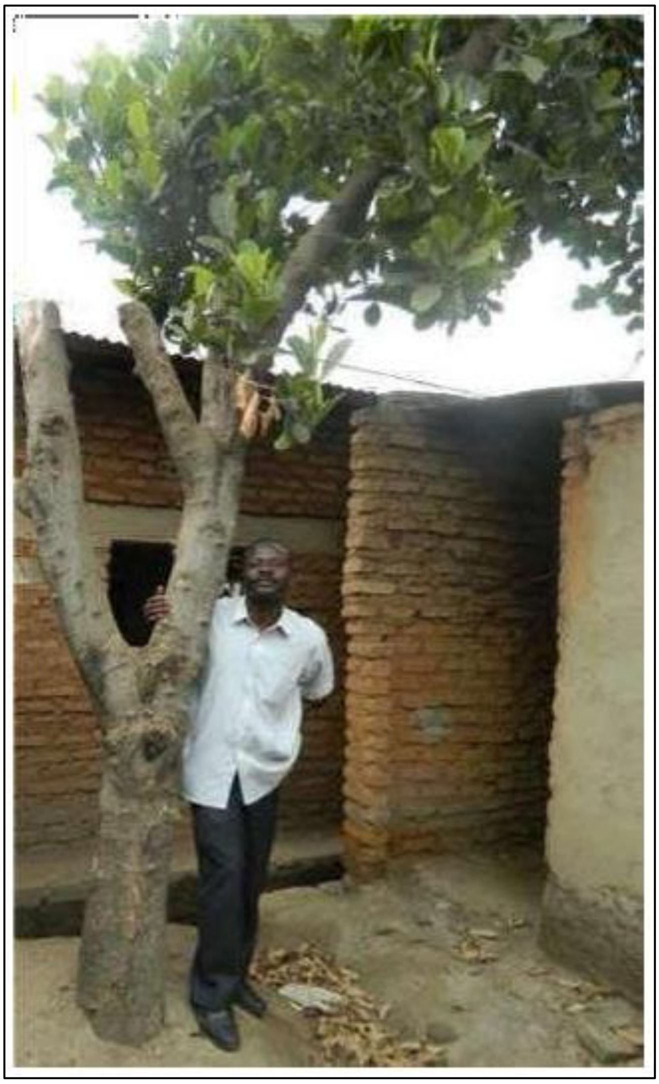

Fig 6 The Jack Fruit Plant that Never Matured

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The jackfruit tree in this photograph was planted on February 3, 2002. By August 28, 2018, when this photograph was taken (17 years old), the tree had not had mature fruits. Every season, it blossoms like the other trees, but the fruits begin to rot and eventually fall off. The tree was to be cut to allow construction to take place, but the researcher continued to give it more time to see if it would bear fruit. In 2025, the plant had not matured any fruit.

An Avocado that was planted on the same plot did not mature. Fruits kept rotting before they were mature.

For this tree in the photograph, some branches were also cut down for firewood, but fresh buds that signaled vitality continued to emerge fruitlessly.

This place in the photograph is located a few kilometers from the equator, which is in the south, in almost equal proximity to the snow on the Rwenzori Mountains in the north. It is an equatorial zone with an equatorial climate (hot & wet throughout the year).

What was the problem? Was the soil lacking temperature, Air / Oxygen or water? The findings have shown that there are more than just these three factors contributing to the problem.

Although at the end of six years some of the jack plants that were studied yielded mature fruits, by the end of the seventh year, plants that were to mature were fully matured and bore fruits ready for harvest. No plant got to the eight year without fruits, save the that which never yielded at all. The process of growth and development happened without loss in time where conditions were favorable. This study led to the Germination-Maturity Correlation Principle, also known as the principle of seed germination and plant maturity, which the researcher stated as follows:

The number of days or weeks a seed takes to germinate corresponds proportionally to the number of months or years it takes for the plant to reach harvestable maturity.

The researcher found out that in edible plants, there exists a proportional relationship between the duration of seed germination (measured in days or weeks) and the time required for the plant to reach harvestable maturity (measured in months or years). Plants with shorter germination periods tend to mature and yield edible produce within a shorter timeframe, whereas those with prolonged germination periods generally require extended growth phases before reaching fruiting or harvestable stages.

From the study a consistent proportional relationship between the time taken for a seed to germinate and the duration required for the plant to reach harvestable maturity was revealed.

Plants that germinated within a few days matured within a few months. The study observations for this category primarily focused on maize, beans, soybeans, groundnuts, and sim-sim.

Plants that took several weeks to germinate required more than a year to mature. They took as many years to reach harvestable maturity as the weeks it took their seeds to sprout. The study observations for this category centered mainly on mangoes, Avocados, Jackfruits, soursop, and guava.

➢ *Quantitative Data on Selected Edible Plants*

The following table summarizes the germination period and corresponding maturity periods for key plant species observed in the study:

Table 1 Sample Seed Species Used and the Observation Results

	Seeds / Species	**Germination Period**	**Observation and Findings**
1.	Beans	Within 3 days	Results were easy to get as seeds did not take long to germinate.
2.	Soya Beans	Within 3.5 days	The researcher repeated the experiment several times to confirm the results in line with fruitage. The longest was 4 days.
3.	Maize	Within 4 days	The longest was 5 days.
4.	Sim-sim	Within 2 days	The longest was 4 days.
5.	Ground Nuts	Within 4 days	The longest was 5 days.
6.	Mango seeds	Between 5 to 6 weeks	The researcher lost track at first because of the length of time. After he had abandoned the seedbed, he saw the seedlings. As a result, he repeated the process, noting in a book the sowing date and time to track the time. This time, he was resilient until he saw the first germinating seed fisher the soil.
7.	Jack fruit Seeds	Within 7 weeks	
8.	Eucalyptus	From week 4 to week 5, more shoots were appearing.	Follow-up had no motivation as the researcher was not able to measure the ripeness of the fruit.

➢ *Important to Note*

- Sim-sim was found challenging when relating its germination period to harvestable time. While the pods matured within 2 months, the harvestable time was a little longer than 2 months because sim-sim is harvested only when the seeds have started drying up within the pods.
- Jackfruit seeds and mangoes did well when they were sown still humid, that is, as soon as they were removed from the fruit without waiting to dry them. The study observed that while for some plants (such as maize, beans, groundnuts), their seeds are dried to make them ready for sowing, in some plants, mainly perennials like jack fruits, mangoes, cocoa, etc., drying the seeds makes them die. They do not germinate.

IV. DISCUSSION

➢ *Introduction*

The results of this 22-year observational study provide strong evidence supporting the Germination Maturity Principle, which the researcher states as: '*The length of time a seed takes to germinate corresponds proportionally to the time required for the plant to reach harvestable maturity'*. This section interprets these findings in the context of plant biology, agricultural applications and potential influencing factors. The length of time stated above is in terms of days, weeks, or months. This can further be refined as follows:

The number of days or weeks a seed takes to germinate is proportional to the number of months or years the plant takes to reach harvestable maturity. In this principle, days correspond to months while weeks correspond to years. If a seed germinates in three days, it will take 3 months to reach harvest. If it germinates in 6 weeks, it will take 6 years to reach its harvest.

➢ *Biological Basis of the Germination-Maturity Correlation*

The observed link between germination time and maturity period matches basic biological growth patterns. Here are some of these patterns:

- *Metabolic Rate and Growth Strategy*

Fast-germinating plants such as sim-sim, beans, maize, etc., exhibit rapid vegetative and reproductive growth, allowing them to complete their life cycle within months. In contrast, slow- germinating species like the mango, avocado, and jackfruit require more time for root establishment and vegetative development before entering the reproductive phase.

- *Resource Allocation Theory*

Plants that take longer to germinate often invest more in long-term structural development. Examples are the woody stems, deep roots, etc. This supports sustained reproductive output over multiple seasons. Here, allocation of resources should be made with this knowledge in view.

- *Dormancy and Germination Delays*

Some seeds, particularly those of perennials, undergo dormancy to ensure survival in unpredictable environmental conditions. This contributes to delayed germination and extended maturation periods. But it is important to understand the conventional period should the environment remain friendly.

➢ *Implications for Agriculture and Crop Planning*

Understanding the Germination-Maturity Principle has several practical applications in agriculture:

Firstly, the study helps farmers and Agricultural planners in Predicting Harvest Time. Farmers can estimate crop maturity based on observed germination time, allowing for better planning of planting schedules and harvest periods.

Secondly, the farmer can Optimize Crop Selection. Short-germination crops (such as beans and other vegetables and grains) are suitable for short-term agricultural cycles, while long-germination crops (like fruit trees) are ideal for long-term investment farming.

Thirdly, the study helps in Improving Breeding Strategies. Selective breeding and grafting techniques can be used to modify germination and maturity times, optimizing yield efficiency without compromising quality.

➢ *Factors Influencing Variability in the Correlation*

Although the study confirms a strong relationship between seed germination time and plant harvestable time, some variations were observed due to:

- *Environmental Circumstances*: Climate, soil fertility, and water availability in the soil affect both germination and maturation rates.
- *Genetic Differences*: Some varieties within the same species exhibit differences due to selective breeding or natural adaptation.
- *Agronomic Practices*: The use of fertilizers, pruning and irrigation can accelerate or delay plant maturity. Soils in which fertilizers have been introduced will always require fertilizers every season.
- This means, if a farmer can avoid fertilizers and apply are forms of maintaining soil fertility, like the use of compost manure, mulching, the soil will remain natural without external harm.
- *Pests and diseases*: Pests such as goats, cows, rats, and other wild animals can greatly affect plant growth and plant maturity. When pests attack the plant, its health is compromised, affecting plant growth. Animals eating up the plant may lead to destruction (depending on how much of the plant was eaten up) or delayed growth and development because a new shoot has to first develop. This also delays maturity as well as harvest.

➢ *Notable Exceptions and Influencing Factors*

While the overall trend was consistent, a few exceptions were noted including environmental conditions (such as drought or excessive rainfall) that caused variations

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in maturity time but did not alter the general correlation. Seed size and seed health caused variations in both germination and plant development. Seeds looking smaller than the others of the same specie took longer time to germinate. Seed sizes of maize, groundnuts, beans, and sim-sim, especially when harvested from the same pod, affected the rate of plant growth.

Furthermore, plant growth and development were also found to be affected by pests and diseases. For instance, a jackfruit and a mango whose shoot was destroyed by free-range animals delayed reaching flowering as well as harvestable time. Animals eating up the shoot once can mean one more year to reach maturity, depending on the degree of destruction. The frequency of destruction determines how long the plant delays to mature.

In addition, there can be other exceptions, such as the depth at which the seed was sown. Soil acidity or contamination cannot be ignored. For instance, the jackfruit that failed to mature was planted in an area that was found so much contaminated with copper as a result of erosion caused by River Nyamwamba, which runs through the copper belt of Kilembe on Mount Rwenzori, where the study was carried out.

- *Comparison with Existing Scientific Literature*

Prior studies in plant physiology and agronomy support the idea that fast-germinating crops tend to have short growth cycles, while slow-germinating species follow a longer ontogenetic trajectory (Niklas & Enquist, 2001).

The data found on seed dormancy and plant longevity (Fenner & Thompson, 2005) also suggests that species with extended germination times have evolved for long-term survival and reproductive success.

This study expands on previous work by establishing a quantitative framework linking germination and maturity, which has been largely anecdotal in agricultural sciences.

Stone, Cozens & Emina (1976) clearly stated that there are three conditions necessary for germination to take place. These three are water, temperature and Oxygen. This is further confirmed by Derek Bewley, et al. (2006). Similarly, William Keeton. (1973), in his book, '*Elements of Biological Science'* does not differ from the above biologists on the conditions that favor germination and plant growth and development.

Fawaz Kurdali (2016) expands the list of the factors by adding light and soil salinity. He states that "Although salinity stress mostly reduces germination rate and delays the onset of germination, its effects are modified by interactions with other environmental factors such as temperature and light. Salinity can affect germination by affecting the osmotic component.

Whereas all the above authors complement one another on a few factors or conditions necessary for germination to take place, they are silent on germination's relationship to plant maturity. This study in seed germination has revealed that there more factors to consider or conditions for germination to take place and that these same factors play a big role in determining plant blooming and maturity which follows after germination.

For the validity of the new principle above, water, air (O_2 in the soil) and warmth or temperature, soil salinity and light are not the only factors to consider. The study found out that there are other factors linked to the ecological conditions of the seed's natural habitat and to its physiology.

Early researchers have been silent on these variables and their contributions to plant maturity:

- Seed size (which should be natural)
- Soil health (absence of pollutants and contaminants) iii. Seed health
- Seedling health & safety (Pest & disease control).
- Soil type (topsoil preferred)
- Sowing depth (a few centimeters deep for most edible seed plants, unlike bananas, where the sucker is buried at dreadful depth).

It is important to note that a seed which would take 3 to 4 days to germinate can keep in the soil for a week or so without germinating. This is called seed dormancy (Baskin 2004). But it has causes. Some of the causes are the factors that have been listed above.

Conversely, there are circumstances that can make the seed expire within the soil. This is beyond seed dormancy and can happen if:

- The soil is very dry deterring imbibition which enhances cellular metabolism and also lead to the rapture of the seed coat and;
- The soil has impurities or is contaminated with substances that can destroy the seed.
- The sun's heat scorches the seed within the parched soil,
- The soil has extraneous elements that may interfere with the circulation of water, air and mineral salts
- The seed is affected / sick.

Abnormal seed size also affects the rate of germination. Stunted seeds require more time to germinate than standard-sized seeds. This is because the uptake of water into the seed is very slow, delaying cellular metabolism that helps in the development of the embryo as well as helping the seed coat to open up for the radicle and epicotyl to grow outside the seed (Keeton 1973).

Favorable conditions also mean that within the period between sowing and the blossoming of the plant, there is no drought, no hailstone, no attack by pests and many other conditions that may interfere with plant physiology, which, in turn won't exhibit the relationship expressed in the principle above.

Studies have shown that poor quality of seeds affects the final crop stand and delays the onset of germination even in the presence of air, water warmth. This too, will adversely affect the potency of the seedling. Seed size and quality will have adverse effects on germination (Misra and Zala 2010).

When pests such as goats, cows, and pigs eat up the shoots or buds of a growing plant, its growth is retarded. For plants such as the jack that takes up to seven years to mature, the period can extend up to eight or even more years, depending on the frequency of visitation or the extent to which the plant was damaged by the pests.

In a separate study, some trees whose shoots were destroyed delayed bearing fruit. For the tree that was badly damaged, it took a time longer than that which was not seriously damaged by the animals. Delay in maturity for mangoes, avocados, and Jack fruit trees (most perennials) due to damage by pests ranged between 1 – 2 years according to the study.

➢ *Future Research Directions*

To further validate these findings, additional research is recommended:

Experimental Studies or controlled trials under standardized conditions to eliminate environmental variability should be carried out.

There is a need for Genetic Analysis to help investigate molecular mechanisms that regulate germination speed and growth rate.

Exploring how this principle can inform genetic modification and breeding programs for higher yields should be done.

Experimental Studies regarding the impact of certain minerals in the soil on plant fruitage should be carried out to establish what specifically hindered one plant sown in the Cooper Drain Valley from developing mature fruits for over 23 years.

Furthermore, there is a need to study the basis for variations in fruit size, fruit growing rate, and fruit ripening, especially when the fruits are growing on the same vine, same stem or stalk. This is common in bananas, beans, tomatoes, groundnuts, mangoes, etc., growing on the same stem/stalk.

V. CONCLUSION AND RECOMMENDATIONS

➢ *Conclusion*

This study provides strong empirical evidence for the Germination-Maturity Principle, which states that the time taken for a seed to germinate corresponds proportionally to the period required for the plant to reach harvestable maturity. Based on 22 years of observations in western Uganda, the findings confirm that:

Fast-germinating crops like beans, soya, sim-sim, maize, tend to have short growth cycles, reaching maturity or harvestable period within a few months.

Slow-germinating species like mango, avocado, jackfruit, soursop, exhibit extended growth cycles, often taking multiple years to reach harvest time.

A strong positive correlation exists between germination duration and maturity time, suggesting a biological basis linked to growth strategy, resource allocation and environmental adaptation.

These findings contribute to a better understanding of plant development timelines and offer practical applications in agriculture, crop selection and breeding strategies.

➢ *Recommendations*

For Farmers and Agricultural Planners, germination time should be used as an indicator of crop maturity when planning planting schedules.

Diversify crop selection based on expected growth cycles, balancing short-term and long-term yield potential.

Adopt best agronomic practices like irrigation, fertilization etc. to optimize both germination and maturity timelines.

For Researchers and Plant Scientists, there is a need to conduct controlled experiments to further validate the Germination-Maturity Principle across different environmental conditions. Researchers should explore the genetic mechanisms regulating seed germination and plant maturation rates.

Furthermore, researchers and plant scientists should investigate the potential for breeding and grafting techniques to optimize growth cycles for improved food production. For policymakers and Agricultural Institutions, it is important to develop extension programs to educate farmers on the relationship between germination and crop maturity.

There is also need to support research and innovation in plant breeding to improve crop productivity based on these findings. Policy makers should also encourage climate-smart agriculture by promoting crops with predictable maturity periods suitable for specific regions.

Further study should be carried out on many other plants especially none-food crops, to determine their maturity and how long their seeds take to germinate and the relationship of their germination period to their maturity. Wild plants and non-flowering or seed bearing plants should also be studied.

Generally, the knowledge of the relationship between seed germination and plant maturity should be helpful to farmers, development workers and science teachers in a number of ways:

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For educationists (especially teachers), they should not depend only on the knowledge in the text books. Sometimes the writers may have had limited experience and knowledge. For instance, this study brings on board more other conditions necessary for germination to take place besides what early researchers have been able to put in books. Teachers should always be practical in their work and should love and be the source of knowledge. Through practical work, learners observe and note new ideas that may even be outside the teacher's intended content. They may ask the teacher about their new findings and observations or about new knowledge. However, if not encouraged, they may keep quiet but with new knowledge which they may apply later. Thus, practical lessons should be emphasized in education. The teaching and learning process should be made practical in all subjects. This is the only way educators will impact the lives of the learners and transform society for sustainable development because *Practice makes [learning permanent]*.

For farmers, they should adjust or make changes in terms of when to plant (in regard to the climate of the area), and which crops to plant (based on when the farmer wants to harvest). This is very important for barren areas, like most parts of Rwanda. In Rwanda, where the researcher also tried to observe some edible plants, the results were very different until he discovered that the soils of the country were very poor. When he prepared his own soils from rotting plant material and animal waste, the results became consistent with what he observed in western Uganda. Plants that take a short time to harvest become less expensive in terms of labor than those that take longer. In addition, this knowledge can help the local people in controlling hunger and country-wide famine.

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