ASPECTS OF THE BIOLOGY OF TAMARIND (*Tamarindus indica L*) SEEDS AND SEEDLINGS

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DECLARATION

I hereby declare that this thesis has been composed by me and that it is a record of my own research work. It has not been accepted in any previous application for a higher degree. All quotations are distinguished by quotation marks and the sources of information are specifically acknowledged by means of references.

Barnabas A. Gankon

Date:.....

CERTIFICATION

This Thesis entitled – Aspects of the Biology of Tamarind (*Tamarindus indica* L) Seeds and seedlings, by Barnabas A. Gankon, meets the regulation governing the award of the degree of M.Sc Educational Biology of Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and Literary presentation:

Chairman Supervisory Committee

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Member Supervisory Committee

..... Date:.....

Head of Department

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Dean of Postgraduate School

..... Date:.....

DEDICATION

This Thesis is dedicated to my Parents, my beloved Wife and all those who thirst after righteousness.

ACKNOWLEDGEMENT

I wish to acknowledge the following whose contributions brought about the successful completion of this work.

First of all, I am endebted to my Supervisor Dr. S. Muazu who gave me valuable suggestions and made corrections right from the beginning to the end of this work. My thanks goes to Dr. Mrs C. Ajakaiye for her assistance with some materials used for this work. I also thank Dr. C. Annene for his assistance in identification of the pest infesting the seeds.

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ABSTRACT

A study on the aspects of the Biology of Tamarindus indica L was carried out from 6/7/90 - 24/12/90, in Zaria which is in the Northern Savanna zone of Nigeria.

Tamarjndus indica L is an economic tree of much value. Almost all its parts are useful. Although it is of such economic value, purposeful propagation of the plant in Nigeria is not done.

A period of dormancy is exhibited by Tamarind. To release this dormancy period, various treatments were used, these being mechanical scarification, concentrated sulfuric acid, pulp extract soaking for 5 days, Distilled water soaking for 5 days, Hot water treatments at 50°C for 30 and 120 minutes, 70°C for 30 and 60 minutes, and 90°C for 5 and 10 minutes time exposures. A control of non-treated seeds was used.

Four experiments were conducted to determine the germination and epicotyl emergence of the seed and seedlings. From this the speed of germination of 3 different seed lots was determined along side with the various treatments. Morphological aspects of the seeds and seedlings were also determined.

The data were analysed using percentages, means, Analysis of variance (ANOVA) and Correlation. ANOVA at P = .05, LSD and SSR showed significant difference between treatments and seed lots, with no difference between replicates for the relationship between treatments and seed lots to germinability. There was significant differences between treatments on the day germination was first noticed; with the concentreated sulfuric acid treatment having earliest germination and also higher percentages, followed by Mechanical scarification treatment.

Epicotyl emergence was similar to germination. Early germination also resulted to early epicotyl emergence. The earlier the germination and epicotyl emergence, the earlier the seedlings establishment. The vigorous seed lots were determined using a visual vigour rating scale which considered germination, epicotyl emergence speed, number of leaves, and leaflets, stem and root length, and seedlings dry weight with the result showing the C seed lot best followed by A and then B seed lots.

Germination in Tamarind is epigeal. No difference between seed lots as regards to number of leaves, within the experimental period existed, but there was for leaflets. The range for the number of leaflets was 6 - 1 1 pairs. The seedling's paired Eophills were found to be opposite each other with 4 stipules while other leaves alternate and have 2 stipules each.

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CHAPTER I

1.1 INTRODUCTION:

Tamarindus indica L is an Angiosperm in the family Leguminoseae and sub-family Caesalpinoideae. It is a common economic tree found growing throughout the Savanna grassland.

According to Dalziel, (1937) it is probably African but introduced to India long ago. The pulp of the Indian variety is welled developed and juicy than the African variety. This might have been as a result of selection. In Africa, it is found predominantly in the Tropical West Africa. In Nigeria it is mostly found in the Northern part of the country. The plant is esteemed for its pulp and use of many other parts of the tree such as, the flower and barks used for medicine to cure leprosy; and the seeds have been found to be a good source of protein and hence can be used as supplementary animal feeds, (Ega, 1986). Also it can be used for Jams, Jellies and confectionary (Dalziel, 1937).

Although the plant is of so much economic importance, nothing much has been done in purposeful propagation of it especially in this part of the world. The seed is the organ of propagation. Its germination is therefore fundamental for utilization of the plant. A period of dormancy is often exhibited by the seeds. It is therefore the duty of this work to determine the cause(s) of this and ways through which the seeds can be easily propagated. The dormancy caused could be as a result of morphological or

physiological factors causing exogenous and endogenous dormancy respectively. While seed dormancy is found common in legumes, Bewley and Black (1982); showed that the typical cause is due to seed coat - imposed impremeability.

Various forms of treatments have been done in order to increase the rate and chances of germination of seeds of different kind. These include: Chemical, Heat, Soaking, stratification and scarification. The scarification treatments include, mechanical and Acid treatments. These treatments with the exception of strafication were used in this work, just as were employed by Singer and Pitman (1988), Kheradnam and Bassiri (1980) and Clemens et al (1977) on other types of seeds.

Among other things this work soughts to determine the relationship between germination, epicotyl emergence and seeding vigour and its establishment within the breeding lines as determined by Taylor and Baltensperger (1987), Lawan et al (1985); and Ibikunle and Komolafe (1973) on other types of seeds. Also, the general morphology of the seed and seedlings were determined.

In all, four experiments were conducted, using the various types of treatments. The experiments were conducted under the normal daily room temperature.

A seed was determined germinated when the series of processes which transforms it from an inert state to a most active growing entity with the manifestation of growth

being the protrusion of the radicle which signals the end of germination (Heydecker 1977). The seeds with radicle protruding upto about 2mm long were determined germinated as in Mabo et al (1988).

1.2 STATEMENT OF RESEARCH PROBLEM:

This work is meant to determine the Aspects of the Biology of Tamarind seeds and seedlings. The following are addressed to:

(i) investigation into the morphology of the seed and seedlings.

(ii) Physiological aspects of the seed and seedlings which includes:

(a) determination of the cause(s) of delay on germination of the seeds (dormancy) and how to solve them.

(b) relationship between seed weight, genotype to the rate of germination and seedling vigour.

1.3 SIGNIFICANCE OF STUDY OR JUSTIFICATION:

An observation has shown that Tamarindus indica L. is not purposefully cultivated in this country even in the Northern Nigeria where it is predominant and mainly used. Despite the increasing research work which determines more uses for the plant, its domestication is yet to reach the extent of purposeful seedling development and cultivation

as in other economic trees. It is not just enough that the seeds germinate but doing so at the right time and place is most important. Therefore this work attempts to determine how seedlings can be easily raised for purposeful cultivation of the plant. It is invisaged that this can lead to subsequent improvement of the plant production rate to cope with increasing requirement as further investigation, or research work reveals more and more uses of the plant. Also of importance is the morphological aspects of the seeds and seedlings.

1.4 SCOPE OF STUDY:

This work or study covers the following:

(i) Physiological aspects of seed and seedlings.

(ii) Morphological aspects of seeds and seedlings.

(iii) Pest of seeds and seedlings.

(i) Physiological aspects of seed and seedlings.

The germination aspects of the seeds and seedlings will be the main area of concern. This will incorporate the following:

- the rate of germination using various treatments.
- determination of causes of dormancy.
- determination of type of germination.
- determination of seed quality and seed vigour of the 3 lots of seeds which are of different genotypes.

- determination of seed weight relationship to rate of germination and seed vigour.

(ii) Morphological aspects of seeds and seedlings:

- seed morphology to be studied at the different stages of development.
- seedling morphology to be determine up to the end of experimental period i.e. 30 days after seed planting. This will include a look at the type of root system, types of leaves, leaves number, shape of leaves, height of seedlings within experimental period.

(iii) Seed and seedlings pest.

Seed pest at harvest upto storage is determined. That of seedlings to be determine within the experimental period of 30 days and within the enclosed chamber.

1.5 RESEARCH AREA:

This research took place in the Zaria area of Kaduna State of Nigeria. The Tamarind trees used were all obtained in the Ahmadu Bello University (ABU) Main Campus, Samaru. One of the trees plucked was obtained in Alex Hall while the others were obtain from the senior staff club area and Agricultural Extension, Research and Liason services (AERLS) Transport section.

CHAPTER II

LITERATURE REVIEW

2.1 INTRODUCTION:

Dalziel (1937) classified Tamarind in the family leguminoseae and genera Caesalpiniaceae. Goldblatt (1981) place it under the family leguminoseae, genera, Caesalpinioideae and tribe, Amberstieae; whereas Gunn (1972) divided the family leguminosae into three sub-families these being, Caesalpinoideae, Mimosoideae and lotoideae with Tamarind belonging to Caesalpinoidea.

Tamarind is a large evergreen tree which is usually about 33m and 8m average height and circumference respectively. The plant grows sponteneously throughout the Savanna grassland. It is frequently found growing beside or on anthills (termitaria) which is probably favourable to the root system (Ega, 1986). The plant is probably originally African and introduced long ago into India where it is now much valued and abundant. In Nigeria it is much valued and abundant in the Northern part of the country (Ega, 1986). Ega (1986) also reported that the plant starts flowering by April - May and fruits ripe by October - November in the Northern Hemisphere which is exactly the situation in Northern Nigeria.

The fruit is brown, straight or curved pod which is 5 - 18cm long to 2.5cm wide. It is somewhat flattened, scurfy, constructed at intervals with a brittle shell (epicarp) containing a succulent mesocarp (pulp) with an endocarp of stone -

cells which surrounds each seed individually; and with a number of seeds varying from 1 - 12 per pod (Ega, 1986 and Marmara, 1989).

Tamarind fruits are harvested using long sticks or by climbing the trees to pluck with hands or using shorter sticks. After harvest the fruit is processed by removal of the dry brittle shell. Depending on the part required and the purpose for which it is needed, the fruit is either soaked in water and seeds removed easily if needed or carefully pierce through the soft tissue and removing the seeds especially where the seeds are needed for experimental purpose. Proper storage is required especially ifseeds are to be stored for experimental purposes to maintain viability of seeds. Seeds are therefore properly dried and packed in suitable containers (could be stopped bottles or airtight tins) for safe keeping in dry, cool places until needed (Owen, 1956). This protect them from pest as well as the harmful effect of mold. Maguire (1977) stressed the importance of drying seeds to suitable storage moisture content, and then packing them in moisture vapour containers or using air conditioning and/or dehumidification especially in sub - tropical and Tropical regions.

According to Heydecker (1977) "A seed is an end and a beginning. It bears all the essentials of inheritance". Dunham (1957) felt that the term 'seed' is loosely and inaccurately used to include fruits and vegetative parts. In this regard, careals which are Biologically fruits are regarded as seeds. We equally have vegetative parts such as potato stems,

Yam tubers, cassava stems etc., regarded as seeds. Kozlowski and Gunn (1972) stated that "a true seed is a fertilized, matured ovule that possesses an embryonic plant stored food material (rarely missing), and a protective coat or coats" furthermore he indicated, that the embryo is made up of one or more cotyledons, a plumule (embryonic bud), hypocotyl (stemportion) and a radicle (rudimentary root). Seeds when germinated gives rise to seedlings.

2.2 USES OF TAMARIND:

The search for cheap source of body building and energy yielding food by man has unveiled many uses for Tamarind. Research work has revealed that this leguminous plant's fruits and especially its seeds are very nutritive having a rich source of protein (Ega, 1986; and Dalziel, 1937).Ega, (1986) showed that the seeds can be used as a protein suppliment for livestock and can comfortably replace the highly cost and scarce conventional livestock feed. Apart from being a rich source of protein, Marmara (1989) showed that it is a rich source of vitamins and important minerals; and contain more calcium than most fruits. The fruit has been found to contain Tartaric acid, Ascobic acid, Acetic acid and sugar (Dalziel, 1937).

Other parts of the tree which include, the leaves, barks and flowers have been found to be useful to man.

Recent research works have revealed the nutritive and chemical content of the plant. This shows why the plant is highly valued by man as reported by Dalziel (1937) among others.

The uses include:

(i) Its pulp may be boiled and a pleasant drink made with sugar or honey from it.

(ii) The pulp can also be soaked in water or licked like that to reduce thirst.

(iii) The extracted liquid when soaked in water can equally be used for cereal pap common in Northern Nigeria.

(iv) Its seeds are edible but only in scarcity when they are roasted or boiled and the kernels made into meal mixed with cereals.

(v) Flowers could be made into salad (sometime called fatefate) along with daudawa, butter, salt, chillies etc.

(vi) Leaves used for soup by some tribes

(vii) The bitter infusion of pod is used for cooking careal foods and as a drink for women after child-birth by the Nankari people in Ghana.

(viii) The twigs are used for chewsticks.

(ix) The plant is medicinal in function, in that it is used as follows:

(a) As a laxative, where the pulp is taken either alone or mixed with lime juice or honey.

(b) It furnishes a refrigerant drink for fever and dysentry patients.

(c) When boiled with careal pap it is drunk to release constipation.

(d) Its bark is used as tonic and roots as a specific in chest complaints in East Sudan.

(e) Leaves boiled to form lotion used to wash wound; dried and pulverised as a dressing to dry up foul sores. The fresh leaves pounded to make a poultice for imflamatory swellings, sprains etc. The boiled pulp also used as a stimulating dressing to accelerate healing of open sores.

(f) The root is an ingredient along with other native medicine in Northern Nigeria in prescription for leprosy, the patient also taking Guinea-corn pap made with a decoction of the bark and husk of the pods and the bark and leaves of Drospyros mespiliformis.

(x) The pulp has been used to coagulate rubber latex

(xi) The ash of wood is used in tanning goat skin. Tannin is contain in the bark and also seed coat.

(xii) The wood is resitant to insects and can be used for furniture, boat and wheel-wright work. It is also used for mortars, pestles and implement handles. In the

east, it is used for gunpowder charcoal.

(xiii) Young branches are used by Fulani youth in 'sharu', the trial of manhood.

(xiv) The seeds are a rich source of pectin, which is largely used in the manufacturing of Jams, Jelies and confectionary.

2.3.0 GERMINATION.

2.3.1 Definition:

Jann and Amen (1977) consider germination as being the resumption of growth activities. Morphologically they see it as the "transformation of embryo into a seedling"; physiologically as "the resumption of the metabolism and growth which were earlier depressed or suspended and the switching on of the transcription of the genome"; and Biochemically as "the sequential differenciation of the oxidation and synthetic pathways". Essentially therefore, they see germination as "the bringing of the embryonic axis into a state which was temporarily suspended during quiescence or dormancy and the initiation of new genetic programs". Heydecker (1977) sees germination as a series of processes which transforms a seed from an almost inert to a most active growing entity, with the first notification being the protrusion of the radicle which signals the completion of germination. Similarly, Ajakaiye (1974) and Copeland (1976) sees germination as the resumption of active growth of the embryo of a seed which results to the rupturing or penetration of the seed coat and the emergence of the seedling or young plant.

2.3.2 Factors Affecting Germination of Seeds:

The seeds genotype (i.e its heredity, species or variety), seed maturity, and the growing environment influence seed germination as well as seedling development (Pollock and Toole, 1961). Factors influencing germination could be broadly considered thus:

(i) Internal factors which deals mainly with viability and life span; and

(ii) The external factors which deals with environmental conditions.

(i) Viability and life span.

According to Copeland (1976) viability "means that a seed is capable of germinating and producing 'normal' seedling". Furthermore it "denotes the degree to which a seed is alive, metabolically active and possesses enzymes capable of catalyzing metabolic reactions needed for germination and seedling growth". In essence a seed is said to be viable when it is capable of germinating under favourable conditions when dormancy causes are removed. From the foregoing a seed has to be viable before other conditions such as genotype and the growing environment can have any meaningful effects on its germination. Various forms of viability test have been put forward by seed men/women in order to determine the seeds that are viable before storage and planting. Copeland (1976) outlined some of these test methods. These include: Germination test, Tetrazolium test, Enzyme activity method, Excise embryo, x-ray test, conductivity test, and free fatty

acid test. Of these test, the Tetrazolium test is most reliable and mostly used as a means of estimating seeds viability. The test is quick since it can be completed within only few hours as compared with germination which can take as long as 2 months or more for some species.

Seeds viability has also been determine by mere immersing the seeds for some time in water in order to separate the viable and the non-viable. Those that float being regarded non-viable (dead) and as such discarded whereas those that sink regarded viable, hence used (Joshua, 1976; Ibikunle and Komolafe, 1973).

Seeds have definite life-span for maintenance of viability. The genome and storage conditions determine life span of seeds (Owen, 1956; and Mayer and Poljakoff - Mayber, 1975). Also, Hydecker (1972) stressed that, ageing occurs in seeds hence viability reduces with age. From this statement "it is clear that the metabolic efficiency of seeds declines with age". The two most important environmental factors influencing seed viability during storage are: relative humidity and temperature. The higher any of them the rapid the deteriorating rate of seeds. Equally, fungal growth or pest invation brings about seeds deterioration. The life span of seeds is usually longer in seeds with hard seed coat a common character of leguminous seeds. This is because the hard coat ensure dormancy and their low moisture content prevent waste of stored food by respiration (Owen, 1956).

(ii) Environmental conditions Influencing Germination:

The environmental conditions or external factors which determine germination include: (a) provision of adequate moisture condition, (b) adequate supply of oxygen, (c) proper temperature which varies with species, and (d) adequate amount of light for some species. The germinating medium usually in form of soil, sand, sawdust, paper towels, Newspapers blotten and cloth being of minor importance (Dunham, 1957; Ajakaiye; (1974) Mayer and Poljakoff-Mayber, 1975; and Copeland, 1976).

Imbition of water is the first process which occur in germination of seeds. The faster a seed imbibes water, the faster its germination process; internal inhibitors being absent. Seeds with impermeable seed coats will not imbibe water immediately even when soak in it. Impermeability of seed coat vary with species. It is most frequent in leguminosae (Mayer and Poljakoff - Mayber, 1975).

Oxidation is very important after the water imbibition of seeds. It provide the required energy for the development of tissues. Oxygen requirement or tension vary with seeds type. In many seeds, increase in oxygen concentration brings about increase in germination. Few seeds such as rice can germinate under low oxygen tension such as under water and much fewer in complete oxygen absence (anaerobic).

The temperature range in which seeds can germinate successfully varies with sources and genetic difference within species of seeds. Very high and low temperatures inhibit germination in

most seeds. There is usually an optimum temperature during which the highest germination percentage is recorded; below or above this records reduction or delay but not prevention of germination (Mayer and Poljakoff - Mayber, 1975). Also, Clemens, et al (1977) support this as their work on Acacia gave highest germination for A.falcuta, at 100°C for between 5 - 600 seconds and A.suaveolens at 80°C.

Light has also been found to influence germination, although its influence on cultivated plants is little. Both light intensity and quality have been found to influence germination (Mayer and Poljakoff - Mayber, 1975 and Copeland, 1976).

Giving a summary of germination test recommendation for the species within Caesalpinoideae tribe of leguminosae, Ellis et al (1985), gave Tamarindus indica a duration of 21 days when tested between paper with additional directions being; clip, file testa or scarify, concentrated sulfuric acid, pre-soak 24 hours.

2.3.3 Pest and Fungal Relationship to Germination:

Owen (1956) reporting various work done between 1940 - 1952 showed that seeds treatment using fungicides, insecticides and herbicides have different effects on stored seeds. The effects include: lost in viability when some chemicals are used, when the right chemical is overdose , when seeds are allowed for too long in the dressed chemical; and maintenance of viability when an appropriate chemical is used with appropriate quantity and time.

Pest invation and fungal development in stored seed leads to deterioration of seeds hence lóst in viability. To cope with this, seeds need to be properly dried, processed and packed in suitable containers for save keeping in clean storage devoid of high humidity and temperature. The need for dryness and low temperature was reported by Owen (1956) that for every decrease of 1% in the seed moisture content and 5°C decrease in temperature, the life of the seed is doubled.

Treatments against pest and mold growth also takes place during the germination process. This being to inhibit germination inhibition and fungal growth in the germinating medium. Just as in the case of treatments against storage pest and fungi, there is specificity in fungicide - fungal action and fungicide - seed action in the maintenance of viability. Neergaard (1975) work done in Nigeria in which coffee seeds were treated against looses of seeds before emergence; the treatment increase emergence from 28 - 60%. Dithane M - 45 and Dithane A - 40 were effective, Captan and Thiotex (Thiram) were most effective as seed treatments. Clemens et al (1977) working on the effect of seed treatments on germination in Acacia, a legume, used a mixture of benomyl (Benlate Dupont) and Captan (Captan Esso) at concentrations of 0.022% and 0.055% active ingredient respectively. His experiment showed a satisfactory control of fungal infection by this mixture. Brown (1982), equally successfully used captan industing his batches of seeds to prevent fungal attack.

Daubenmire (1947) reported the fact that animals bring about destruction of seeds and seedlings. These are therefore equally pest.

2.4.0 SEED DORMANCY

2.4.1 Definition:

Ellis et al (1985) sees seed dormancy as an imprecise term with different meanings. In its most broadest or most imprecise sense it could be applied to describe the period when the seed embryo discontinue growth on the mother plant to when it begins to germinate again. This is often refered to as ecological dormancy. However seed dormancy has narrower meaning to seed Technologist particularly seed testers for germination. It is viewed as a condition in a viable seed which prevent it from germination even when supplied with those factors or conditions normally considered adequate for germination. It is this later view that Cooper (1982) upheld as he described seed dormancy as the failure of viable seeds to germinate when supplied with conditions of water, oxygen, and temperature normally favourable for plant growth. When some seeds are able to germinate even on the parent plant immediately after maturity while others do not even after provision of the normal conditions for germination there is no other thing hindering the germination but dormancy. Furthermore, Singer and Pitman (1988) showed that freshly harvested Alysicapus vaginalis seeds require after-ripening or storage period. He noted that though both seed lots were scarified, the older (i.e 6 years older) was almost immediate with 100% germination by day 4, while the other gave only 12% on that day. It gave only 47% even after 24 weeks experimental period. Similarly, Wareing and Philips (1970) reported that removal of Husk of barley, wheat, Oats and Rice will permit germination soon after harvesting whereas

when left intact such seeds require several weeks of after ripening.

2.4.2 Classification of Dormancy:

Various classifications of dormancy types have been put forward by authorities, most of these, though describes the same phenomenon are confusing (Ellis et al. 1985). Cooper (1982) reported a division of dormancy into Primary dormancy and secondary dormancy. Primary dormancy being that which is found in ripe seeds as it is shed while secondary dormancy for the condition which can subsequently develop as a result of environmental interaction. He further reported the classification made by Herper in 1959; a classification much useful to seed Technologist as it describes the observed behaviour of seeds rather than the physiological processes which might take place; as; innate, induced and enforced dormancy. He nevertheless felt that the initial reported classification can be married with that of Herper since the innate dormancy corresponds to primary dormancy while induced and enforced dormancy equates to secondary dormancy. From his argument, the classification should be thus: (1) Primary dormancy and (ii) Secondary dormancy which is also divided into induced and enforced type.

Ellis et al (1985) and Cooper (1982) though independently explained and expressed Herper's classification thus:

(i) Innate dormancy:

This type of dormancy is also refered to as primary dormancy, natural dormancy, inherent dormancy and endogenous dormancy

(Ellis et al, 1985). It describes the dormancy present immediately the new embryo ceases to grow during maturation in the parent plant and persist for varying length of time after the seed has been shed. This type prevent the seed from germinating viviparously (i.e on the mother plant) and usually last for some time after the ripe seed is shed or harvested. This is genetically controlled with the degree of expression varying according to climatic condition during seed maturation. Some workers sub-divided it into two (a) seed coat dormancy and (b) embryo dormancy.

(a) Seed Coat Dormancy:

This is a condition in which a viable seed imbibes water but fails to germinate until the seed coat is remove or embryo exised i.e. the seed coat prevent the germination. This differ from hardseededness in that in hardseededness the seed does not imbibe moisture which will revive activity of seed while it does in this other case but the coat prevent the activity not lack of moisutre.

(b) Embryo Dormancy:

This occur when a viable seed from which the seed coat is removed but fails to germinate. It is sometime described as physiological dormancy.

Some seeds can exhibit both the seed coat and embryonal dormancy, a situation refered by some workers as double dormancy.

(ii) Induced Dormancy:

Ellis et al (1985) also refered to this as secondary dormancy. It develops as a result of seeds being supplies with water but exposed to an environment where some other particular

environmental or climatic factors such as high temperature and low oxygen is unfavourable for its germination. The seeds fails to germinate then, and will continue in that state even when transfered to conditions favourable for non-dormant seeds to germinate. However, they will germinate only after the dormancy period elapses.

(iii) Enforced Dormancy:

It is a situation where normally non-dormant seeds become dormant due to the ambient conditions. Unlike the induce dormancy, this type of dormancy enforced does not persist when the condition is changed to normal. For instance some seeds remain dormant while beneath the soil but germinate when brought to the soil surface during ploughing. Absence of light exposure and reduce temprature alternation enforces this type of dormancy beneath the soil. Also, water sensitivity in Barley where seeds will not germinate when put in excess water but does germinate when removed, dried and placed in a reduced quantity of water where they are not completely immersed.

Other forms of classification include that by Pollock and Toole (1961) who classified dormancy into the physical and chemical blocks of which the physical blocks being caused by structures surrounding the embryo such as seed coat. While chemical blocks are of two types (i) the inhibiting chemicals in the tissues around the seeds and (ii) the inhibiting agents within the embryo. Nikolaeva (1977) also classified dormancy broadly into two types (i) Exogenous and (ii) endogenous dormancy.

These being equally sub-divided thus:

i. Exogenous Dormancy:

(a) Physical Dormancy: Being caused as a result of impermeability of seed coat to water.

(b) Chemical Dormancy: Being caused as a result of inhibitors of pericarp.

(c) Mechanical Dormancy: Being as a result of mechanical resistance of covers to embryo growth.

ii. Endogenous Dormancy:

(a) Morphological Dormancy: Due to under development of embryo.

(b) Physiological Dormancy: Due to physiological inhibition mechanism.

2.4.3 Mechanism of Dormancy:

Nikolaeva (1977). Copeland (1976) and the classification of mechanisms of dormancy reported by Cooper (1982), have some similarity, these being:

i) Immaturity of embryo (or rudimentary embryo) dormancy:

In this mechanism, seeds of some species are shed before they are morphologically mature in this case the seeds cannot germinate due to the immature embryo. The embryo develops further when it imbibes water and placed under favourable temperature. Germaniation then takes place after the embryo mature. This usually take; several weeks or months depending on the species.

ii. Seed Coat dormancy or effects:

This type can be divided into: (a) Impermeability to water and (b) to gases. In the case of impermeability to water usually refered to as hardseededness by some authors, the seeds does not imbibe water for a pretty long time except when scarified. This type is common in legumes. A similar case happens when the seeds are not permeable to gases except when seed coat is removed.

iii. Endogenous Dormancy of the Embryo:

In this mechanism the embryo is morphologically mature yet germination does not occur due to some physiological factors. A stimulus is therefore usually needed to remove dormancy. These include:

(a) Chilling requirements: In this case chilling (vernalization) example the placing of seeds of apple at - $4^{o}C$ for 2 - 3 months before planting.

(b) Light sensitivity: In this case light exposure at different or particular length of time or period; could equally be at a particular wavelength; enhence germination, but when not provided germination is inhibited.

(c) Endogenous germination inhibitors: In this case inhibitors which are water soluble or exidizable to inactive forms are in the embryo. There may also be lack of certain chemicals which when added, release dormancy. This type of dormancy is removed through using water solubility of the seeds, oxidation and application of certain chemicals

e.g gibberellic acid that will enhence the removal of the inhibitory action.

(d) Combination of different dormancy types: Some species of seeds have a combination of the above mechanisms. To release such dormancy a combination of the release agents ought to be used.

2.5.0 METHODS FOR DORMANCY RELEASE OR REMOVAL:

2.5.1 General:

Over the years, several studies have been conducted by seed technologists and others interested in crop production on methods for overcoming seed dormancy, These studies have brought about an understanding of how dormancy is released naturally and artificially. Copeland (1976); and Pollock and Toole (1961) pointed out that seed dormancy is released naturally by alternate freezing and thawing, wetting and drying, forest fires, passage through digestive tract of animals, action of natural soil acidity and attack by micro-organisms. The artificial methods being used seems a refinement and improvement of the natural methods. Methods used for dormancy removal depends on type of dormancy in the seed.

2.5.2 Hardseededness:

Seed scarficiation methods have been used to release dormancy in various types of seeds by various workers or researchers. These include: Machlis and Torrey (1956), Johnston (1975), Singer and Pitman (1988), and Ibikunle and Komolafe (1973). Scarification method enhence moisture permeability or imhibition. This is done through gradual dissolving the seed coat or chipping

it off. The term is usually sometimes used to describe acid treatment where the testa is permeable but the seed covering structures prevent or delay germination. Scarification is done in order to release seed coat caused dormancy which may be as a result of one or more of the following (i) barrier to water uptake, (ii) barrier to oxygen uptake, (iii) physical barrier to radicle emergence, (iv) chemical germination inhibitors or a barrier to their outward diffusion from the seed or fruit, (v) a selective filter affecting light quality and (vi) as a source of micro-organisms especially fungi (Ellis et al, 1985).

Seeds scarification is either mechanically done, or chemically treated. When mechanically treated, they are either blown against abrassive materials or rubbed with or on the abbrassives or burning them with an electric needle or chipping them with sharp objects such as knives. When chemically treated, some chemicals such as concentrated sulfuric acid can be applied. Also Hot water could be used as a treatment for release of dormancy caused by hardseeddedness. (Johnson, 1975; Ellis et al, 1985, and Singer and Pitman, 1988). Singer and Pitman (1988) reported that acid scarification though good is frequently use mainly for experiments, it is difficult applied to large quantities of seeds due to cost of the acid.

Clemens et al (1977) work on Acacia showed a mark difference between chipped seeds and Hot water treated seeds as 100% Germination was observed after 8 days for the chipped

while the hot water had only 50% after 16.99 days. This shows that type of treatment determine germinability.

2.5.3 Other forms of dormancy release treatments.

The other forms of dormancy release treatments include: (i) pre-chilling (stratification) (ii) light, (iii) alternating temperature (iv) chemical treatments (v) extension of the germination test period and pre-washing or soaking of seeds for a period of time before planting, (Mobo et al, 1988 and Esashi et al, 1975).

2.6.0 SEED AND SEEDLING VIGOUR

2.6.1 Definition:

Heydecker (1972) and Copeland (1976) defined vigour as "that condition of active good health and natural robustness in seeds which upon planting permits germination to proceed rapidly under a wide range of experimental conditions". However Hydecker went ahead to describe vigour

> "as the condition of a seed which is at the height of its potential powers, when all factors that may destract it from its quality are absent and those that make up a 'good' seed are present in the right proportions, promissing a satisfactory performance over a maximum range of environmental activities".

2.6.2 Causes for Difference in seed and seedling vigour:

There are several causes for difference in seeds and seedling vigour. These have been determine by different workers. The causes naturally falls into two groups being: (i) Intrinsic variation due to genotype and (ii) Variation induced by the external environment interacting upon the genotype. The genotype (genotypic make up) of a plant partly determines its

seed vigour. Even within the same plant, there is variability within the seeds. Due to the variations obtainable even within seeds of the same plant, there will be difference in vigourwithin the seeds of the same plant. Since there is difference in vigour even within seeds of the same plant (same genotype), the variation in vigour becomes much more expressed within seeds of different species which have different genotype (Copeland, 1976 and Ellies et al, 1985). According to Perry (1976) the genotype controls the maximum potential of vigour inherent in seeds, such as growth rate and emergence ability but frequently it can not be expressed fully because of the influence of the environment before and after seed harvest. The environment and not only the genetic make up of the seed determine to a great extent the vigour of seedlings, and the next progeny of seeds to be produced right before seed formation, and maturation. These environmental factors which include, water availability, temperature, light and nutrients availability acts either seperately or collectively, resulting to seed immaturity; variation in size, weight and density; mechanical damage; deterioration at storage or invation by seed born fungi etc (Perry, 1976). Mechanisms which enhence vigour will also enhence seed viability. Those that brings about lost in vigour will always lead to lost in viability and they could be regarded as precursors of seed death.

Various research work have been done to show that seed weight, density, and size influence seed vigour. Working on seed weight amongst other workers include: Taylor and Baltensperger (1987) and Brown (1980). On seed size are:

Lawan et al (1985) and by Perry (1980). While on seed density are: Lawan et al (1985) and Ibikunle and Komolafe (1973).

2.6.3 Seed vigour Determination:

Seeds and seedlings vigour has been evaluated using seedling's growth rate in the field along with standard germination test. The physical parameters used for the seeds and seedlings in field condition include:

(i) Speed of germination
(ii) Plant weight at time interval
(iii) Decrease in cotyledon weight
(iv) Unfolding of plumule per unit time
(v) Seedling weight at time intervals
(vi) Leaf area expansion rate
(vii) Crop yield and
(viii) Storability under optimum and adverse conditions. (Copeland, 1976 and Perry, 1976).

2.7.0 SEEDS AND SEEDLINGS MORPHOLOGY:

2.7.1 Seeds Structure:

Hutchinson (1964), described the seeds in the family leguminosae as being Obovate - orbicular, compressed. Also Gunn (1972) described seeds in the subfamily Caesalpinoideae as being straight, rounded at apex, tapering to basal hillum; seed coat may bear superficial fracture lines, seldom with a closed pleurogram (light line) on each face; embryo straight; cotyledons investing and usually covered by endosperm; ovule anatropous. Brandis (1906), described specifically Tamarind

seeds as being brown, shining and without albumen.

2.7.2 Seedlings Structure:

(i) Seedling Emergence:

During seedlings emergence, some leguminous seeds e.g. sweet clover and soybean, shows an elongation of the hypocotyl which as grows, forms an arc which pushes up through the soil pulling the cotyledon with it and when it contacts light the bent hypocotyl is straighten bringing the seed leave above the soil surface (Dunham, 1957).

(ii) Seedling Classification.

Many authors including Mayer and Poljakoff-Mayber (1975) and Copeland (1976), classified seedlings by giving kinds of germination; thus divided it into Epigeal and hypogeal germination in which cotyledons are above the ground level and usually photosynthetic; and in which the cotyledons remain below ground level and not usually photosynthetic respectively. The classification of seedlings as epigeal and hypogeal germination which is the initial simple classification, has been observed as inadequate by several workers, who proposed other forms of classifying seedlings. These workers include: NG (1978) report of Duke's work who divided the initial seedling morphology into "phanerocotylar" (cotyledons exposed) and "Cryptocotylar" (Cotyledons hidden). These terms are synonymous with epigeal and hypogeal germination that are to be replaced. NG therefore still maintained the term epigeal and hypogeal in his classification but added semi-hypogeal and durian germination. The semi-hypogeal being the condition when the hypocotyl is underdeveloped and the

cotyledons are exposed with the exposed cotyledons either on or in the ground; while durian germination is the condition when the hypocotyl is developed and the cotyledons are hidden. DeVogel (1980) proposed 16 types of seedlings based on a variety of characteristics that express the mode of development. Out of these 16, legumes have 6 types or classes which are:

a) Mecaranga type, phaneroepigeal with folier cotyledons;

b) Soloanea type, phaneroepigeal with fruit wall adherent;

c) Horsfieldia type;

d) Endertia type, phaneroepigeal with storage cotyledons bearing the testa abaxially or around one catyledon; and

e) Cynometra ramiflora type, phaneroepigeal with testa and fruit wall adherent abaxially (Duke and Polhill, 1981).

(iii) The Root:

This is often the descending part of the seedling axis developed from the radicle (embryonal root) and being separated from the ascending part (shoot) by the collet. The root grows in length by addition of their tip as a result of cell division, elogation, and enlargement of those cells just behind the protecting root cap. The root tip is forced into new soil region by this growth. The root hairs arises from the stationary region of the root just behind the elongation portion. As the root continue growth new root hairs are formed just at the back of the elongation portion with those earlier formed on older portions of root disintegrating. The root continue through its growth to explore more areas for absorbing moisture and nutrients and also establish the

plant more. The root which first appears from the seed is regarded as the primary root. The secondary roots grow or diverge from the primary root, and could branch and rebranch indefinitely; thus providing additional absorption, conduction and anchorage function to the plant. (DeVogel, 1980 and Graber, 1954).

(iv) The Stem:

This is the ascending axis of the plant consisting of the hypocotyl, nodes and internodes. It serve to bring leaves into position and has a conducting function for water, minerals and assimilates. As the hypocotyl elongates, it pulls out the cotyledons from the soil. Its elongation reduces as it breaks through the soil and becomes exposed to light. The unexposed underside continue the rapid elongation with the upper portion retarding in growth. This differential growth brings about straightening of the hypocotyl and carrying of the cotyledons. As the growth activity of the hypocotyl ceases, cells of the terminal bud becomes very active. Continuity of growth in length of the stem is brought about by elongation and subsequent development of new internodes; with a terminal bud situated at the apex. (Graber, 1954 and DeVogel, 1980).

The leaves:

According to Graber (1954), the embryo of a field bean (a legume) has four leaves visible on the stem apex. These being in form of the two cotyledons on the first node and two unifolite leaves on the second node. So, the embryonic stem has 4 leaves, 2 nodes and one internode. The foliar leaves

differing from the cotyledonal leaves in shape and texture. There are many more leaves actually present at the node near the end of the embryonic stem, but these are visible only by the use of a microscope. Furthermore, Graber, stated that leaves of leguminous plants have characteristic stipules, petioles and one to several leaflets. The arrangement of the leaves on the stem (Phylotaxy) is usually specific. While most seedlings have a spiral arrangement, others may have a decussate, opposite, whorled or alternate type of arrangement. The leaves on a seedling do not usually have to be of the same kind, they have different morphology in some situation. "Compound leaves in the seedling may be the result of a gradual sequence from simple leaves to more complex ones, or the first seedling leaves may already be compound". (DeVogel, 1980). The character of seedlings leaves help in identification of seedlings.

As indicated by Hutchinson and Dalziel (1958), Tamarindus leaves are paripinnate with leaflets between 12 - 15 pairs and are upto 3cm long. Brandis (1906), also gave the number of leaflets as between 10 - 15 pairs.

2.7.3 Seedling Establishment:

When a seed germinate it initially has to anchor itself in the soil. This ensure nutrient and water intake. Furthermore the ability for the plant to produce the food needed by it (photosynthesis) at an early stage before the cotyledons shravel and fall establishes the seedling much more. It makes it much more vigorous to others that may be dependent on its cotyledons or any other form of food reserve for a longer

time. (Copeland, 1976; and Mayer and Poljakoff-Mayber, 1975). Generally the seedling dry weight decreases during initial germination process, but later increases as seedling gets more and more developed and established. This lose in dry weight being as a result of metabolic reactions which decrease the food substances in the cotyledon, converting it for the seedling development and establishment.

CHAPTER III

MATERIALS AND METHOD

3.1 Fruit Harvest, Seed extraction, Seed weight, seed treatment and storage.

(i) Harvest:

The Tamarind fruits were harvested during the months of February and March, 1990. Three different trees were harvested with the fruits kept separately. The specific dates for their harvest were A, 4/2/90; B, 25/2/90 and C, 4/3/90. The trees were located on a plain land in Ahmadu Bello University(ABU) Main Campus Zaria.

(ii) Seed Extraction:

The fruits were dehusked and the seeds carefully extracted from the pods to avoid the chipping off of the testa. Soaking of the pulpy fruit after dehusking which could have eased seeds extraction was avoided as this could initiate the germination process.

(iii) Seed Weight:

After the seed extraction, they were wiped clean, counted, and 100 seed weight of each seed lot was determined.

(iv) Seed Treatment and Storage:

During extraction, some seeds were observed to have been infested with insect pest. They were therefore spread and aerated. The pest were hand picked and the infested ones removed. The seeds were then packed into new polythene bags which were sealed or made air tight as much as possible; then

stored in a cupboard at room temperature until needed.

3.2 Germination:

Before sowing of the seeds for all the treatments, they were initially immersed in distilled water for two minutes in order to determine those viable from the non-viable ones. Those that floated were removed and regarded non-viable as was done by Ibikunle and Komolafe (1973); and Joshua (1976) who refered to such seeds as dead. Also seeds that had their testa slightly chipped off either by the object of seeds extraction or insect pest, were easily identified and removed as the testa showed a gradual curling due to water imbibition.

Four experiments were conducted, with the first two being similar: In experiment I and II (regarded as replicates), 50 seeds for each seed lot per treatment were sown in 2 lunch boxes containing equal quantity of vermiculite. For these two experiments the seeds were subjected to all the treatments under 3.3 below, before sowing. To facilitate and ease examination or observation of the germinating seeds this sowing method was used. A layer of filter paper was placed on the vermiculite in the lunch boxes; the seeds were arranged on it; Another layer of filter paper was placed on top of the seeds, and a thin layer of vermiculite was placed on top. Equal quantity of distiled water was used to moisten the seeds. Subsequently watering and observation took place every other day for an experimental period of 30 days. For the 3rd experiment, 150 seeds from seedlot C, were used. These were sown in

6 lunch boxes using the same germinating medium and method of sowing as for experiment I and II above. A daily observation for a week experimental period was done. Only the sulfuric acid Hot water treatments at 70°C were used. Seedlings for this experiment were later left and watered for another period of four weeks after which the leaves arrangement was noted. In the fourth experiment 50 seeds from seedlot C were swon using the sulfuric acid treatment. This lasted only two weeks, during which time some morphological aspects of the seedlings were studied. The procedure for sowing and the sowing medium was the same as in other experiments.

A seed was considered germinated when the series of processes which transforms it from an innert state to a most active growing entity with manisfestation of growth being the protrusion of radicle upto 2mm observed as used by Mabo et al (1988).

3.3 Treatments:

Baron (1977) among others have shown that most leguminous plants possess hard seeds coat (Hardseededness). In view of this finding methods to facilitate water intake or imbibition by the seeds were employed initially.

(i) Control:

Seeds for this were sown without applying any form of treatment as will be seen below.

(ii) Mechanical Scarification:

In this treatment the seed coat were chipped off using

either grinding stone or sand paper.

(iii) Concentrated sulfuric acid treatment:

This is a method of seed scarification where seeds were treated with concentrated sulfuric acid for 5 - 10 minutes similar to the method reported by Johnston (1975). After this period the seeds were washed in water four times within 30 minutes in order to remove the acid and chipped off testa of the seeds.

(iv) Pulp Extract Treatment:

A 100g to 200ml propotion of pulp to distilled water was boiled until a semi - solid paste was formed 100ml of distilled water was then added and stirred, then allowed to cool. Seeds were then immerse in the solution for a period of 5 days after which they were removed and washed in water before sowing. This was done in order to see whether the pulp promote or inhibits seed germination, similar to work done by Fasidi et al (1979). Who showed that the pulp extract of lettuce inhibits its germination.

(v) Hot water Treatments:

Hot water was used rather than any other heat treatment that involves dry heat or steam. In this, the seeds were heated in a water bath at specific temperatures and time exposure as follows:

a) at $50^{o}C$ for 30 minutes and 120 minutes

b) at $70^{o}C$ for 30 minutes and 60 minutes

c) at $90^{o}C$ for 5 minutes and 10 minutes.

(vi) Soaking in distilled Water:

Seeds were soaked in distilled water for a period of 5 days after which they were planted.

3.4 Seed Pest and Treatments Against Pest.

Insects pest observed on seeds were carefully selected and identified. An improvised germination chamber i.e. a box covered with wire netting was used to securely keep germinating seeds from rats which eat soaked seeds as was observed during the trial experiment.

3.5 Morphological Aspects of Seeds and Seedlings.

Both cross and longitudinal sections of water imbibed seeds before their germination were made and drawn. Also split diagrams of the seeds after germination were made showing the radicle and plumule. The external features of both the seeds and seedlings were equally studied as seeds developed to seedlings within the experimental period. The following were determined:

(i) Number of leaves and leaflets

(ii) Length of shoot system

(iii) Length of root system

(iv) Dry weight of seedlings at $60^{o}C$.

Only the mechanically scarified seeds and control seeds were sampled for i - iii, while only mechanically scarified treatment used for iv.

In order to determine the growth rate of seedlings after germination, the 4th experiment using only the mechanical and sulfuric acid scarified seeds was done. The germination and initial seedling development was monitored for a period of 14 days during which period germinating seeds and seedlings were uprooted at intervals with the following determined.

(i) Date of germination

(ii) Rate of seedling growth by measurement of

(a) Root length

(b) Shoot length which consisted of:

- epicotyl length and
- hypocotyl length

The shoot and root length measurements were started after 7 days, when seedlings had emerged from the germinating medium.

3.6 Seed vigour Determination

Based on Copeland (1976) and Perry (1976) and other parameters on seed vigour determination; a five item rating scale base on germination, epicotyl emergence, leaves number, seedling length and dry weight to determine vigour for the 3 seed lots was determined. Any seed lot that came first on any of the items was rated 5 marks; Second - 3 marks and third 1 mark.

30 seedlings were randomly sampled from experiment II for the determination of seedlings root and shoot length; number of leaves and leaflets; and seedlings dry weight.

3.7 Analysis of Data:

The data was analysed using percentages, means, Analysis of variance (ANOVA) and correlation.

CHAPTER IV

R E S U L T S

4.1 The Seed - General:

The harvested seed lots had variation in shape, color, size and weight. These variations were not just noticed between the seed lots but within also.

(i) Shape:

Generally the 3 seed lots could be described as being flattened, oblong though with length not straight and with the apical regions somewhat rounded. They also had some slight depression of the central portions of the flattened surfaces. The sides of some seeds especially for the B. seed lot equally had their sides along the length depressed too. The A. seed lot seeds were more flattend and larger in size than the other seed lots.

(ii) Color:

The seeds were brownish in colour with their depressed surfaces being darker than the other portions of the seeds. The different seed lots had some slight variation in colouration. The A - being light - brown, B. - darkbrown and C. - brown.

(iii) Size:

The seeds had different sizes between seed lots and also within seed lots. Although no measurement was made, a visual rating on size showed that the A. - seed lot had largest seeds followed by the C. - and finally the B.

(iv) Weight:

The different seed lots had difference in seed weight. The weight per 100 seed is as shown in table I

Table I:

Seed weight in grams

Seed lot	No. of seeds collected	Total seed weight	100 seed weight
A	1,330	609.2	40.5
B	1,656	884.4	53.4
C	2,123	1,289.3	60.7

4.2 Seed Pest Infestion:

During seeds extraction from the pods, pest infestation was observed. There was an increase in these pest during the initial storage. The seeds were later air-dried and properly stored in airtight containers in cool places. The insect pests were identified by Dr C. Anene, 1990 (using personal communication) as being Sitophilus granarius and Coryedon serratus. The infested seeds apart from having holes bored on them, had their stored food consumed. After water imbibition of the seeds which is the first stage for the germination process, the imbibed seeds with soft cotyledons were found to be eaten by rats, which also serve as pest.

4.3 Germination:

A trial experiment showed that the seeds don't germinate within few days as most seeds do. They seem to have a fairly long period of dormancy, because of this, various treatments in

order to release the dormancy period and hence hastening germination were used.

(i) Relationship between Treatments and Seed lots to Germinability:

Data for the first and second experiments which are replicates, were analysed using Analysis of variance (ANOVA) at P = 05 for germination. This gave a significant difference between treatments and seed lots, but no differen between the replicates. Furthermore, it showed sulfuric acid and mechanical scarified seeds treatments to be significantly faster in germination than the control, with a mean day of 4.00 as against 7.33. This was followed by the distilled water soaked for 5 days. The Hot water treatment at 70°C for 30 minutes was significantly slower than the control (Least significant differente (LSD) = 1.96 P = 0.05). The C. and A. seed lots showed significant difference with the B., but no difference between themselves with seed lot mean days of 5.56 for C, 5.67 for A and 7.33 for B. ⌐shortest significant range (SSR) = 2.367 see Table 2a and b below regarding the percentage germination on the first day germination was noticed, ANOVA showed a significant difference between treatments and replicates. The sulfuric acid treatment was found to possess the highest percentage followed by the mechanically scarified seeds treatments with 82.00 and 73.67 means respectively. The Hot water treatment at 50°C at 120 minutes time exposure came next in terms of percentage

Table 2a. Mean germination percentage within 30 days experimental period.

Treatment	SEED LOT A Replicate 1	A Replicate 2	B Replicate 1	B Replicate 2	C Replicate 1	C Replicate 2	Total	AVE.
Control (Non-treated)	31.29	48.29	8.14	38.00	34.86	52.14	212.72	35.45
Mechanical scarified	96.57	97.29	95.14	98.57	97.71	98.86	584.14	97.36*
Sulfuric Acid	96.14	100.29	96.57	99.71	98.29	100.00	590.71	98.45*
Pulp Extract soaked for 5 days	43.29	60.29	40.43	43.57	50.86	62.29	300.73	50.12*
Distilled water Water soaked for 5 days	38.14	61.71	33.71	44.29	60.14	62.71	300.70	50.12*
Hot water at 50oC for 30 minutes	39.49	56.00	11.71	36.29	50.86	56.57	250.92	41.82NS
Hot water at 50oC for 120 minutes	44.57	58.86	20.14	40.57	52.29	56.00	272.43	45.41*
Hot water at 70oC for 30 minutes	10.29	47.71	13.43	44.57	18.00	46.29	180.29	30.05NS
Hot water at 70oC for 60 minutes	33.49	51.71	22.29	42.57	37.43	52.00	239.49	39.92NS
Total	333.27	581.86	341.56	488,14	500.44	586.86	2932.13	
MEANS	50.84		46.09		60.41		LSD = 8.91 P = 0.05	
SSR = 6.24							*= Significant	

Table 2b. ANOVA for mean germination percentage.

Source of variation	S.S	DF	M.S	F-ratio
Treatments	31340.07	8	3917.51	64.53•
Seed lots	1962.05	2	981.03	16.16•
Replicates	2696.60	1	2696.60	44.42
Residual	2549.82	42	60.71	
Total	38548.44	53		

P = 0.05

• = Significant

performance (LSD = 1.96. P = 0.05). Relating the day of germination and percentage germination, the sulfuric acid treatment became best, followed by the mechanically scarified seed treatment. Data collected from experiment III when a daily observation was made, showed germination starting on day 3 but its percentage was very neglegible as compaired to that on day 4 see Table 3.

Table 3: Number and percentage germination within 7 days

DAY TREATMENT	No	%	No	%	No	%	No	%	No	%	No	%
Sulfuric Acid	-	-	3	2	129	86	148	98.6	148	98.6	148	98.6
Hot water at 70°C 30 minutes									5	3.3	7	4.7
Hot water at 70°C 60 Minutes									9	6	12	8

Analysis of the mean germination percentage within the 30 days experimental period showed a significant difference between treatments, seed lots and replicates (P = 0.05). The sulfuric acid treatment had the highest, followed by the mechanically scarified seed treatment. The pulp extract and Distilled water soaked for

5 days came next, followed by the Hot water treatment at 50°C for 120 minutes time exposure (LSD = 8.91. P = 0.05). In terms of seed lots, the C was highest with mean percentage of 60.41, followed by A with 50.84 and lastly B. with 46.09 (SSR = 6.24. P = 0.05). No germination was noticed with the seeds at 90°C Hot water treatment. Apart from this rapid decay of the seeds was observed.

From the above analysis, a summary performance of treatment and seed lots is thus: For treatments, the sulfuric acid was first in terms of early germination and percentage germination on the day germination started followed by mechanically scarified seeds, Distilled water soaked seeds, pulp extract soaked and then followed by Hot water treatment at 50°C for 120 minutes exposure. In the case of seed lots, the first or best in terms of early germination percentage was seed lot C followed by A and lastly the B seed lot. See Table 2, 4 and 5.

Table 4a. Day Germination was first Noticed

	Seed Lot						Total	Average
	A replicate		B replicate		C replicate			
Treatment	1	2	1	2	1	2		
Control (non-treated)	6	6	8	10	8	6	44	7.33
Mechanical scarified	4	4	4	4	4	4	24	4.00*
Sulfuric Acid	4	4	4	4	4	4	24	4.00*
Pulp soaked for 5 days	4	6	10	6	6	4	36	6.00N.S
Distilled water soaked for 5 days	4	4	4	6	4	4	26	4.33*
Hot water at 50oC for 30 minutes	6	6	8	10	8	4	42	7.00N.S
Hot water at 50oC for 120 minutes	6	4	6	10	4	8	38	6.33N.S
Hot water at 70oC for 30 minutes	10	8	16	8	6	8	56	9.33*
Hot water at 70oC for 60 minutes	8	8	6	8	6	8	44	7.33N.S
TOTAL	52	50	66	66	50	50	334	
MEANS	5.67		7.33		5.56		LSD = 1.96	
SSR = 2.36							P = 0.05	

See Table 4b below

*Significant

Table 4b. ANOVA for Day Germination was first Noticed.

Source of variation	S.S	D.F	M.S	F-ration
Treatments	157.48	8	19.69	6.84 •
Seed lots	35.71	2	17.86	6.20 •
Replicates	0.08	1	0.08	0.03 N.S
Residual	120.88	42	2.88	
Total	314.15	53		

Table 5a. Percentage Germination on first day Germination was Noticed.

	Seed Lots						Total	Average
	A		B		C			
	Replicate		Replicate		Replicate			
Treatment	1	2	1	2	1	2		
Control	4	4	4	2	4	2	20	3.33
Mechanical scarified	64	82	46	88	78	84	442	73.67•
Sulfuric Acid	60	100	54	96	82	100	492	82.00•
Pulp soaked for 5 days	2	4	2	2	2	2	14	2.33N.S
Distille water soaked for 5 days	4	4	2	2	4	2	18	3.00NS
Hot water at 50°C for 30 Minutes	8	8	4	4	4	4	32	5.33N.S
Hot water at 50°C for 120 minutes	4	4	4	12	4	8	36	6.00N.S
Hot water at 70oC for 30 minutes	4	8	4	4	4	4	28	4.67N.S
Hot water at 70oC for 60 minutes	12	4	4	4	4	8	36	6.00N.S
Total	162	218	124	214	186	214	1118	
MEANS	21.11		18.76		22.22			

LSD = 9.53
P = 0.05
N.S = Not Significant
• Significant

Table 5b. ANOVA for percentage Germination on first day Germination was first noticed.

Source of variation	S.S.	D.F	M.S	F-ratio
Treatments	50644.59	8	6330.57	92.95*
Seed lots	111.26	2	55.63	0.82 N.S
Replicates	560.67	1	560.67	8.23*
Residual	2860.74	42	68.11	
Total	54177.26	53		

ANOVA (P = 0.05) equally showed a significant difference between replicates. It is important to note that these were planted with an interval of 31 days, during which time the second replicate seeds were being stored. This time difference could be responsible for this difference since dormancy has been found to be released with storage as Singer and Pitman (1988) work indicates.

4.4 Seedling Development:

When germination took place, seedling growth and development continued. Initially the hypocotyl rapidly grew, raising the cotyledons above the germinating medium. As this occured, the epicotyl in turn grew to liberate the Eophills i.e the first foliar leaves and finally emerge out of the cotyledons raising the Eophills above.

Similar to germination, the rate of epicotyl emergence was noted as below: See table 6 a and b.

Table 6a Mean Percentage Epicotyl Emergence within the 30 days experimental period.

	Seed lot						TOTAL	AVE.
	A		B		C			
	Replicate		Replicate		Replicate			
Treatment	1	2	1	2	1	2		
Control	10.40	29.11	1.80	15.56	9.60	34.00	100.47	16.75
Mechanical Scarified	47.40	47.78	40.40	59.78	48.80	54.00	298.16	49.69*
Sulfuric Acid	40.00	71.11	47.10	61.11	49.80	71.56	340.78	56.80*
Pulp Extract soaked for 5 days	8.20	37.78	6.00	22.22	13.60	39.78	127.58	21.2 NS
Distilled Water Soaked for 5 days	13.40	44.67	10.20	26.89	26.40	42.89	164.45	27.41*
Hot Water at 50oC for 30 minutes	9.60	33.78	4.00	11.11	14.80	36.00	109.29	18.22NS
Hot Water at 50oC for 30 minutes	12.00	32.89	5.20	18.67	16.80	33.78	119.34	19.89NS
Hot Water at 70oC for 30 minutes	1.60	27.56	3.20	24.44	4.00	27.56	88.36	14.73NS
Hot water at 70oC for 60 minutes	6.00	28.89	3.60	24.44	12.80	30.67	106.40	17.73NS
Total	148.10	353.57	121.60	264.22	196.60	370.2	1454.83	
Mean		27.90	21.43	31.49			LSD = 5.80	
SSR = 4.07							P = 0.05	

Table 6b. ANOVA for mean Percentage Epicotyl emergence.

Source of Variation	S.S	D.F	M.S	F-ratio
Treatments	11431.63	8	1428.96	55.45
Seed lots	934.96	2	467.48	18.14
Replicates	5031.12	1	5031.12	195.23
Residual	1082.39	42	25.77	
Total	18480.10	53	P = 0.05	

Treatments and seed lots in relation to Epicotyl Emergence:

ANOVA at P = 0.05 showed a significant difference between treatments and seed lots on day epicotyl was first noticed. The sulfuric acid and mechanical scarified seed treatments were shown to be significantly faster than the control with mean day when epicotyl was first noticed as 14.00. Also a significant difference with the control was shown by the Distilled water treatment with a mean day of 17.00. Other treatments showed no difference statistically with the control which had a mean day of 21.17. (LSD. 2.67 P = 0.05). Table 7 a & b.

There was also significant difference between the seed lots as shown in table 7b. Seed lot C started first, followed by A and finally B. with means of 17.56, 18.44 and 20.00 respectively (SSR = 1.85).

The percentage epicotyl emergence on the first day it was noticed, showed significant difference between treatments and replicates but none for seed lots. The mean percentage emergence on that day showed the sulfuric acid treatment to be significantly different with the control, followed by the mechanical scarified treatment. The percentage germination and epicotyl emergence on the first day germination was noticed was

Table 7a. Day Epicotyl Emergence was first noticed.

Treatments	Seed lot A Replicate 1.	A Replicate 2	B Replicate 1	B Replicate 2	C Replicate 1	C Replicate 2	Total	Average
Control (Non-treated)	18	20	26	22	22	22	130	21.17
Mechanical	14	14	14	14	14	14	84	14.00*
Sulfuric Acid	14	14	14	14	14	14	84	14.00*
Pulp Extra soaked for 5 days	22	18	26	20	22	16	124	20.17*
Distilled water soaked for 5 days	18	16	16	20	16	16	102	17.00*
Hot water at 50oC for 30 minutes	20	18	20	20	18	18	114	19.0NS
Hot water at 50oC for 120 minutes	18	20	20	20	18	20	116	19.33NS
Hot water at 70oC for 30 minutes	28	20	28	20	16	20	132	22.00NS
Hot water at 70oC for 60 minutes	20	20	26	20	16	20	122	20.33NS
Total	172	160	190	170	156	160	1008	
Means	18.44		20.00		17.56		LSD = 2.67	

SSR = 1.85

Table 7b, ANOVA for Day Epicotyl Emergence was first noticed.

Source of variation	S.S	D.F	M.S	F-ratio
Treatments	442.67	8	55.33	10.38*
Seed lots	55.11	2	27.56	5.17*
Replicates	14.52	1	14.52	2.72 N.S
Residual	223.70	42	5.33	
Total	736.00	53		

found to be possitively correlated (correlation coefficient (r) = 0.46 at P = 0.05). See Table 8a and b.

4.5 Seed and seedling vigour:

Statistical analysis showed a possitive correlation between germination and Epicotyl emergence within the 30 days experimental period (r = 0.92. P = 0.05). It also showed a correlation between day germination was first noticed with that of epicotyl emergence (r = 0.75 at P = 0.05). This shows that a vigorous seed starts from early germination to that of epicotyl emergence upto seedling establishment. ANOVA showed a significant difference between treatments and not seed lots or replicates for the period between germination and epicotyl emergence see Table 9 a and b. The sulfuric acid Treatment had the least number of days followed by the mechanical scarified seeds, with 9.33 and 10.00 mean days respectively (LSD = 2.77). The lower the number of days between germination and epicotyl emergence, the faster the seedling development. This therefore shows that type of treatment employed contribute in vigour determination.

Table 8a Percentage Epicotyl Emergence on first Day Emergence was Noticed.

Treatment	Seed lot A Replicate 1	A Replicate 2	B Replicate 1	B Replicate 2	C Replicate 1	C Replicate 2	Total	Average
Control (non-treated)	4	2	2	10	2	30	50	8.33
Mechanical Scarified	8	10	2	6	6	4	36	6.00NS
Sulfuric Acid	6	22	10	20	12	20	90	15.00*
Pulp Extract soaked for 5 days	2	8	4	2	6	2	24	4.0NS
Distilled water soaked for 5 days	4	2	2	12	6	2	28	4.67NS
Hot water at 50oC for 3 mins	4	4	4	4	4	8	28	4.67NS
Hot water at 50oC for 120 mins	4	8	4	8	4	4	32	5.33NS
Hot water at 70oC for 30 mins	4	8	4	4	4	8	32	5.33NS
Hot water at 70oC for 60 mins	4	4	4	4	4	16	36	6.00NS
Total	40	68	36	70	48	94	356	

LSD = 5.31
* Significant
P = 0.05

Table 8b. ANOVA for percentage epicotyl emergence on first Day it was Noticed.

Source of variation	S.S	D.F	M.S	F-ratio
Treatments	550.37	8	68.80	3.25*
Seed lots	45.48	2	22.74	1.07NS
Replicates	216.00	1	216.00	10.20*
Residual	889.19	42	21.17	
Total	1701.04	53		

9a Period Between Germination and Epicotyl Emergence

	Seed lot A		B		C		TOTAL	AVERAGE
	Replicate		Replicate		Replicate			
Treatment	1	2	1	2	1	2		
Control (non-treated)	12	14	18	12	14	18	88	14.67
Mechanical scarified	10	10	10	10	10	10	60	10.00*
Sulfuric Acid	10	10	8	10	8	10	56	9.33*
Pulp Extract Soaked for 5 days	18	12	16	14	16	12	88	14.67NS
Distilled water soaked for 5 days	14	12	12	14	12	12	76	12.67NS
Hot water at 50oC for 30 minutes	14	12	12	10	12	14	74	12.33NS
Hot water at 50oC for 120 minutes	12	16	14	10	12	12	76	12.67NS
Hot water at 70oC for 30 minutes	18	12	12	10	10	12	74	12.33NS
Hot water at 70oC for 60 minutes	12	12	20	12	10	12	78	13.00NS
TOTAL	120	110	122	102	104	112	670	
MEANS	13.33	12.22	13.56	11.33	11.56	12.44	LSD = 2.77	
							P = 0.05	
							* = Significant	
							NS = Not Significant.	

9b ANOVA Between Germination and Epicotyl Emergence.

Source of variation	S.S	D.F	M.S	F-ratio
Treatments	155.71	8	19.46	3.39*
Seed lots	5.48	2	2.74	0.48NS
Replicates	8.97	1	8.97	1.56NS
Residual	240.88	42	5.74	
Total	371.04	53		

To determine the seed and seedling vigour of the 3 seed lots used in this work, a five item visual rating scale was established as seen below. See table 10 and also see table 11a and b.

Table 10: Seed and seedling rating scale.

Item	Seed Lots A Means	A Rating	B Means	B Rating	C Means	C Rating
Rate or speed of germination	56.4	3	46.09	1	60.41	5
Rate of epicotyl emergence	27.9	3	21.1	1	31.49	5
Average number of leaves/ leaflets	7.35	3	6.35	1	8.35	5
Average root or stem length	9.45	3	8.5	1	11.4	5
Seedling dry weight	0.44	1	0.45	3	0.49	5
Total Ratings		13		7		25

Table 11a. Means for 30 seedlings sample. Fresh and Dry weight in grams.

	1						2					
	Control			Mechanical			Control			Mechanical		
Seed lot	A	B	C	A	B	C	A	B	C	A	B	C
Fresh weight	22.6	17.7	30.0	23.9	24.7	28.8	36.0	41.9	42.0	36.1	40.1	42.5
Fresh weight mean	75	.59	1.0	.80	.82	.96	1.2	1.4	1.4	1.2	1.3	1.4
Dry weight	9.21	7.21	11.38	12.0	11.8	12.1	16.0	17.2	17.3	16.0	17.4	17.3
Dry weight Mean	.31	.24	.38	.4	.39	.4	.53	.57	.58	.53	.58	.58

Table 11b. Means for seed lots. Fresh and dry weight in grams

	A	B	C
Dry weight	.44	.45	.49
Fresh weight	.99	1.03	1.19

From this vigour rating, the C seed lot emerged most virgorous followed by A and lastly B.

4.6 Seed and Seedling Morphology:

Generally, the stages of development from seed to seedlings were the same for all the seed lots or genotypes except for the speed of development which varied with seed lots and treatment applied before sowing.

(i) Seed structure:

After water imbibition, the seeds became swollened; and when split opened a radicle and plumule with two developing foliar leaves were observed. See fig 1a.

(ii) Seedling Emergence:

The seedling emerged from the germinating medium through elongation of the hypocotyl, which pulls along with it the cotyledons. The portion of the hypocotyl towards the cotyledons were always curved initially, but straightens as they got exposed to light. This is similar to sweet clover and soya beans as reported by Dunham (1957). Initially, the cotyledons were closed and had portions of the testa on it. The testa finally fall off completely as cotyledons split open to liberate the epicotyl and Eophills. See Fig. 2a & 3a

(iii) Type of Germination:

An epigeal type of germination was shown, since the cotyledons were raised above the germinating medium. It is the type Duke as reported by NG (1978) refered to as phanerocotylar and epigeal respectively. DeVogeal (1980) in his classification place it under the Endertia type.

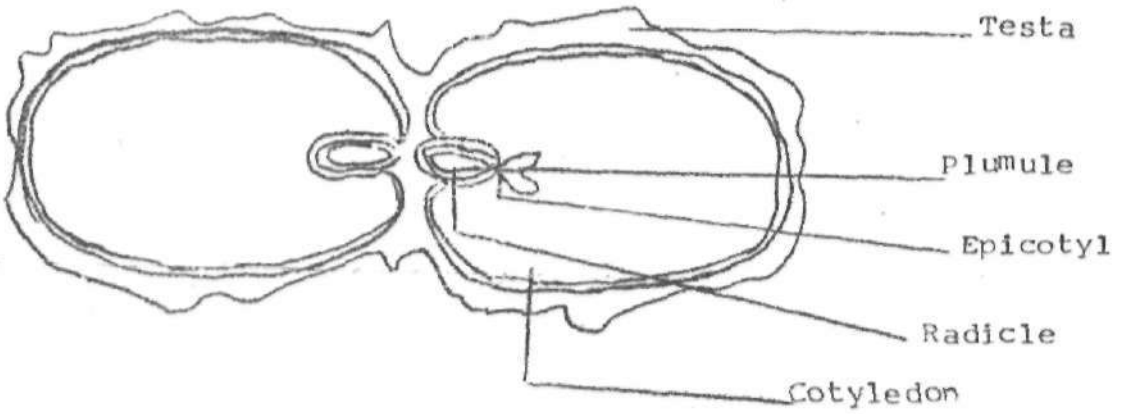


Fig. 1a. LONGITUDINAL SECTION OF A SEED AFTER WATER IMBIBITION FOR 5 DAYS.

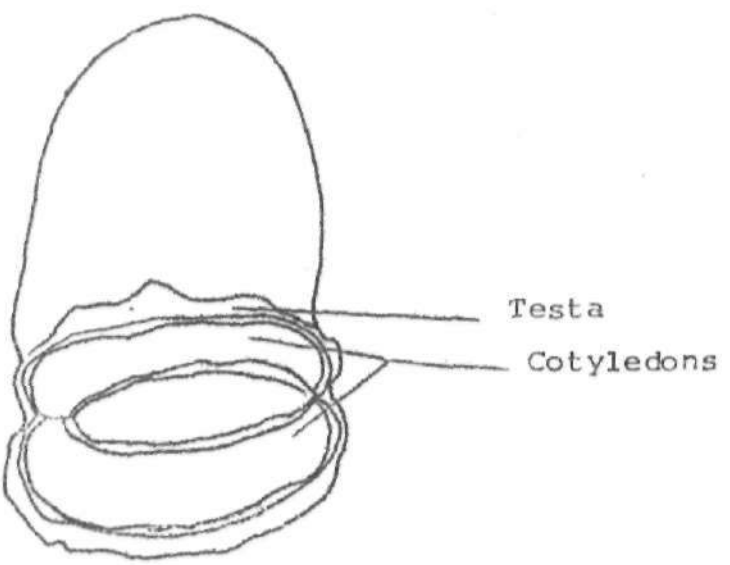


Fig. 1b. TRANSVERSE SECTION OF TAMARIND SEED AFTER WATER IMBIBITION FOR 5 DAYS.

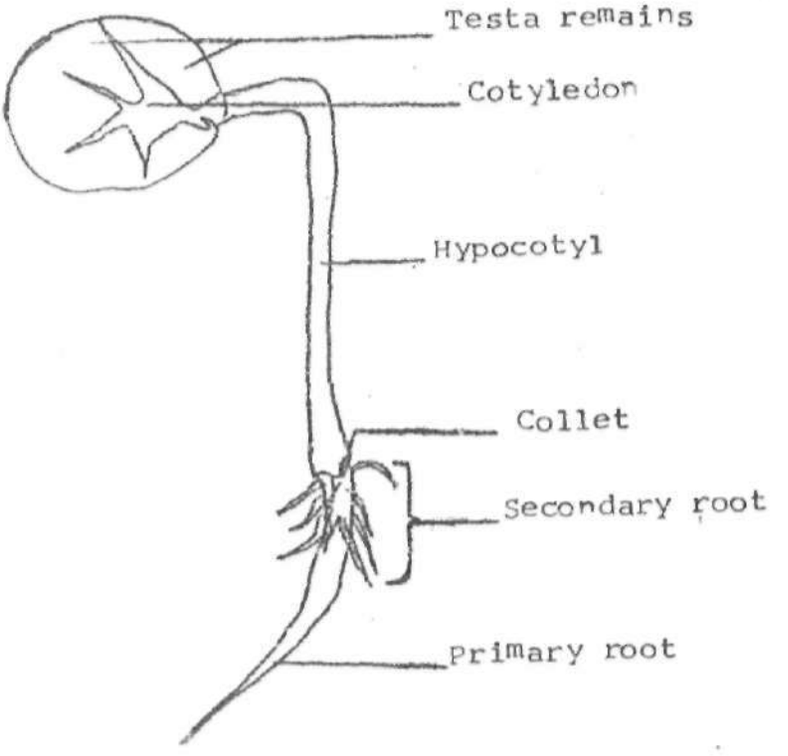


Fig. 2a. SEEDLING 7 DAYS AFTER SOWING.

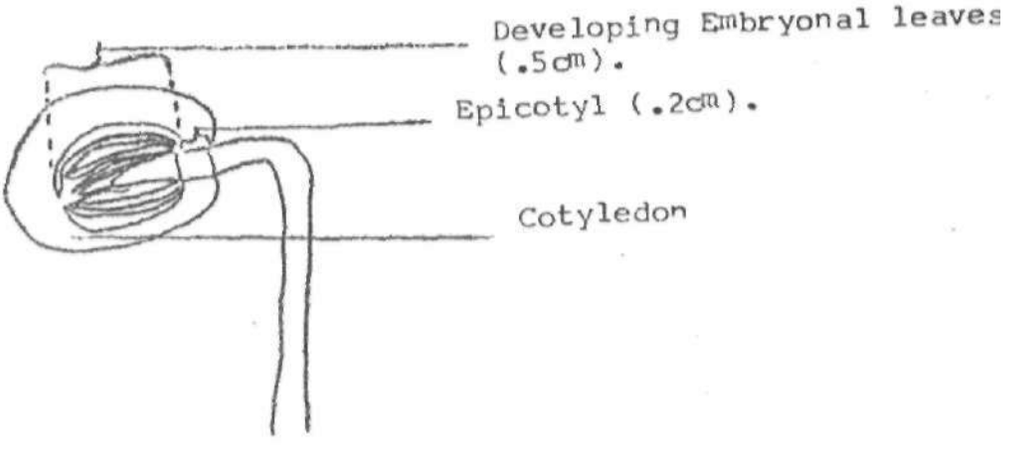


Fig. 2b. A SECTION SHOWING ONE COTYLEDON REMOVED EXPOSING THE DEVELOPING EMBRYONAL SHOOT OF THE 7 DAY SEEDLING.

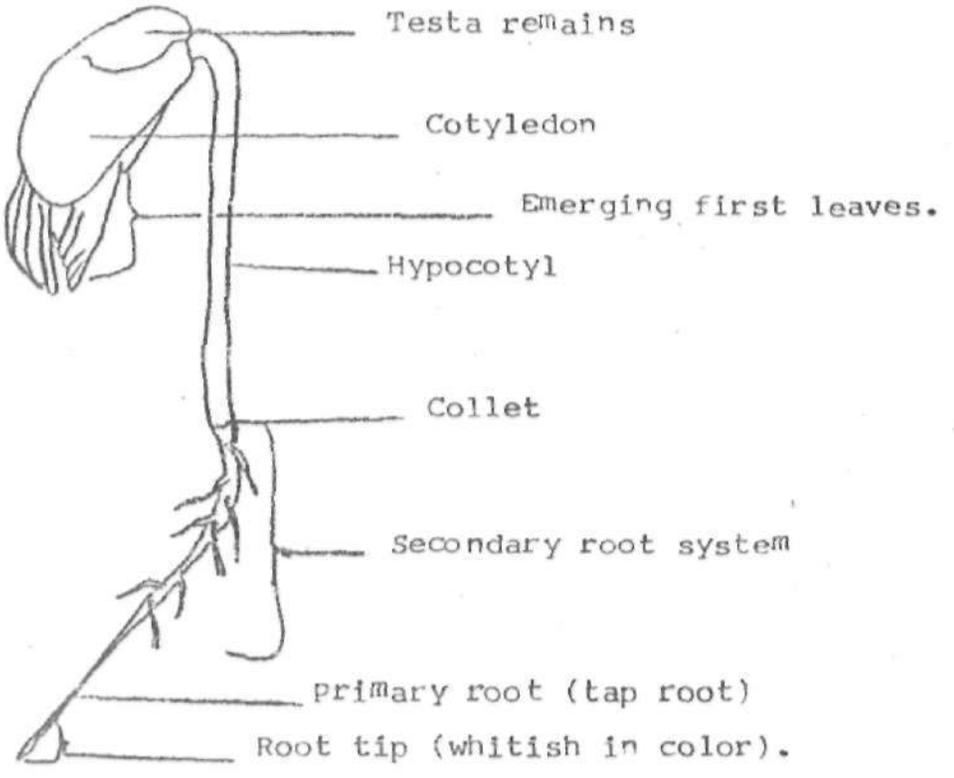


Fig. 3a. SIDE VIEW OF WHOLE SEEDLING 9 DAYS AFTER SOWING.

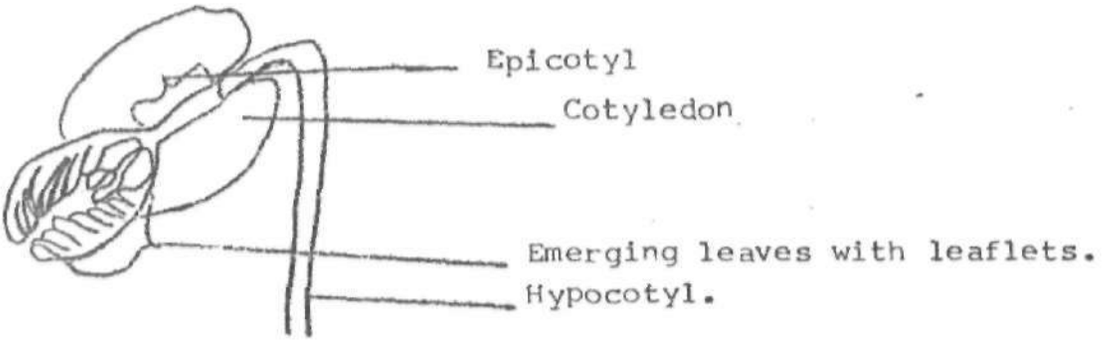


Fig. 3b. A VIEW SHOWING SEEDLING ABOVE WITH ONE COTYLEDON REMOVED.

(iv) Root System:

The radicle (embryonal root) first emerged from the cotyledons breaking out the testa. Its growth was descending into the germinating medium and being seperated from the shoot system by the collect. As the root grew forcing the rootip into the germinating medium, root hairs were formed just at the back of the elongation region, while older root hairs on matured regions of root disintegrate. The secondary roots being formed on the matured regions of the primary root increased in number and length, and also branch and rebranch as the root got older. See Fig 2 - 5 and Table 12.

Table 12. Mean Root length (in cm) within 13 days seedling Age.

Day after sowing	7	9	11	13
Total	5.6	6.0	9.0	10.5
Region covered by Secondary roots	1.8	3.0	6.0	8.0

ANOVA showed that there is a significant difference between treatments, and seed lots but not between the replicates (P = 0.05). The C. Seed lot had the longest root length of 10.3cm and 12.5cm; followed by the A. with 7.8cm and 11.1cm; and lastly the B. with 7.1cm and 9.9cm of the control to the mechanically scarified seeds treatments respectively see Table 13a and b.

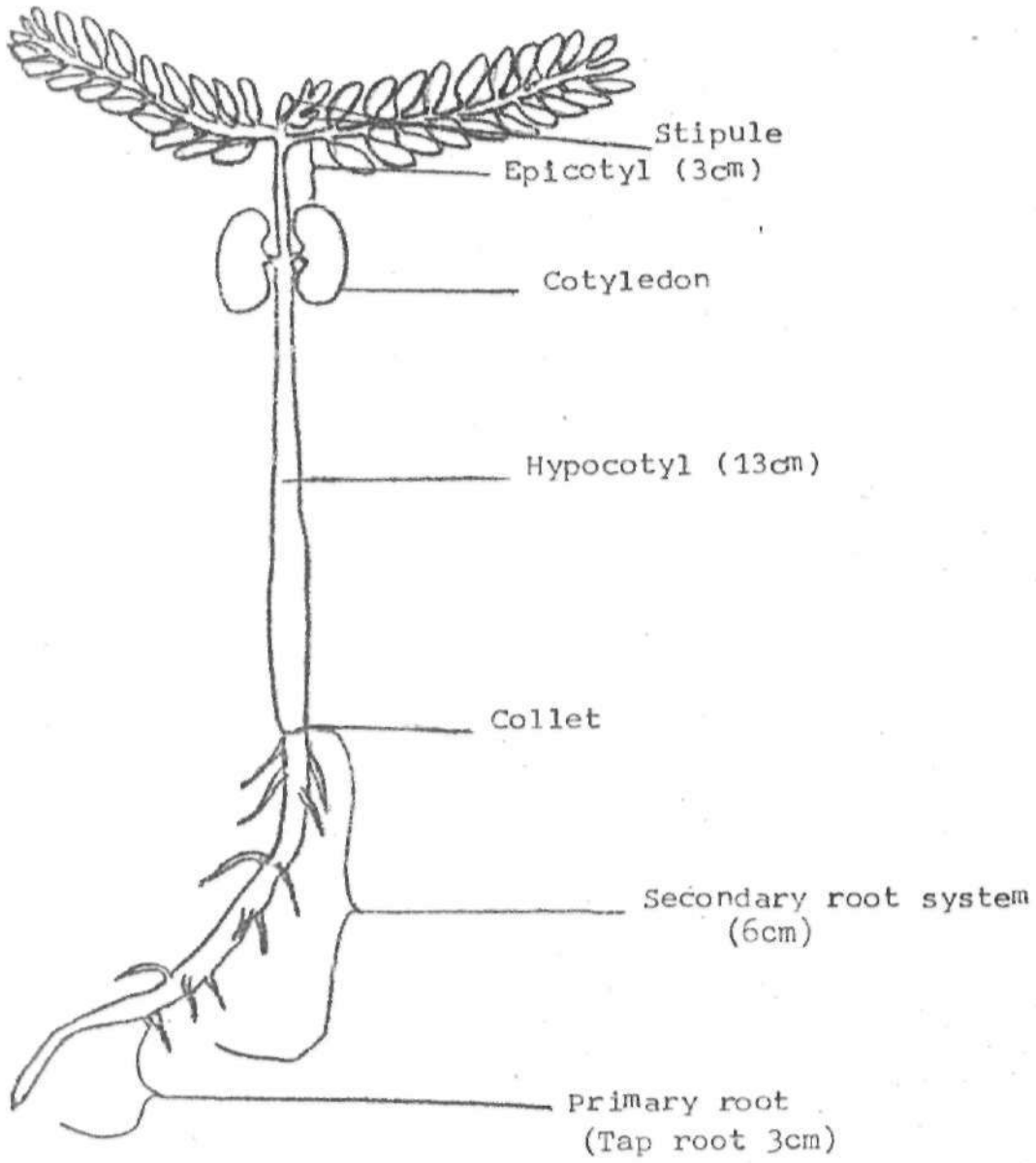


Fig. 4. SEEDLING MORPHOLOGY 11 DAYS AFTER SOWING.

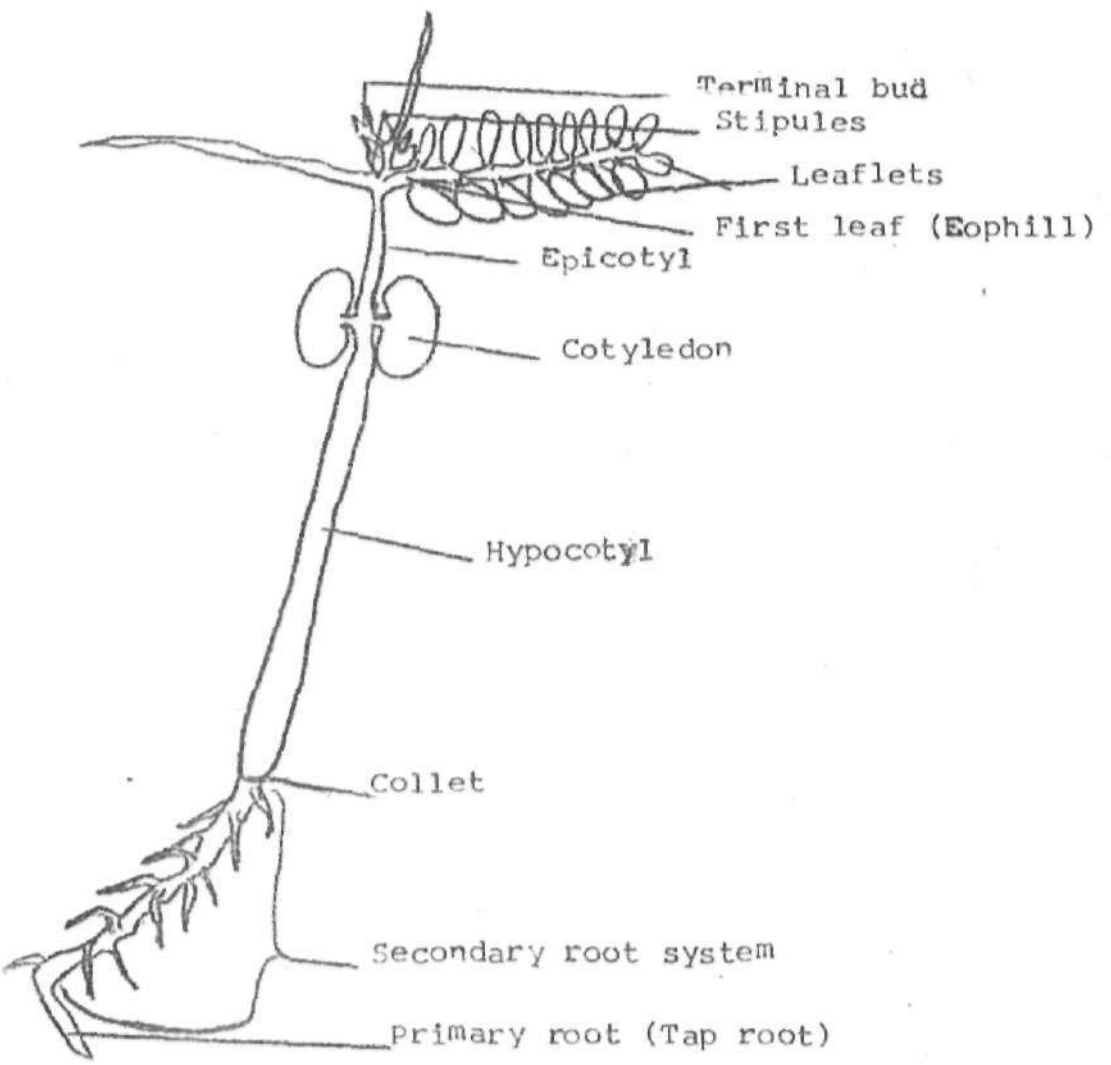


Fig.5. SEEDLING MORPHOLOGY 13 DAYS AFTER SOWING.

Table 13a Mean Root length within 30 days experimental period.

	CONTROL			MECHANICAL SCARIFIED		
Seed Lot	A	B	C	A	B	C
Replicate 1	7.3	4.3	10.7	10.6	8.8	12.0
2	8.3	9.9	9.9	11.6	11.0	12.9
Total	15.6	14.2	20.6	22.2	19.8	24.9
Mean	7.8	7.1	10.3	11.1	9.9	12.5

Table 13b. ANOVA for Root length.

Source of variation	S.S	D.F	M.S	F-ratio
Treatments	22.69	1	22.69	12.89*
Seed lots	17.16	2	8.58	4.88*
Replicates	8.17	1	8.17	4.64NS
Residual	12.32	7		
Total	60.31	11		

LSD = 1.81
SSR = 2.76
P = 0.05
* = Significant
NS = Not significant

The mean root length of seed lots for the control and Mechanically scarified treatments gave A. as 9.45cm, B. 8.5cm and C. 11.4cm. The means of the seed lots showed a signficant difference between C and B but not between C and A; and B and A. (SS^R = 2.76).

The plant possess a tap root system.

(v) The shoot system:

Usually this is the ascending portion of the plant which consist of the stem, leaves and reproductive parts, which are obtained at maturity.

a. Stem:

Seedlings possessed the hypocotyl, epicotyl, nodes and internodes representing the stem. At a stage of its development, the stem holds the cotyledons between the hypocotyl and epicotyl. As the hypocotyl elongates it carried along with it the cotyledons which enclose the Eophills and epicotyl. Initially the hypocotyl was usually curve towards the point of attachment to the cotyledons, but as it was gradually exposed to light it gradually straightened and became completely straight when cotyledons were fully epened. Also its elongation reduced as it was exposed to light as indicated by DeVogeal (1980). The epicotyl usually possessed some tiny hairs.

A closed examination of the growth rate within two weeks showed a rapid growth rate between day 9 and 11. The hypocotyl was responsible for most of the seedlings height with the epicotyl contributing only little, within these weeks. See Table 14.

Table 14.

Mean Stem length (in cm) within 13 days of seedling Age.

Day after sowing	7	9	11	13
Stem length	3.7	4.7	16.0	21.0
Hypocotyl length	3.5	4.2	13.0	18.0
Epicotyl length	.2	.5	3.0	3.0

The stem height after 30 days experimental period showed no difference between seed lots and treatments but between replicates although slight difference (not statistically significant) were observed with the C seed lot and mechanically scarified treatment which showed higher lengths see Table 15a and b.

Table 15a. Mean stem length within 30 days Experimental period.

		Control			Mechanical Scarified		
Seed lot		A	B	C	A	B	C
Replicate	1	13.3	7.6	15.2	15.7	14.9	15.6
	2	17.1	15.8	18.3	16.7	16.5	17.3
Total		30.4	23.4	33.6	32.4	31.4	32.9
Mean		15.2	11.7	16.8	16.2	15.7	16.5

Table 15b. ANOVA for stem length.

Source of variation	S.S	D.F	M.S.	F-ratio
Treatments	7.37	1	7.37	1.90NS
Seed lots	17.63	2	8.82	2.27NS
Replicates	31.37	1	31.37	8.06*
Residual	27.22	7	3.89	
Total	83.59	11		

* Significant

NS Not significant

b. Leaves:

The cotyledons (seed leaves) formed the first observable leaves of the seedlings. These had the leaf premordia which gradually develop to the foliar leaves within it. Before emergence of the foliar leaves, they were small, hairy and possessed the same number of leaflets with the matured emerged leaves except for being small and unopened see fig. 2b and 3.

Seedling leaves at the 30 days experimental period showed no significant difference regardless of treatment, seed lot or on the replicates. There was nevertheless a slight difference/mean number of leaves with the A seed lot taking the lead followed by C and B. Also, the mechanical scarified had more leaves than the control. See table 16a and b.

Table 16a. Mean number of leaves within the 30 days experimental period.

	CONTROL			MECHNICAL SCARIFIED		
Seed lot	A	B	C	A	B	C
Replicate 1	2.4	0.9	2.9	3.4	3.2	3.0
2	3.2	3.3	3.1	3.6	3.4	3.3
Total	6.6	4.2	6.0	7.0	6.6	6.3
Mean	3.3	2.1	3.0	3.5	3.3	3.2

Regarding number of leaflets there was a difference with the seed lots but not with treatments and replicates. The difference was seen between the C and B seed lots but not between A and B; C and A. The C. seed lot was highest followed by A and then B. (SSR 2.23. P = 0.05).

Generally the range of the number of leaves and leaflets at the 30 days experimental period was 2-5 and 6-11 pairs respectively. See Table 16 and 17.

The leaf type could be classified as compound pinnate leaf with the number of leaflets varying from 6-11 pairs.

Table 16b. ANOVA for leaves Number.

Source of Variation	S.S	D.F	M.S	F-ratio
Treatments	1.40	1	1.40	4.00N.S
Seed lots	0.46	2	0.23	0.66N.S
Replicates	1.40	1	1.40	4.00N.S
Residual	2.46	7	0.35	
Total				

N.S. = not significant

Table 17a. Mean Number of leaflets pairs within the 30 days experimental period.

	Control			Mechanical Scarified		
Seed lot	A	B	C	A	B	C
Replicate 1	6.2	2.8	8.2	7.7	6.4	8.7
2	7.6	7.4	8.6	7.9	6.9	8.9
Total	13.8	10.2	16.8	15.6	13.3	16.6
Mean	6.9	5.2	8.4	1.8	6.8	8.3

Table 17b. ANOVA for leaflets pairs within the 30 days experimental period.

Source of variation	S.S	D.F	M.S	F-ratio
Treatments	2.71	1	2.71	2.36N.S
Seed lots	14.88	2	7.44	6.47*
Replicates	4.44	1	4.44	3.86N.S
Residual	8.03	7	1.15	
Total	30.06	11		

SSR = 2.23

P = 0.05

The leaves usually possess stipules with 4 found at the base of the pair of the Eophills which were opposite and 2 at the single leaves.

phylotaxy: The leaves $\angle^{\text{arrangement}}$ showed the first leaves (Eophills) as being opposite and found on the same node while subsequent leaves alternated as the plant grew.

CHAPTER V

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 The Seed:

Tamarind seeds have variation in shape, color, size and weight, especially between seed lots which are seeds collected from separate trees. Although these factors have been found to play some role in germination as shown by Ibikunle and Komolafe (1973) and other workers reported by Lawan *et al* (1985); their roles were not investigated.

5.2 Seed Pest:

Insect pest identified as *Sitophilus granarius* and *Coryedon serratus* were found to feed on the seeds thus depleting their stored food and destroying their embryonal parts. Such seeds had their germination capabilities impired and hence were not sown. Similar to the observation of Ibikunle and Komolafe (1973), rats which are also rhodents were observed feeding on the soft water imbibed seeds, thus also serving as pest.

5.3 Germination and Dormancy Release:

To continue the life cycle of a plant from a seed, water imbibition to re-activate the dormant embryonal stage becomes inevitable. In this regard, various treatments to facilitate water imbibition, thus releasing seed dormancy were used. These treatments were initially employed because of findings by Baron (1977) among others that most leguminous plants dormancy is as a result of hardseededness.

The treatments employed showed the Sulfuric acid and the mechanical scarified seeds to be faster in germination and with higher percentage germination on the day germination started. The mean day for the beginning of germination being day 4 with percentage germination being 82% and 73.67% respectively as against the control with a mean day of 7.33 with only 3.3% on that day. Although the 3rd experiment showed germination of this treatment to have started on day 3 as daily observation was done then, the percentage germination was insignificant as compaired to that of day 4. This being 2% on day 3 as to 86% on day. 4. This finding shows much difference with that reported by Ellis et al (1985) who gave Tamarindus indica 21 days when tested between paper with additional treatments being file testa, concentrated acid and pre-soak for 24 hours.

On the issue of the best treatment of this work, this is in agreement with a documentation by Maguire (1980), on work done by some workers who in comparing Acid, Hot water and Heat treatments found, Acid treatment to be most effective in overcoming hardseededness in legumes. Following the Acid treatment in performance is the mechanical scarification. Also in support of this findings is Clemens, et al (1977) work on Acacia which showed that chipped seeds complete germination earlier than those not chipped. Next to the acid treatment and mechanical scarification in terms of efficiency this work found the distilled water soaked for 5 days and the Hot water treatment at $50^{o}C$ for 120 minutes time exposure to follow.

The 90°C Hot water treated seeds gave no germination even at a brief time exposure of 5 minutes. Most of the seeds decayed before the end of the experimental period. Further work to determine the optimum temperature could be carried out as Clemens, et al (1977) did on Acacia finding A falcuta to perform best at 100°C for between 5 - 600 seconds and A suaveolens at 80°C.

Although it is known that certain fruit extracts inhibit seed germination; such as Fasidi et al (1979) findings on lettuce seeds; the pulp extract treatment showed no such effect but rather performed better than the other Hot water treatment and also comparable to the Distilled water treatment.

The difference observed on the seed lots mean day for germination and percentage germination was not unexpected as there are no two individuals exactly the same. The different trees from which the different seed lots were obtained should have had different genotypes as regarding dormancy release period. It is most probable that the seed coat in seed lot B is harder than the others seed lots.

Significant difference was observed for percentage germination both for the day germination started and the total germination for the replicates which were experiments conducted at different time interval of 31 days. This difference could be as a result of certain chemical inhibitors overcomed through storage or after ripening period. After-ripening or storage period effects were not considered or investigated into as was done by Singer and Pitman (1988), whose work in support of after-ripening effects showed that on day 4, freshly harvested

Alysicarpus vaginalis seeds gave only 12% and even after 24 weeks experimental period gave only 47% while older ones (i.e those store for 6 years) gave 100% germination on day 4 using scarified seeds for each of the seeds sown. Eventhough a difference was observed between replicates which is thought to be as a result of after-ripening period, the scarified seeds i.e the sulfuric acid and mechanical scarified treatments were much similar in terms of speed of germination to the un-scarified thus limiting the cause of dormancy in Tamarind to hardseededness.

5.4 Seedling Development and Vigour:

After germination, seedlings emerged from the germinating medium. Seedling growth then continued upto epicotyl emergence from cotyledons with the first leaves or Eophills also opened. The period between germination and epicotyl emergence being closely related, shows that the early germination occur, the early the epicotyl emergence. In the light of this, the type of treatment influence the pace at which growth occur. In the same vein, seedling vigour could be associated with type of treatment as the seeds that germinated first also had an initial epicotyl emergence and leaves growth. The root length difference and the slight difference of the stem height also buttress the idea that vigour is determined by treatments. None of the treatments resulted in seedlings deformation. It is an established fact that genotype determine vigour, (Copeland, 1976 and Ellis, et al (1985). This was actually

observed right from germination to epicotyl emergence and also from the difference in root length and leaflets number of the seed lots (See the visual vigour rating scale).

Although possitive relationship between seed weight, and size to germinability and seedling establishment has been reported by serveral workers including Lawan et al (1985); and Taylor and Baltensperger (1987); such relationships were not given much attention but a visual observation showed that the heaviest seed lot performed better than the others. The next in performance was not the next in weight but had the largest seed sizes. Further work could be done to determine these factors in Tamarind.

From all indications, the earlier a seed germinate, develop leaves and an elaborate root system, the faster its establishment and Vigour.

5.5 Seed and Seedling Morphology:

Water imbibition of seed is the first step towards re-activating dormant embryonal states of seeds. Just like in other seeds, during imbibition, the cotyledons became swollen and because rapid cell division of the embryo is stimulated, the hypocotyl elongates carrying with it the cotyledons. As Dunham (1957) reported on sweet clover and Soybean, the portion of Tamarind hypocotyl towards the cotyledons were initially always curved and gradually straightens as exposed to light. The embryonal number of leaves and leaflets were the same with that of the seedling after epicotyl emergence as indicated by Graber (1954).

The root growth rate also depended on type of treatment and seed lot just like in the case of germination.

The shoot system: Initially growth of the shoot system consisted of rapid elongation of the hypocotyl which carried along with it the epicotyl and Eophills which later emerged from the cotyledons. Within the 30 days experimental period, the epicotyl contributed little to the general stem height. No significant difference was observed between seed lots and Treatments but there was between replicates, This could be as a result of the slower growth rate after the initial rapid growth rate of the hypocotyl. A slight difference was nevertheless shown both for Treatments and seed lots.

The leaves: The cotyledons i.e the first leaves shraved and fall after the Eophills had opened and photosynthesis started. The ability of a plant to manufacture its food early establishes it more than another that depend on the cotyledons for a longer time (Copeland, 1976; and Mayer and Poljakoff-Mayber, 1975). The rate of the seedling independence from the cotyledons varied with seed lots and treatments. Although there was no significant difference for leaves number between seed lots, treatments and replicates; slight difference was noted. This difference should have been because of the slow growth rate right from the time epicotyl emergence occured.

As regards to the number of leaflets, there was a significant difference observed between the seed lots. The seed lots that had been taking the lead from germination to epicotyl emergence were also at the fore-front. The mean range of number of leaflets for the 3 seed lots was between 6 - 11 pairs. This number

being different from that given by Hutchinson and Dalziel (1906) who gave 10 - 15 pairs.

Phylotaxy: Graber (1954) stated that most leguminous plants possess specific leaf arrangement. That of Tamarind is equally specific. It has its Eophills on a single node and are opposite. The subsequent leaves alternate on separate nodes. 4 stipules are usually located at the base of the Eophills and 2 at the base of each other single leaf.

5.6 CONCLUSIONS AND RECOMMENDATIONS

Tamarind plants have been found growing well in the Northern part of Nigeria which is equally being treatened by desertification. As a hardy plant, concious efforts could be made to produce seedlings for transplantation as the plant can serve a dual purpose i.e. serve for afforestation, where it could serve as wind break and for the increasing economic values being discovered for it as in literature. Being an indeginous plant it will have no adaptation difficulties and will not demand much for its establishment.

The variation shown by the seedlings right from germination, epicotyl emergence, shoot height, root length and leaflets are not unfounded. Copeland (1976) and Ellis et al (1985) showed that such variations which shows difference in vigour exist even within seeds of the same plant or tree which has the same genotype. The difference in seed lots vigour is therefore expected due to their genotypic difference. Although genotype

controls the vigour maximum potentials inherent in seeds such as growth rate and emergence ability, this can not be fully expressed due to influence of the environment (Perry 1976). In this light the different treatments employed showed different effects on the seed lots. The sulfuric acid treatment showing more vigour regardless of seed lot.

The sulfuric acid treatment is therefore recommended for bulk production of seedlings to be used either for experiments or transplantation; while mechanical scarification treatment (although a difficult method of seeds scarification) could be employed by individuals who may wish to plant few trees and will not be able to obtain or afford the cost of the acid. But if an easier method of mechanical scarification can be employed the method could comfortably take the place of the sulfuric acid treatment in nurseries.

When a nursery is establish a selection program to obtain varieties most suitable in terms of pulp quality and quantity, seed size and weight; and vigour should be propagated for afforestation and commercial purpose.

As a hardy plant (hardy because seedlings could stay over two weeks without watering after discarding experiments) they are recommended as forestry trees.

It is important to note at this juncture, that as this work is not a comprehensive account on Tamarind seeds and seedlings, further work could be done. Areas could include:

- After-ripening or storage dormancy period effects.
- Relationship between seed coat size with germination.
- Hot water treatments to release dormancy in Tamarind.
- The Hypocotyl and epicotyl growth rate in Tamarind.
- Relationships between seed weight, size, seed density, and colour to germinability.
- Water stress of seedlings.

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APPENDIX 1

Number and Percentage germination of seeds in relation to time within 30 days experimental period (Seeds sown on 7/7/90 period ended 5/8/90)

Treatments	DAY	4		6		8		10		12		14		16		18		20		22		24		26		28		30	
	Seed lot	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%
Control (non-treated)	A			2	4	3	6	5	10	13	26	13	26	14	28	18	36	21	42	22	44	25	50	24	48	28	56	31	62
	B					2	4	2	4	2	4	1	2	1	2	1	2	3	6	5	10	5	10	9	18	13	26	13	26
	C					1	2	1	2	7	14	9	18	12	24	14	28	22	44	24	48	26	52	38	76	45	90	45	90
Mechanically scarified seeds	A	32	64	46	92	48	96	50	100																				
	B	23	46	43	86	50	100																						
	C	39	78	45	90	50	100																						
Sulfuric Acid Scarified seeds	A	30	60	43	86	50	100																						
	B	27	54	49	98	50	100																						
	C	41	82	47	94	50	100																						
Pulp extract soaked for 5 days	A	1	2	1	2	1	2	1	2	9	18	13	26	15	30	28	56	32	64	35	70	37	74	37	74	44	88	49	98
	B							1	2	2	4	3	6	12	10	20	21	42	31	62	36	72	38	74	42	84	48	96	49	98
	C			1	2	2	4	2	4	8	16	15	30	21	42	36	72	41	82	42	84	43	86	47	94	48	96	50	100
Distilled water Soaked for 5 days	A	2	4	6	12	9	18	12	24	15	30	15	30	17	34	19	38	24	48	27	54	27	54	30	60	30	60	34	68
	B	1	2	3	6	6	12	6	12	7	14	11	22	13	26	14	28	18	36	24	48	25	50	29	58	35	70	43	86
	C	2	4	8	16	15	30	18	36	24	48	27	54	34	68	36	72	40	80	42	84	42	84	43	86	45	90	45	90
Hot water treatment at 50°C for minutes	A			2	8	4	16	4	16	5	20	7	28	10	40	12	48	14	56	15	60	15	60	15	60	16	64	14	76
	B					1	4	1	4	1	4	2	8	2	8	2	8	2	8	4	16	5	20	5	20	6	24	10	40
	C			1	4	3	12	3	12	4	16	7	28	13	52	14	56	20	80	21	84	21	84	22	88	24	96	25	100
Hot water treatment at 50°C for 120 minutes	A			1	4	3	12	3	12	5	20	9	36	10	40	12	48	16	64	17	68	18	72	19	76	20	80	23	92
	B			1	4	1	4	1	4	1	4	1	4	2	8	3	12	3	12	5	20	5	20	10	40	16	64	21	84
	C			1	4	2	8	3	12	5	20	10	40	14	56	15	60	17	76	21	84	21	84	23	92	24	96	25	100
Hot water treatment at 70°C for 30 minutes	A							1	4	1	4	2	8	2	8	3	12	3	12	3	12	4	16	4	16	6	24	7	28
	B													1	4	1	4	4	16	4	16	5	20	7	28	10	40	15	60
	C			1	4	1	4	1	4	2	8	2	8	2	8	2	8	4	16	8	32	8	32	9	36	11	44	12	48
Hot water treatment at 70°C for 60 minutes	A					3	12	3	12	3	12	7	28	9	36	9	36	11	44	12	48	12	48	15	60	16	64	17	68
	B			1	4	1	4	1	4	1	4	2	8	2	8	2	8	5	20	7	28	8	32	14	56	16	64	18	72
	C			1	4	1	4	3	12	6	24	7	28	9	36	11	44	13	52	14	56	15	60	15	60	18	72	18	72

Key: At 90°C for both 5 minutes and 10 minutes exposure there was no record of germination.
Almost all the seeds decayed before the 30 days experimental period elapsed.

APPENDIX 2

Number and percentage Epicotyl emergence from cotyledons within 30 days experimental period. Dates for experiment: 6/7/90 - 5/8/90.

	DAY	12		14		16		18		20		22		24		26		28		30	
Treatment	Seed lot	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%
Control(Non-treated)Seeds	A							2	4	3	6	5	10	6	12	9	18	10	20	17	34
	B															1	2	2	4	6	12
	C											1	2	2	4	7	14	11	22	27	54
Mechanically scarified scarified seed	A			4	8	13	26	15	30	29	58	32	64	34	68	34	68	38	76	38	76
	B			1	2	9	18	11	22	25	50	25	50	26	52	29	58	38	76	38	76
	C			3	6	13	26	16	32	33	66	33	66	33	66	35	70	39	78	39	78
Sulfuric Acid Scarified seeds	A			3	6	11	22	14	28	21	42	24	48	25	50	30	60	34	68	38	76
	B	1	2	5	10	15	30	18	32	27	54	32	64	32	64	32	64	38	76	38	76
	C	5	10	6	12	20	40	21	42	27	54	30	60	31	62	31	62	38	76	40	80
Pulp Extract soaked for 5 days	A											1	2	2	4	5	10	12	24	21	42
	B															2	4	4	8	24	48
	C											3	6	4	8	9	18	20	40	32	64
Distilled water soaked for 5 days	A							2	4	4	8	7	14	9	18	10	20	14	28	21	42
	B					1	2	2	4	4	8	5	10	5	10	5	10	8	16	21	42
	C					3	6	6	12	10	20	13	26	15	30	19	38	27	54	39	78
Hot water treatment at 50°C for 30 minutes	A									1	4	1	4	1	4	2	8	7	28	12	48
	B									1	4	1	4	1	4	1	4	1	4	5	20
	C							1	4	2	8	2	8	2	8	3	12	10	40	17	68
Hot water treatment at 50°C for 120 minutss	A							1	4	1	4	3	12	3	12	3	12	7	28	12	48
	B									1	4	1	4	1	4	1	4	2	8	7	28
	C							1	4	2	8	2	8	2	8	5	20	12	48	18	72
Hot water Treatment at 70°C for 30 minutes	A																	1	4	3	12
	B																	1	4	7	28
	C					1	4	1	4	1	4	1	4	1	4	1	4	1	4	3	12
Hot water treatment at 70°C for 60 minutes	A									1	4	1	4	2	8	3	12	3	12	5	20
	B															1	4	1	4	7	28
	C					1	4	1	4	2	8	2	8	3	12	4	16	7	28	12	48

NB: At 90°C for both 5 minutes and 10 minutes exposure, no record of epicotyl emergence was noticed since no germination was shown.

APPENDIX 3

Number and Percentage germination of seeds in relation to time within 30 days experimental period. Date: 14/8/90 – 13/9/90

	DAY	4		6		8		10		12		14		16		18		20		22		24		26		28	
Treatment	Seed lot	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%
Control (non-treated)	A			2	4	2	4	6	12	13	26	18	36	21	42	25	50	27	54	40	80	41	82	43	86	50	100
	B							1	2	1	2	3	6	4	8	10	20	24	48	35	70	43	86	45	90	50	100
	C			1	2	2	4	5	10	12	24	19	38	23	46	28	56	31	62	45	90	49	98	50	100		
Mechanically scarified seeds	A	41	82	44	88	46	92	50	100																		
	B	44	88	47	94	49	98	50	100																		
	C	42	84	50	100																						
Sulfuric Acid scarified seeds	A	50	100																								
	B	45	96	50	100																						
	C	50	100																								
Pulp Extract soaked for 5 days	A			2	4	3	6	22	44	25	50	28	56	30	60	33	66	35	70	44	88	50	100	50	100	50	100
	B			1	2	2	4	4	8	5	10	8	16	11	22	20	40	23	46	35	70	46	92	50	100		
	C	1	2	3	6	4	8	22	44	26	52	29	58	31	62	35	70	37	74	48	96	50	100				
Distilled water soaked for 5 days	A	2	4	5	10	8	16	19	38	21	42	29	58	30	60	36	72	38	76	44	88	50	100				
	B			1	2	2	4	4	8	6	12	12	24	14	28	20	40	23	46	36	72	42	84	50	100		
	C	1	2	6	12	10	20	20	40	27	54	30	60	32	64	35	70	37	74	41	82	50	100				
Hot water treatment at 50°C for 30 minutes	A			2	8	2	8	5	20	8	32	10	40	13	52	16	64	18	72	22	88	25	100				
	B							1	4	1	4	2	8	2	8	4	16	7	28	15	60	20	80	25	100		
	C	1	4	3	12	4	16	6	24	9	36	11	44	12	48	15	60	16	64	21	84	25	100				
Hot water treatment at 50°C for 120 minutes	A	1	4	2	8	3	12	6	24	7	28	9	36	15	60	19	76	20	80	24	96	25	100				
	B							3	12	7	28	5	20	6	24	8	32	8	32	10	40	22	88	23	92	25	100
	C					2	8	4	16	7	28	10	40	13	52	18	72	19	76	23	92	25	100				
Hot water treatment at 70°C for 30 minutes	A					2	8	2	8	3	12	4	16	6	24	11	44	12	48	20	80	25	100				
	B					1	4	2	8	3	12	3	12	5	20	11	44	13	52	20	80	23	92	25	100		
	C					1	4	2	8	2	8	6	24	7	28	11	44	14	56	19	76	25	100				
Hot water treatment at 70°C for 60 minutes	A					1	4	3	12	4	16	10	40	10	40	14	56	15	60	24	96	25	100				
	B					1	4	2	8	3	12	3	12	4	16	5	20	11	44	21	84	24	96	25	100		
	C					2	8	2	8	3	12	9	36	10	40	15	60	18	72	23	92	25	100				

NB At 90°C there was no germination observed at any of the time exposures.

APPENDIX 4

Number and percentage Epicotyl emergence from cotyledons within 30 days experimental period.

Dates: 14/8/90 - 13/9/90.

Treatment	DAY	14		16		18		20		22		24		26		28		30	
	Seed lot	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%
Control(Non-treated)	A							1	2	15	30	19	38	27	54	31	62	38	76
	B									5	10	9	18	11	22	15	30	30	60
	C									15	30	22	44	32	64	38	76	46	92
Mechanically Scarified Seeds	A	5	10	8	16	23	46	25	50	30	60	31	62	31	62	31	62	31	62
	B	3	6	5	10	24	48	26	52	38	76	41	82	44	88	44	88	44	88
	C	2	4	3	6	20	40	22	44	35	70	37	74	40	80	42	84	42	84
Sulfuric Acid Scarified Seeds	A	11	22	16	32	34	68	35	70	40	80	44	88	46	92	47	94	47	94
	B	10	20	14	28	23	46	24	48	35	70	39	78	43	86	43	86	44	88
	C	10	20	17	34	30	60	34	68	43	86	46	92	47	94	47	94	48	96
Pulp Extract Soaked for 5 days	A					4	8	6	12	21	42	30	60	35	70	36	72	38	76
	B							1	2	13	26	15	30	21	42	24	48	26	52
	C			1	2	5	10	7	14	25	50	31	62	36	72	36	72	38	76
Distilled water soaked for 5 days	A			1	2	5	10	18	36	24	48	34	68	36	72	40	80	43	86
	B							6	12	10	20	17	34	25	50	30	60	33	66
	C			1	2	4	8	9	18	25	50	33	66	38	76	41	82	42	84
Hot water treatment at 50°C for 30 minutes	A					1	4	2	8	8	32	13	52	16	64	17	68	19	76
	B							1	4	3	12	3	12	4	16	6	24	8	32
	C					2	8	2	8	9	36	14	56	17	68	18	72	19	76
Treatment Hot water treatment at 50°C for 120 mins	A							2	8	8	32	15	60	19	60	16	64	18	72
	B							2	8	5	20	6	24	8	32	10	40	11	44
	C							1	4	8	32	14	56	17	68	17	68	19	76
Hot water treatment at 70°C for 30 minutes	A							2	8	8	32	9	36	12	48	15	60	16	64
	B							1	4	6	24	10	40	10	40	14	56	14	56
	C							2	8	6	24	10	40	12	48	16	64	16	64
Hot water treatment at 70°C for 60 minutes	A							1	4	8	32	10	40	14	56	16	64	16	64
	B							1	4	5	20	8	32	11	44	14	56	16	64
	C							4	16	9	36	13	52	13	52	13	52	17	68

Since no germination occured at 90°C

No epicotyl emergence was observed.