Summary of Some Germination Studies in the Division of Forest Investigation, Bureau of Forestry College, Laguna*

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INTRODUCTION

One of the most difficult problems that constantly confront nurserymen in our reforestation projects is successful seed germination. Very often, these men complain of their repeated failures and of the poor germination results obtained in their nurseries. This may be due to the lack of definite knowledge regarding the proper care and methods of germinating seed, particularly the behavior of seeds, the proper treatment to be used and other factors.

Despite the meager knowledge of the behavior and requirements for successful germination of the seeds of our various and important tree species, only a few investigations along this line have been conducted. Besides, the few enlightening and useful results of published completed studies are scattered, thus they are overlooked by nurserymen, officers-in-charge of reforestation projects and by others interested in such data.

Hence, for the interest and benefit of these men, the writer compiled the results of previous and present studies in the form of a summary wherein the methods or techniques employed by the individual researchers are incorporated.

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DISCUSSION OF RESULTS OBTAINED BY VARIOUS WORKERS

Seed storage.—All seeds that are not sown immediately after collecting and cleaning are stored carefully in order to keep or prolong their viability until such time as they are needed to be sown in the nursery or directly in the field. How long the seeds will stay viable, however, depends on a large degree upon the manner of storage used and on keeping to the minimum the adverse factors affecting viability.

The methods used and the results of experiments conducted by Lopez (9) on mahogany (*Swietenia macrophylla* King) and Acuña (1) on West Indian Cedar (*Cedrela odorata* Linn.), are presented in the following tables:

Length of viability of the seeds of Mahogany (*Swietenia macrophylla* King) stored under various media.

Method of storage	Length of storage No. of days	Germination per cent
Fruits stored in closed cans with powdered charcoal and buried 40 cm. deep in the ground under shade	132	72
Seeds stored in closed cans with powdered charcoal and buried 40 cm. deep in the ground under shade	132	70
Control seeds stored in cans without charcoal	132	4
Storing the seeds in closed cans with powdered charcoal	132	30
Seeds stored with powdered charcoal in glass jars sealed with paraffin	101	30
Seeds stored with powdered charcoal in closed paper envelopes	101	6

Effect of storage in paraffin sealed bottles on the germination of West Indian Cedar (*Cedrela odorata* Linn.) seeds.*

Length of storage (in days)	Germination per cent
35	90
63	80
91	60
112	2-40
147	No germination

* Germination media: Fine sand in seed flats.

Considering the ease, practicability and economy in labor and material, the former researcher recommended that seeds of mahogany be stored in closed cans with powdered charcoal and buried 40 centimeters deep in the ground in the shade after the fruits are gathered. To obtain satisfactory results, the seeds of this species should not be kept under such kind of storage more than 120 days. The second table shows that the seeds of West Indian Cedar could be kept in paraffin sealed bottles up to 91 days without very much loss of viability, during which time, it is still possible to get over 60 per cent germination. The author also found that the germinative energy of the species is greatest within 21 days from the date of sowing.

Germination media.—The choice of the most suitable medium for germination and for raising planting stocks of any species of seeds is often difficult. For most species, however, the soil is the most satisfactory because it is the natural medium. Also it gives the most uniform results especially in extensive scale.

Caguioa (3) made a study on white lauan (*Pentacme contorta* (Vid) Merr. & Rolfe) seeds. The various media used in his experiment consisted of clayloam (control), sawdust-clayloam mixture, 1:1 by volume; charcoal-clayloam mixture, 1:1 by volume; ash-clayloam admixture of 1:2 by volume; pure fine sand, sawdust and charcoal.

On the basis of germination per cent, the results obtained were as follows: sawdust, 95.01% in a period of 14 days; ash-clayloam, 94% in 10 days; sawdust-clayloam, 92% in 12 days; clayloam, 89.75% in 16 days; charcoal-clayloam, 86.8% in 14 days; charcoal, 86.4% in 14 days and sand, 76% in 8 days period.

From the standpoint of mortality and of producing the greatest number of vigorous and healthy seedlings, the order of suitability of the said media are as follows: clayloam, sawdust-clayloam, sand, charcoal-clayloam, ash-clayloam, sawdust, and charcoal.

This study reveals that the above materials and mixtures as germination media

give satisfactory results and that the seeds of white lauan germinate very rapidly, the period of germination being from 2 to 16 days. While sawdust gave the highest percentage of germination, it did not prove to be a good type of surface soil for growing planting stocks and the mortality is high. Such is also the case with the ash-clayloam mixture. Sawdust-clayloam mixture is a good type of surface soil medium next to clayloam, as judged from the bases mentioned above. Sand was found to be a very poor germinating medium and a poor surface soil for such species. Charcoal is absolutely unfit for germinating and growing white lauan seedlings.

Density of sowing.—What is important to consider in the density of sowing is the amount of light and space requirements of the species and whether the stock will be transplanted when 1 year, 2 or 3 years old, and whether it will undergo one or more transplantings in the nursery before they are permanently set in the field. In sowing seed, therefore, the amount needed per square unit of seed bed should be carefully determined. This will depend on the characteristics of the species, the size and vigor of the seed and the number of seedlings desired per unit of area.

In computing the amount of seed to sow in a seedbed, Hawley (8) gives the following formula:

$$P = \frac{A \times D}{G \times S \times Z}$$

where:

P = pounds of seeds
A = area in square feet
D = number of seedlings desired per square foot
G = germination per cent
S = number of seeds per pound
Z = a variable factor expressing the difference between the germination secured in the tests and that secured in the seedbed (Olson, 1930).

Studying the effects of density of sowing on the germination of seeds of Benguet Pine (*Pinus insularis* Endl.), Defensor (5) found that density of sowing has no direct effect on the percentage of germination; that density, however, has some direct relationship to mortality partly due to damping-off and to the fact that the seed that is not protected is eaten by ants.

Depth of sowing.—Most seeds need soil covering to induce germination and to keep them from drying up through insulation. It also protects the seeds from birds, ants, rodents and other agencies.

Although the seed is usually covered to a depth equal to its greatest diameter, some seeds germinate best when sown just a centimeter or so under the surface of the soil while others require deeper sowing. The depth of the soil cover, as found by various studies in the Division of Forest Investigation, varies with the species.

A study of Quimpo (12) on the effects of depth of cover on the germination of seeds of large leaf mahogany (*Swietenia macrophylla* King) showed that depths of 4, 6, 8, and 10 centimeters are favorable; 8 centimeters gave the highest percentage.

The following table shows his findings on the effects of soil cover on the germination per cent of mahogany studied:

Sowing depth	Average germination per cent	
	Experiment I	Experiment II
2 centimeters	27.25	5.75
4 "	58.27	13.00
6 "	68.26	28.39
8 "	69.75	35.38
10 "	63.38	35.50
surface	0.10	0.90

The comparative results of the experiment of Caguioa (3) on Alupag (*Euphoria didyma* Blanco) is shown in the following table:

Sowing depth	Germination per cent	Period (days)
2 centimeters	46.5	75
4 "	57.5	80
6 "	60.0	80
8 "	56.0	90
10 "	33.0	80
15 "	27.0	85
surface	7.0	65

As shown in the above table, the suitable depth of sowing alupag seeds is from 2 to 8 centimeters. The author also found that at these depths, the quality and size of planting stock produced is better than that when the seeds are sown at the surface or at 10 to 15 centimeters depths.

Denoga (7) in connection with his studies on hastening the germination of untreated teak (*Tectona grandis*, L.f.) seeds, sown in untreated soil, obtained percentage of germination of 40% by surface sowing, 32% for 1 centimeter depth and 29% for 2 centimeters depth. He got very poor results with 3, 4, and 6 cms. depths. Seeds failed to germinate altogether beyond 6 centimeters deep. The only drawback in surface sowing is undue exposure of the seeds to ants, rodents and other pests. With regard to the seeds stored 60 days in a shaded pit and later sowed 2 centimeters deep in untreated soil, 69% germination was obtained.

Seed treatments.—Delayed germination in many forest tree seeds is due mainly to the impermeability of the seed coat which inhibits water absorption, or to a state of dormancy inherent in the embryo itself. Inherent dormancy generally disappears during a rest period or an after-ripening period in which certain physical and chemical changes necessary for germination occur within the embryo. In seeds which require a rest period, these changes must occur either during storage or while the seeds are in the germination bed before satisfactory germination can be obtained.

Toumey and Korstian (14) suggested the following methods of seed treatments to hasten germination:

1. Removing the pericarp or testa in whole or in part when it is more or less impervious to moisture because of its hardness or leathery characters.
2. Softening and rendering an impervious pericarp or making testa more absorptive by the use of chemicals as sulphuric acid or potash lye.
3. Soaking in hot water, especially when the endosperm or kernel of the seed is cartilaginous in character.
4. Storing at low temperature during the rest period to stimulate after-ripening so as to overcome inherent dormancy.

A number of experiments on seed treatments have been conducted in the Division of Forest Investigation ranging from soaking the seeds in tap water, scalding at certain temperatures, burning the seed with cogon grass, immersing in 36 normal sulphuric acid, cutting the ends of the seeds (nicking), mixing the seeds with wet wood ash, mulching, removing the shell, slightly cracking the shell, and using peat moss, or horse dung. Some satisfactory results were obtained and were recommended by those who made the studies.

Conducting an experiment in 1936 to find the relative efficacy of some of the most common methods locally used to hasten, and to get a better percentage of germination of akle (*Albizzia* acle (Blanco) Merr.), Delizo (6), used the following methods:

1. Soaking the seeds in 36 normal H_2SO_4 at varying length of time, i.e., 15 minutes, 25 minutes, and 60 minutes, respectively.
2. Soaking the seeds in tap water for two hours.
3. Cutting the ends (nicking) of the individual seeds.

The results of this study showed that mechanical wounding of the seeds (nicking) induced rapid germination but the advantage was offset by the low percentage of germination because of fungus infection. The most effective of the treatment used is immersion in concentrated sulphuric acid for one hour. The acid partly dissolved the cutin and thus allowed a more rapid imbibition of water by the seed.

The normal germination period of akle seeds without treatment is 120 days.

The comparative results of the various treatments are shown in the following table:

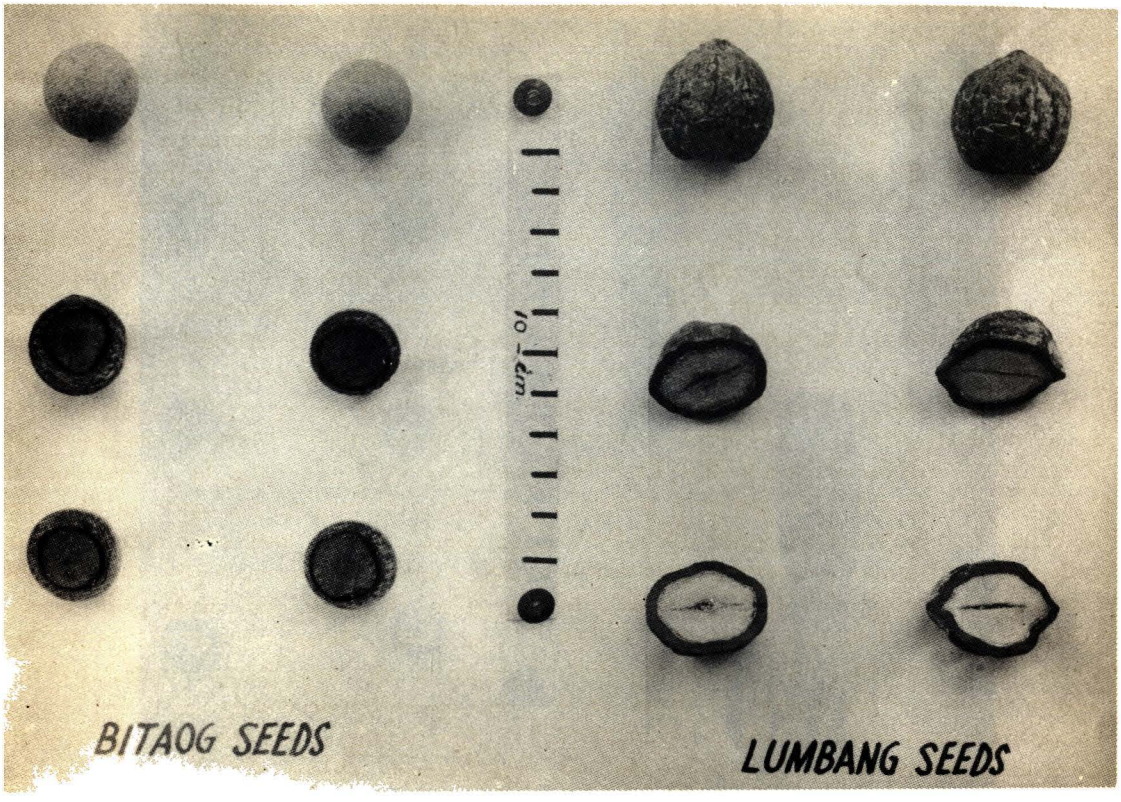

Plate 1.—Seeds and Cross Section of Bitaog and Lumbang Seeds.

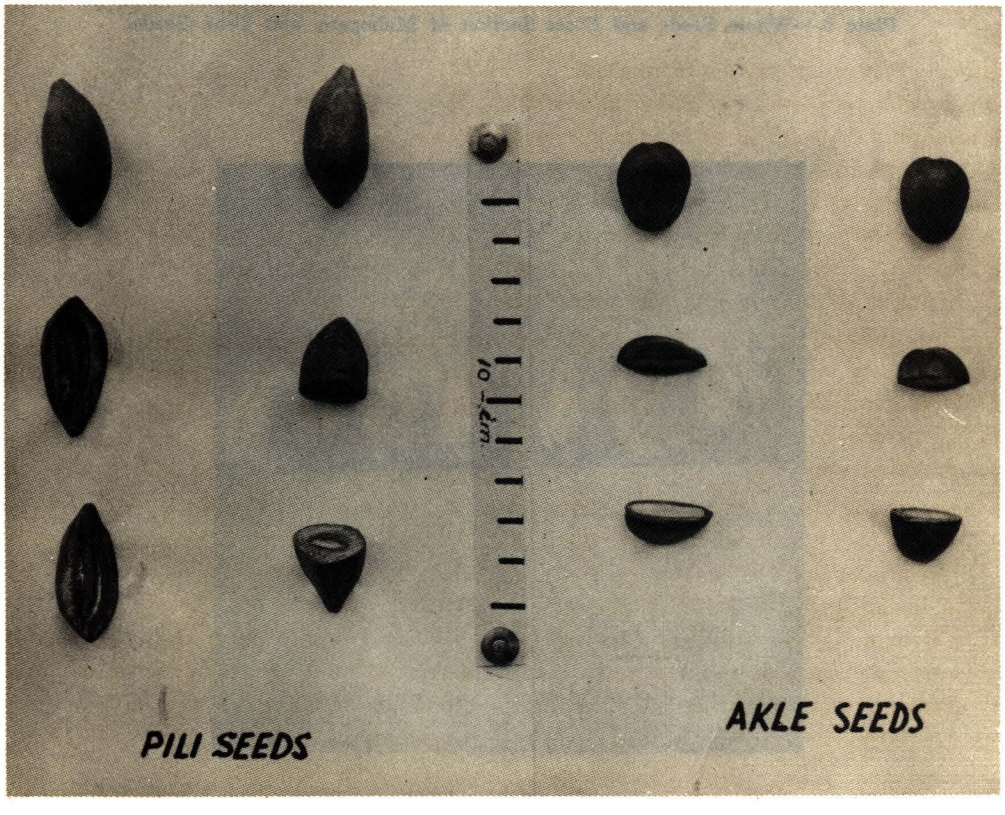

Plate 2.—Whole Seeds and Cross Section of Pili and Akle Seeds.

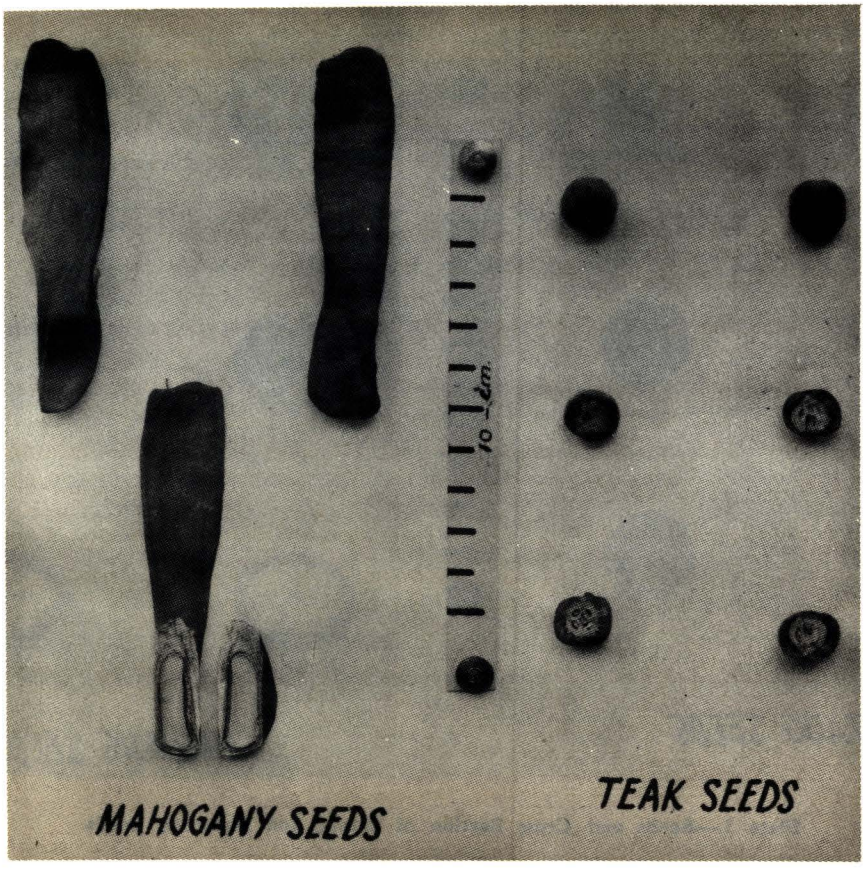

Plate 3.—Whole Seeds and Cross Section of Mahogany and Teak Seeds.

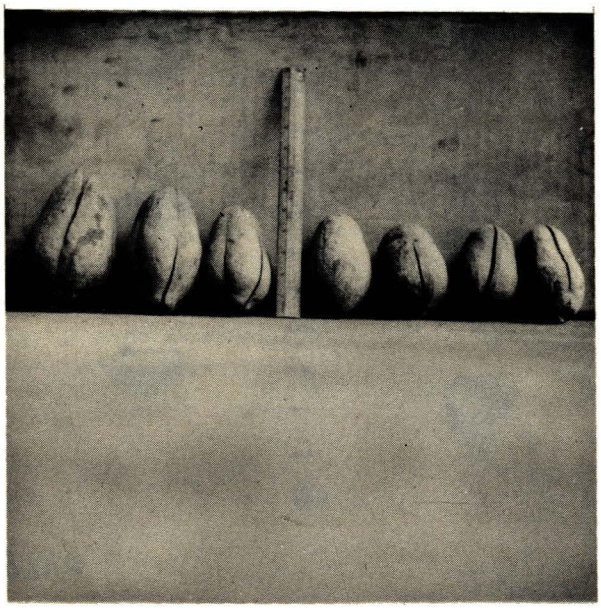

Plate 4.—Mahogany Fruits.

Number of days required to start and complete germination

TREATMENT	No. of days to start germination	No. of days to complete germination
1. Soaking the seeds in H_2SO_4, 1 hr.	9	27
2. Ends of seeds cut	9	23-½
3. Soaking in H_2SO_4, 25 min.	10-½	35
4. Soaking in H_2SO_4, 15 min.	10-½	48-½
5. Two hours in tap water	20-½	120
6. Untreated seeds (control)	22	119

Paras (11) who made a study also on hastening the germination of bitaog (*Calophyllum inophyllum* Linn.) seeds which without any treatment normally takes about two months to complete germination is shown in the following table; the results of three trials of different treatments:

Number of days required by the seeds to start and complete germination

Treatment	FIRST TEST		SECOND TEST		THIRD TEST		AVERAGE	
	Beginning *	Finish *	Beginning	Finish	Beginning	Finish	Days	
Control	48	100	67	33	57	25	57.33	52.66
Cracked	48	112	32	60	34	39	38.00	70.33
With cogon mulch	62	86	45	47	—	—	53.50	66.50
Shell removed	23	25	18	49	25	42	22.00	38.66

* Beginning: Number of days to start germination.
* Finish : Germination completed after 1st germination.

The complete shelling of bitaog seeds hastens the start of germination to only 22 days from 57 days in the case of those planted unshelled. The duration is shortened from 52.66 in the case of untreated to 38.66 and the percentage of germination increased from 63.00 to 93.10 per cent. Apparently this shows that the chief cause of delay in starting germination was the hardness of the shell or seed coat. Partial or complete removal of the coat, therefore, hastened germination.

A study of the nut of pili (*Canarium ovatum* Engl.) by the removal of the shell, cutting the end of the seeds, cracking it slightly with a blacksmith vise, mulching, soaking in water, and scalding, Miras (10) obtained favorable results.

Removal of the shell caused the seeds to start germination in 13 days but the germination was only 34 per cent. Soaking the seeds in tap water for 10 days started germination within 31 days and the germination per cent is the highest per cent of all methods employed for the species. It was observed that seeds of pili without any treatment starts germinating very much longer than one month.

Investigating on lumbang (*Aleurites moluccana* (L.) Will.) seeds to hasten its germination, Tabat (13) found that of the three methods used, dibbling the seeds in nursery bed to a depth of about 2 centimeters and mulching the same with 3 to 4 inches of cogon grass (*Imperata exaltata* Brongn.) and watering the bed everyday to make it very wet (about two gallons for every square meter) caused the seeds to start germination within one month and four months to complete germination. The percentage of germination by this method was 86.5 per cent.

Lumbang seeds with one side ground down (similar to nicking) caused the seeds to start the germination one month after sowing and to complete germination required eight or nine months. The germination per cent, by this method, was 21.05.

Another method employed by Tabat (13) was covering the seeds with cogon grass and setting it on fire after they were spread evenly on the ground. The seeds were immediately immersed in cold water to crack them. By this method, germination began 18 days after sowing and another month to complete germination; and the percentage of germination was only 24.1.

Experimenting also on teak (*Tectona grandis* L.f.) seeds Denoga (7) approached the problem of hastening the germination by treating the germinating beds and the seeds separately. Various amounts of sawdust, ash, leafmold, peat moss, and horse manure were added and mixed in separate beds. As to the treatment of the seeds, such methods as burning the seeds at various length of time with cogon (*Imperata exaltata* Brongn.), weathering the seeds in open and shaded pits at various length of time also, and cracking the shell of the seeds were used.

The result of the experiment showed that treating the seeds gave better results in inducing early germination than treating the germinating media. The best treatment of the soil to hasten germination is: 1/3 horse dung to 2/3 clayloam mixture. By this method, the germination started in 17 days. The best treatment of the seeds is storage for 20 days to 60 days in a shaded pit. Germination started within 33 days after sowing with a germination of 69.7 per cent, being the highest.

Viability test.—A knowledge of the number of seedlings to be expected on a given area from a lot of seeds is important, because it will obviate the waste of seed and of space in the nursery. For this reason, the viability of seeds should be tested as soons as collected and immediately before sowing or shipping. The percentage of viability should be recorded and kept, and should accompany the seed when shipped.

In his experiments on ipil-ipil (*Leucaena glauca* (L.) Benth.), Banaba (*Lagerstroemia speciosa* (L.) Pers.), and ipil (*Instia bijuga* (Colebr.) O. Ktze.) Viado (15), found that test by cutting gave a fairly accurate and reliable results and are close to the results of germination tests.

In this experiment, he compared the results of each of the three methods of testing viability, i.e., cutting test, physical test and germination. He is of the opinion that "cutting test" gave comparatively good results, considering the simplicity and rapidity of use. His results were as follows:

Species	Cutting Test Per cent	Germination Test Per cent
Ipil-ipil	29.0	27.0
Banaba	30.5	34.5
Ipil	77.0	70.0

CONCLUSIONS AND RECOMMENDATIONS

The results of these studies reveal several interesting facts, the merits and demerits of which are discussed here for evaluation.

1. The results of the studies of Acuña (1) and Lopez (9) reveal that seeds need proper storage to prolong their viability; and that a storage method good for one species may not be good for another. Although only a few studies have been conducted on this subject, the results may be useful in the proper method of storing seeds to maintain their viability for a longer period.

2. The experiment of Viado (15) on "cutting" for testing viability is considered a reliable, practicable, easy and rapid method with big seeds. However, this may not be practicable with hard-shelled seeds like pili and lumbang, because the seed coat is too hard for the knife to cut. Neither is it possible with small or tiny seeds.

3. Defensor (5) found that the density of sowing has some direct relationship to mortality caused partly by damping-off but that this does not have any direct effect on

the percentage of germination. While this is true, there are other effects of the density of sowing because as the seedlings grow bigger, they compete not only for crown space but also for soil moisture and soil nutrients, as their roots spread in the ground. The growth will show some of the effects of density of sowing. This, however, needs further study.

4. The experiments of Quimpo (12), Caguioa (3) and Denoga (7) on the effects of depths of sowing on the germination and quality of seedlings indicate that seeds require well aerated soil for germination, and as a general rule sowing at from 2 to 10 centimeters in depth favor germination. Deeper than these depths were found to be injurious to the seed and this may be another cause of mortality of seedlings and decrease of the percentage of germination.

5. In the studies on seed treatments, the results showed that one treatment is good for one species of seeds but not for another.

The variations in the findings in the different studies may be attributed to the difference in the types of seeds, the character of treatment, the time of the year, and other factors. It has been proved, however, that certain types of seeds as cartilaginous and hard coated seeds need some pre-treatment to hasten their germination.

6. Caguioa's experiment on the use of germinating media showed that not all types of soil are fit for the germination of seeds and the development of seedlings.

The studies presented in this paper show the extent of research conducted in the Division of Forest Investigation on forest tree seed germination. Considering the number of important tree species used in our reforestation projects, the necessity of an immediate and more concerted effort toward more researches along this line is in order. It is an accepted fact that in the studies of natural reproduction of forests, the start should be made with the seed and seed production of stands. A better knowledge of the behavior of tree seeds is required not only for successful propagation of trees in nurseries for reforestation and ornamental purposes, but also for the intelligent control of forestry operations to assure natural and artificial regeneration.

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