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PARAMETERS INFLUENCING *MAGNOLIA GRANDIFLORA* L. SEED GERMINATION

A Thesis

Presented for the

Master of Science

Degree

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ABSTRACT

The seeds of Magnolia grandiflora are diverse in weight, size and density; therefore this study was undertaken to measure these physical parameters and to determine their relationship to germination. Additional parameters of paired seed, non-paired seed, seed location within the aggregate, bloom period and harvest periods were also studied to determine their relationship to germination.

The blossoms of the Magnolia grandiflora trees were tagged each week and then harvested when matured. After seed collection the seeds were cleaned, weighed and their densities estimated by floatation. The seeds were planted and stratified for ninety days. After stratification was complete, a forty-five day germination test was conducted.

Data were analyzed using an analysis of variance for germination percent and it was determined there were no significant differences between trees, between weight groups, between seed locations on the aggregate or between paired and non-paired seed. The density classes of .91 g/ml and 1.0 g/ml had significantly higher germination percentages than the .78 g/ml and <.78 g/ml density classes. The later harvest period, November 21, 1985 resulted in larger germination percentages. Peak blossom was also determined and occurred near June 20, 1985.

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CHAPTER I

INTRODUCTION

The Southern Magnolia, Magnolia grandiflora L., offers interesting possibilities in the quest for understanding seed quality and germination. This common landscape tree flowers in May and June and sporadically thereafter until frost (Dirr 1975). Seeds are diverse in size, weight and density and usually ripen in October and November. It is important to understand and evaluate these physical qualities in regard to the Southern Magnolia just as it is important to understand the factors which influence the performance and seed production of many horticultural crops.

Most seed plants produce seed which vary considerable in quality including the capacity to germinate. Many species produce an abundance of seeds that compensate for poor germination and assure survival. According to Copeland and McDonald (1985) each viable seed has the capacity to produce a seed-bearing plant resulting in more plants and seeds in the future. Seeds possess an internal mechanism which controls the sequence of nutritional and physiological development.

The next growth stage of the seed is germination. Many researchers have determined that germination and the resulting seedling vigor is directly influenced by certain physical characteristics. Tupper (1969) measured five physical

characteristics of cottonseed and determined that seed density had a significant influence on both earliness and total germination and that seed weight provided the greatest influence on seedling growth.

The separation of quality seed apparently lies within a regime of the physical characteristics, particularly seed density and seed weight. Very few researchers have studied seeds individually in a controlled climate to determine if the relationship between physical characteristics and quality seed actually exists. Agronomic crops such as rice, alfalfa, barley and especially cotton have been analyzed using these physical characteristics as a separation mechanism. However, an extensive review of literature reveals very little research has been attempted on individual seed selection and analysis relating to the variability of seed quality of woody plant material.

The quality of an individual seed can not be improved, only measured. Therefore, the challenge in this research and for further research is to determine specific physical characteristic regimes for woody ornamental seeds, in this case Magnolia grandiflora.

The objectives of this study were:

1. To determine if a specific bloom period or harvest period has an influence on seed density and/or seed weight.

2. To determine if seed density and/or seed weight influences the germination of the seed.
3. To determine if seed density is associated with seed weight.
4. To determine seed viability on seeds in various harvest periods.
5. To determine if paired seeds in one locule are characteristically more similar than seeds in different locules.

CHAPTER II

REVIEW OF LITERATURE

To begin the process of a seed quality study, researchers first look at individual plant species and study anthesis and seed formation. After maturation and harvest, seeds are analyzed for quality by determining the physical characteristics of those seed which yield the greatest germination percentages and the most vigorous seedlings.

Magnolia grandiflora L., commonly called Southern Magnolia, fills the air with a sweet fragrance from its magnificent white blossoms usually from May until November. This is the longest continuous bloom period in the Magnoliaceae family. Hillier (1981) commented that Magnolias embrace the most magnificent of flowering trees in the temperate region. It was named *Magnolia grandiflora* in 1759 by Carolus Linnaeus, but prior to that time it had been named by Phillip Miller in *The Gardener's Dictionary VII*, *Magnolia folus lanceolatus persistentibus caule erecto arboreo* meaning Magnolia with evergreen spear-shaped leaves and an erect tree-like stalk (Treseder 1978).

Magnolia grandiflora (Figure 1) is a member of the Magnoliaceae family, which as Treseder (1978) points out, consists of eighty species of both deciduous and evergreen trees and shrubs. Twenty-six species are found in the Americas with

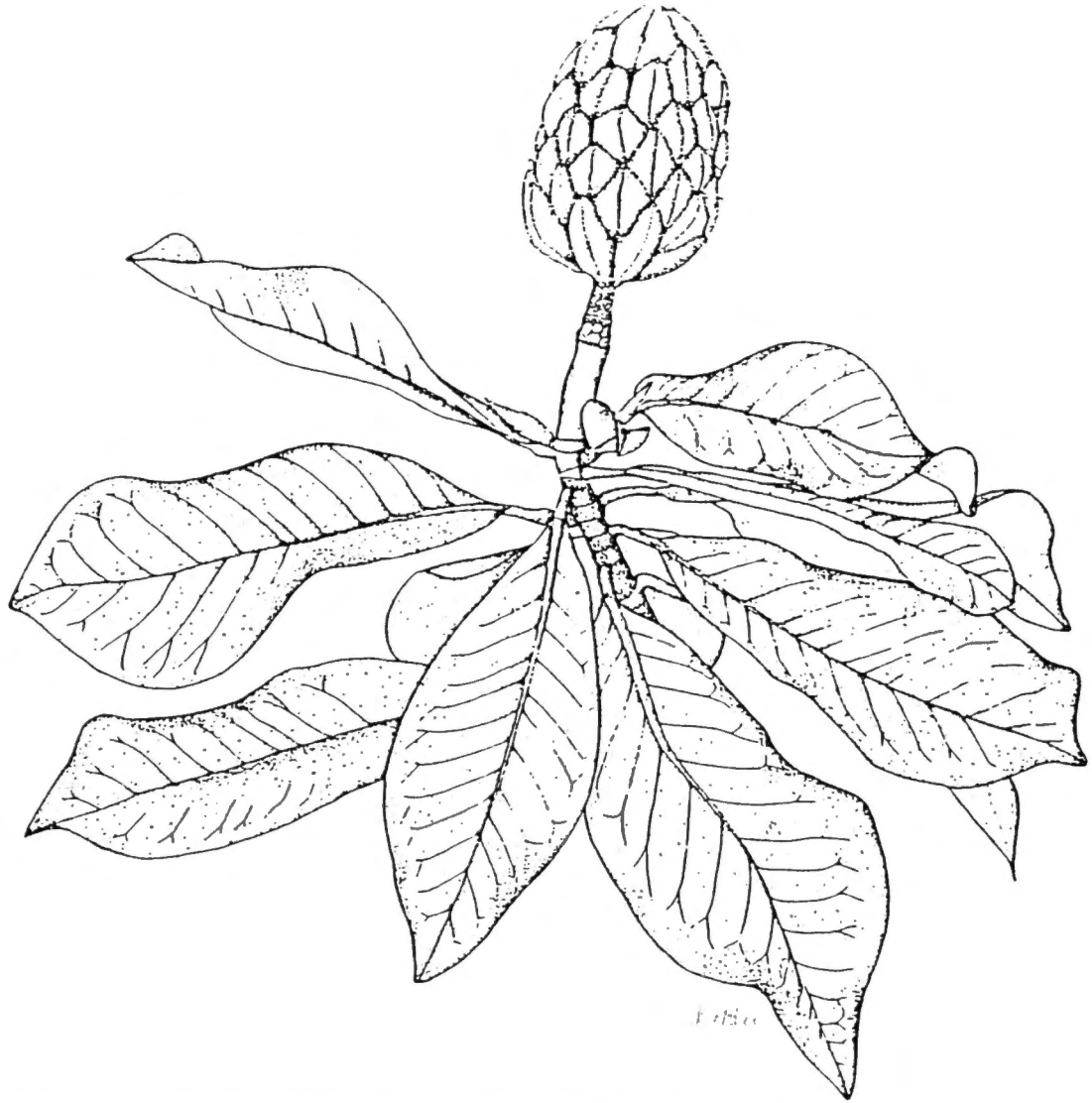


FIGURE 1. MAGNOLIA GRANDIFLORA WITH DEVELOPING AGGREGATE.

the remainder in Asia. M. grandiflora belongs in the subgenus Theorhodon Spach, which is one of the American types of Magnolias. The trees in this subgenus are large evergreens that grow in the tropics with the exception of M. grandiflora. Southern Magnolia is a coastal plains species and is classified by the United States Department of Agriculture as a zone seven plant which limits the areas of growth to climates that do not have minimum temperatures below 0^{o} to 10^{o} F. The natural limit of growth in the United States is an area from eastern Texas along the Gulf of Mexico to central Florida and northward to the coastal areas of North Carolina. M. grandiflora trees grow well in rich, moist, acid soils that allow good drainage. Although these conditions are the most favorable it survives in swampy regions, drought areas and tolerates heat and wind. It obtains heights of sixty to ninety feet with normal trunk diameters of two to three feet, but records indicate diameters of up to five feet in Louisiana.

FLOWERING

In the Southern United States, mature Magnolia grandiflora trees begin blooming in early May and continue to bloom into October and November depending on the low temperature. The main flush of flowers occurs in May and June and sporadically thereafter. Flowers are borne singly and are termed solitary and determinate. The terminal position

represents a very simple and primitive condition. The floral organs are polymerous, which describes the spiral arrangement of the floral parts on the elongated receptacle.

According to Guedes (1979), Magnolia grandiflora branches only by means of proleptic shoots, i.e. the floral shoot is formed the season prior to flowering within the resting apical bud meristem.

In the perianth the sepals and the petals are undifferentiated and therefore are referred to as tepals. The tepals occur in three whorls of three. Various cultivars of Magnolia grandiflora have tepals which occur in more than three whorls.

Above the area of the perianth attachment is the androecium which is the male portion of the flower. The stamens are narrow laminar in shape and whorled. When the pollen dehisces, it sheds introrsely or to the center of the flower.

Above the androecium lies the gynoecium, which is composed of the female organs or stigmas. The gynoecium protrudes in the form of a column or cone composed of numerous stigmas which are also spirally arranged.

As floral buds become active, cell division and elongation occurs. The outermost covering, perule, opens and is shed. A second protective covering, spathaceous bracts, is then exposed. As the bracts open, the tightly closed pale green perianth becomes visible. The flower is cup shaped on the first day of opening, then on the second day the anthers are shed and held

around the basal area of the tepals. As the flower opens, they become fragrant, turn creamy-white and last for about two days.

Flowers are dichogamous where the stigma is receptive before the anthers of the same flower are mature. The pollen therefore, must come from a flower which has previously opened. Leppik (1975) explained that this may be one reason for the stagnation in the development of Magnolias. Pollination is accomplished by the action of beetles reportedly from the Nitidulidae family and Cetoniinea subfamily.

During the first stage of anthesis, beetles find protection under the tepals, which arch over the carpels. They leave only when the tepals are shed at the time of anther dehiscence. They feed on the protein-rich pollen and a nectar-like sugary fluid excreted between the stigmas. After pollination, beetles move to other flowers in the initial stage of anthesis. They pollinate the receptive stigmas of the unopened flower while they search for mature pollen and nectar to feed upon.

SEED DEVELOPMENT

Fertilization occurs when the pollen grains have germinated on the receptive surfaces of the stigmas resulting in growth of the pollen tube. Male nucleus cells fuse with the female egg cells in the ovary of the carpels. Two female egg cells occur in each carpel resulting in a capacity for two seeds in each carpel. However, all ovaries are not fertilized. One explanation is

that there appears to be a critical temperature for pollen germination. Treseder (1978) points out that temperatures need to be as high as 70^{o} to 80^{o} F for the pollen to germinate.

Eumes (1961) states that what was thought to be self-incompatibility has been more recently attributed to the absence of pollinating beetles at the brief and critical period of pollen shedding. This could explain the problem of many aborted aggregates. Twisted and deformed aggregates could also be the result of non-pollinated carpels.

At seed maturity, the minute embryo is fully developed with clearly differentiated cotyledons and hypocotyl. Endosperm is much larger than the embryo and is composed of large, thin-walled cells containing proteins and oils. Evans (1933) described three distinct tissue types in the seed; pericarp, seed coat and nucellus. The outermost layer is the fleshy pericarp which is bright red when mature and consists of three layers of cells. Beneath the pericarp is a hard tan seed coat composed of several rows of cells with thick lignified cell walls. A single layer of nucellus composed of large elongated cells occurs between the endosperm and the seed coat.

There are forty to sixty seed per aggregate (USDA 1974). As the aggregate dehydrates it opens along the dorsal sutures. The seed is apparently pushed out of the carpel due to the drying of the tissue of the carpel area and is suspended from the aggregate by a modified raphe which is thread-like and fibrous.

GERMINATION

The germination process is the mechanism that assures the continuance of the plant species. There are numerous definitions of germination. For seed analysis, germination is defined as the emergence and development from the seed embryo of those essential structures which, for the kind of seed in question, are indicative of the ability to produce a normal plant under favorable conditions (AOSA 1981). Mayer and Poljakoff-Mayber (1963) defined germination as the consecutive number of steps which cause a seed, with low water content, to show a rise in its general metabolic activity and to initiate the formation of a seedling from the embryo.

The process of germination occurs when suitable environmental conditions are present. Meyer et al. (1973) lists the necessary conditions as water, favorable temperature, and the presence of oxygen. These environmental conditions trigger a particular internal mechanism and the process of seed germination begins. The process begins with water imbibition and continues through enzyme activation, initiation of embryo growth, rupture of the seed coat and emergence of the seedling (Copeland and McDonald 1985).

SEED SIZE AND WEIGHT

McDonald (1975) concluded in an evaluation of various seed vigor tests that generally the larger, heavier, or denser the

seed the more vigorous the seedlings will be. He also suggests this physical characteristic-vigor relationship is a reflection of the seed's maturity. This may be due to the idea that larger seeds contain greater food storage reserves for utilization by embryos and seedlings.

In size and weight studies on cottonseed, various researchers have reported conflicting results. Balls (1910) reported higher germination percentage with larger cottonseeds than with smaller seeds. However, Helmer and Abdel-al (1965) found negative correlations between cottonseed size and germination percentage. According to Fisher and Presley (1959) separation of cottonseed by size was useless in relation to both field emergence and laboratory germination tests. But Porterfield and Smith (1956) found intermediate size cottonseed produced earlier emerging seedlings and more vigorous seedlings than either smaller or larger seed sizes. Kunze et al. (1969) on the other hand, found that within cottonseed varieties, the heaviest seed showed the earliest seedling emergence, increased vigor and larger total seedling emergence.

SEED DENSITY

The relationship of the seed's density to horticultural crops is a new area for research. However, many researchers have studied its affect on agronomic crops and forest species.

Sung and Delouche (1962) found that rice seeds in the higher density categories produced earlier, stronger, and more uniform seedlings. Switzer (1959) concluded the quality of loblolly pine seedlings were greatly affected and enhanced by the use of seeds in the highest density classes.

Density has proven to be the best indicator of seed quality in cotton rather than older methods of determining quality by using the weight and size of seed. Kreig and Bartee (1975), using air separation techniques for density determination, concluded that among physical properties, the seed's density appeared to be the most closely associated with the ultimate quality as measured either chemically or biologically. Germination tests using cottonseed that floated in water was found by Chester (1938) to have less than half the germination percentage as the seed that sank in water. Arndt (1935) claimed that variety differences influenced the percent of floating seed. He observed that in floated cottonseed there was nearly twice as much disease incidence as in the seed that sank. Other researchers have also stated that cottonseed separation for seed quality improvement should be based on seed density alone (Fergusion and Turner 1971).

Burk (1965) separated tobacco seed for density rather than using size separations and found that the faster germinating seedlings and most uniform seedlings were in the highest density classes. Pauli and Harriott (1968) found in lettuce seed that

density was far more important than size in obtaining the highest germination percentages. They discarded low density seed, which made up over ten percent of the entire seed lot weight, and obtained ninety-five percent germination. From their investigation they also reported that through selection of the highest density seed, there was an increase in the overall uniformity of seed size.

TETRAZOLIUM TESTS

The tetrazolium test is an accurate measure of seed viability that is widely recognized and used extensively as a quick test in many seed laboratories today. The test utilizes 2,3,5-triphenyl tetrazolium chloride and is used extensively on vegetable and agronomic crops. The tetrazolium test has not been extensively used on tree seeds but Moore (1964) states that the methods and evaluations are essentially similar for all types of seeds and trees are no exception.

Magnolia grandiflora seeds do not always germinate the first season after stratification, but may germinate the second season (USDA 1974). Therefore, to test seed viability, a second test must be utilized with the germination test for an accurate account of the number of live seeds. Seed viability is the percent of seed capable of germination when exposed to favorable conditions (USDA 1974) and can be tested using tetrazolium salt.

These tests permit observations of the embryo to reveal damaged parts or dead areas, but do not identify certain other conditions such as dormancy or improper fungicide treatments (Moore 1969). Rapid viability determinations can be made by knowing the various relationships of the live tissue and dead tissue interactions with the tetrazolium salt (Tupper 1969).

The only difference in interpreting tetrazolium tests for Magnolia grandiflora, as in cotton, is in the interpretation of the radicle tip injury. This difference was noted by Grabe (1959) as he studied the single root bud of cotton. If the cotton radicle was injured a normal seedling could not emerge. This is the only noted difference between plants like cotton and grasses; grasses develop normal seedlings even if there is an injury or a lesion on the radicle tip. Grass embryos develop roots from buds located above the radicle tip, whereas cotton does not have additional buds located above the tip. Therefore, plants with only one bud at the radicle tip did not develop roots if that bud is dead.

Copeland and McDonald (1985) described chemical reactions of tetrazolium salt with the tissues of the seed. Distinctions are made between viable and dead tissue of the embryo. The evaluation is made on the basis of the tissues relative respiration rate when fully hydrated. The test utilizes the dehydrogenase enzymes activity as an index to the respiration rate and seed viability. Color intensity gradually increases as

the chemical reaction produces formazon, which is a red water-insoluble chemical (Moore 1964). Seed viability can then be evaluated by the topographic pattern of staining and the intensity of the stain on the embryo.

CHAPTER III

MATERIALS AND METHODS

The purpose of this study was to gain greater insight into factors affecting the variability in size, weight and density of Magnolia grandiflora seeds. To understand exactly what factors influence this variability, the study would have ideally included every aspect of the individual seed from the individual flowering blossom, pollination, fertilization, seed growth and maturity, harvesting and later seed storage. But since that was impractical for the purpose of this study,a compromise was made to look at the various physical characteristics such as weight, density and aggregate position and their relationship to bloom periods, harvest dates and subsequent germination.

BLOSSOM TAGGING

Three mature Magnolia grandiflora trees were selected on the University of Tennessee Agricultural Campus for this study. Five blossoms on each tree, which had recently opened, were tagged each week. Distinguishing between the various weeks, a different colored plastic ribbon or combinations of ribbons were attached to the flowering shoots.

The first bloom was observed on May 12, 1985. Tagging began on May 16, 1985 and continued at seven day intervals until

October 24, 1985 when no further blossoms were evident. The total number of open blossoms was recorded each week to determine the peak bloom period for each tree.

HARVESTING

The aggregates began to open and expose seeds on September 25, 1985. Tagged aggregates were collected as they began opening. Untagged aggregates were also collected on a weekly basis to analyze the affect of harvest periods on seed germination and variability. The seeds were removed from the aggregates and stored until the last harvest period on November 21, 1985.

Numerous aggregates with two mature seed in each carpel were harvested. Paired seeds were removed from the carpels, separated and labeled. As seeds were collected they were numbered from one to seven depending on which row they were removed from. Row one was the basal row with row seven being the apical row on the majority of the aggregates. The seeds were also separated according to their position in the carpel compartment, with the letter A representing the topmost or apical seed and B for the bottom or basal seed.

After the seeds were removed and stored, they were placed in labeled coin sacks until cleaned. The seeds were soaked in water

for three hours to soften the outer red pericarp to allow for easier cleaning. The process of pericarp removal involved scraping the hydrated fleshy pericarp on a brass screen under running water to remove the pulpy substance from the seed and reveal the hard tan seed coat. The seeds were then air dried for twenty-four hours to remove the excess water so they could be weighed.

WEIGHT DETERMINATION

After drying, the seeds were separated into categories. Each sack which contained seeds from a different tree, bloom period, or harvest period were weighed with a Mettler electronic balance. The seeds were then separated into thirteen categories based on the differences of centigrams.

DENSITY DETERMINATION

The density of each seed was determined within each weight class from each tree, bloom period, or harvest period. The determination of the density categories was accomplished in a preliminary study where densities ranged from just above 1.0 g/ml to just below .75 g/ml.

To determine the density of each seed, a series of solutions were made with distilled water and ninety-five percent alcohol. The densities for each solution was calculated by weighing a dry

fifty milliliter (ml) density bottle (B), 50 ml of distilled water (W) and the mixtures of the alcohol and water in the density bottle (S). To obtain the density (D) of the liquids, the following formula was utilized: D= mass/volume = g/ml (Hein and Best 1980), where mass = S - B and volume = W or D = S - B / W. The densities of the solutions were 1.0 g/ml, .91 g/ml and .78 g/ml.

Each seed was dropped in the lightest density solution and the seed either sank or floated in the solution. If the seed floated then it was rinsed in water, recorded as having a density of below .78 g/ml. But if the seed sank in the first solution, it was then rinsed and moved to the next increasing density solution until it floated in a solution or sank in the 1.0 g/ml density solution. When the seed sank in the 1.0 g/ml density solution it was recorded as having a density of at least 1.0 g/ml. The seeds were then ready for planting and stratification.

PLANTING AND STRATIFICATION

Each seed was identified by it's specific category of tree number, bloom period, harvest period, weight, density, pair number and position, and planted. Seeds were planted in a completely randomized pattern in the compartments of flats filled with moist Sunshine Mix potting soil. The flats were placed in a cooler in the Agricultural Campus Plot Barn and seeds were

stratified for ninety days at temperatures between 39° and 41° F. Flats were watered biweekly to maintain moist soil and to raise the relative humidity levels.

GERMINATION TESTS

The stratification period was terminated on March 20, 1986 when the flats were moved into the greenhouse. The flats were placed under intermittent mist and bottom heat was provided for the forty-five day germination test period. Germination was recorded every two days after the first seedling emerged from the soil, which was on April 9, 1986.

TETRAZOLIUM TESTS

A lot of twenty seeds were taken from each harvest period to determine the seed viability using a tetrazolium test. The seeds were placed in a ten percent chlorox solution for thirty minutes to disinfect the seed coat. After the seed's disinfection, the end opposite the embryo of each seed was removed to allow for water imbibition and to soften the seed coat. A method recommended by Belcher (1975) of soaking seeds in water for twenty-four hours for complete tissue hydration was utilized to enhance the later uptake of the tetrazolium salt.

After the water presoak, seeds were soaked for twenty-four hours in a .1 percent solution of 2,3,5-triphenyl tetrazolium

chloride in total darkness. They were then rinsed and stored in petri dishes in a refrigerator for three weeks until they were observed under a stereoscope.

Upon examination of the seeds under the microscope they were given a value rating of one to five. The value scale utilized was as follows: 1). uniform staining, 2). small colorless areas on the cotyledons, 3). large colorless areas on the cotyledons, 4). slight to moderate colorless areas on essential seed structures and 5). colorless embryo (Moore 1964). Ratings of one, two and three were reported to be capable of germination, but ratings of four and five were not capable of germination. This rating scale was used to correlate the seed viability with the actual seed germination.

CHAPTER IV

RESULTS

The data collected from the germination percentages of the Magnolia grandiflora has been analyzed for the results of the various experiments. Results have been determined from the paired seeds, non-paired seeds, cumulation of the paired and non-paired seed experiments, bloom period, harvest period, peak blossom periods, seedling emergence and the results of the seed viability from the tetrazolium tests.

The cumulative germination percent of paired seeds, non-paired seeds, and combination of the paired and non-paired seeds was 20.6%. The weights of the seeds ranged from .13 grams to .01 grams with the overall mean of .08 grams. Germination percentage as affected by density of solution were: 7.7% in <.78 g/ml, 20.8% in .78 g/ml, 47.1% in .91 g/ml and 24.4% in 1.0 g/ml. The correlations between weight, density and germination were positive but were extremely low and ranged from .118 to .156. Thus, there was little relationship between the seed's weight, density or its resulting germination.

Data were analyzed using an analysis of variance for germination percentage and it was determined that there was no significant difference between the three trees from which seed were collected. The parameter of weight was analyzed as a factor which effected germination percentage and it was found that

germination percent was not influenced by the various weight groups.

Analysis of variance was also performed on the density categories and highly significant differences were recorded at the 5% level of significance (Table 1). Seeds with a density of .91 g/ml had a mean germination percent equal to the seeds which had densities of 1.0 g/ml, but germination percent was significantly better than those with densities of .78 g/ml and <.78 g/ml. The germination percentages in the <.78 g/ml density class were significantly lower than those of other density classes.

BLOOM PERIOD AND HARVEST PERIOD

Seeds from each specific bloom and harvest period were weighed and the density was determined. Weights were extremely variable and ranged from .01 grams to .13 grams with a mean of .07 grams. Four categories of germination percentages as related to density were observed: 13.6% in <.78 g/ml, 26.7% in the .78 g/ml, 30.9% in the .91 g/ml and 28.7% in the 1.0 g/ml. The correlations between weight, density, germination percent and between trees were positive but extremely low.

An analysis of variance was performed on the seeds and there were not significant differences between the trees or the weights groups at the 5% level of significance. However, data were analyzed for density and highly significant differences were

TABLE 1. Effect of density on the cumulative mean germination percent of *Magnolia grandiflora*.

Density	Mean[1] Germination Percent	
.91 g/ml	27.82	a
1.0 g/ml	20.24	ab
.78 g/ml	12.20	b
<.78 g/ml	0.84	c

Duncan's new multiple range test, 5% level.

[1]Numbers followed by the same letter are not significantly different.

recorded (Table 2). Seeds of 1.0 g/ml density had significantly higher germination percentages than seeds with densities of .78 g/ml and <.78 g/ml. The .91 g/ml density seeds had germination percentages equal to or the same as the 1.0 g/ml and .78 g/ml density seeds but were significantly lower in germination percent than the seeds with a density of <.78 g/ml.

The data also showed highly significant differences when analyzed for the harvest periods at the 5% level (Table 3). The harvest period of November 21, 1985 was significantly equal to the November 13, 1985 harvest period in germination percentage, but was significantly greater than the other harvest periods. The November 13 harvest period was equal in percent germination to the remainder of the harvest periods.

In an analysis of variance performed on the specific bloom periods there were also highly significant differences recorded (Table 4). The June 20, 1985 bloom period had significantly larger germination percentages than the bloom periods of May 16, June 27 and June 8 bloom periods.

PAIRED SEEDS AND NON-PAIRED SEEDS

Germination percentage of paired seeds (two mature seeds in one carpel) were compared to non-paired seeds (one mature seed per carpel). Separate germination tests were performed for each category of seeds. Within the paired seeds, separate tests were

TABLE 2. Effects of density on bloom period mean germination percent of Magnolia grandiflora.

Density	Mean[1] Germination Percent
1.0 g/ml	12.66 a
.91 g/ml	9.25 ab
.78 g/ml	5.57 bc
<.78 g/ml	0.96 c

Duncan's new multiple range test, 5% level.

[1]Numbers followed by the same letter are not significantly different.

TABLE 3. Effects of harvest periods in 1985 on mean germination percentages of *Magnolia grandiflora*.

Harvest Periods	Mean[1] Germination Percent	
November 21	22.32	a
November 13	12.16	ab
October 11	8.92	b
October 15	8.17	b
October 4	8.13	b
October 24	6.27	b
October 7	5.56	b
November 8	5.05	b
November 1	3.98	b
September 30	3.41	b
September 25	2.54	b

Duncan's new multiple range test, 5% level.

[1]Numbers followed by the same letter are not significantly different.

TABLE 4. Effects of bloom periods in 1985 on mean germination percent of *Magnolia grandiflora*.

Bloom Periods	Mean[1] Germination Percent
June 20	22.66 a
May 30	14.06 ab
July 11	13.64 ab
June 14	13.07 ab
July 4	8.82 ab
May 23	8.25 ab
May 16	3.57 b
June 27	2.78 b
June 8	2.14 b

Duncan's new multiple range test, 5% level.

[1]Numbers followed by the same letter are not significantly different.

conducted to determine if differences existed between the apical and basal seeds.

The weights for the cumulation of paired seeds ranged from .119 grams to .033 grams with a mean of .08 grams. Non-paired seed weights ranged from .130 grams to .021 grams with a mean of .08 grams also. The density categories of the paired seed contained the following percentages: 1.6% in <.78 g/ml, 14.9% in .78 g/ml, 69.9% in .91g/ml, 13.5% in 1.0 g/ml. Density categories and percentages from the non-paired seeds were as follows: 9.4% in <.78 g/ml, 23.2% in .78 g/ml, 36.9% in .91 g/ml, 30.4% in 1.0 g/ml.

The analysis of paired and non-paired seeds showed no significant differences between trees, for weight groups for harvest dates. Analysis of variance was also utilized on the seed densities for each group and a highly significant difference was obtained in the non-paired seed group only (Table 5). The germination percentage of seeds in the 1.0 g/ml density category were significantly different than seeds in the .78 g/ml and <.78 g/ml density categories.

The germination percentage for the non-paired seeds was 10.63 and for the paired seeds was 42.11. In the comparison of the apical and basal seeds in the paired experiment the germination for apical seeds was 43.05% and for basal seed the germination was 41.94%. The mean weights and the densities of the apical and basal seed were equal in the paired seeds with each other.

TABLE 5. Effect of density of non-paired seeds on mean germination percent of *Magnolia grandiflora*.

Density	Mean[1] Germination Percent
1.0 g/ml	14.68 a
.91 g/ml	12.61 ab
.78 g/ml	6.27 bc
<.78 g/ml	0.59 c

Duncan's new multiple range test, 5% level.

[1]Numbers followed by the same letter are not significantly different.

An analysis of variance was also performed for seed weight and density, but the results showed there were no significant differences in either weight or density for the apical and/or the basal seeds. There were also no significant differences between the seeds of the various rows of the aggregates.

PEAK BLOSSOMS

The number of blossoms were recorded each week to determine the peak bloom period for each tree. The peak period occurred near the same time for all three trees (Figure 2). Tree one peaked from June 14, 1985 until June 20, 1985 with 45 to 47 blossoms open. Trees two and three peaked the week of June 20 with a total of 189 and 46 open blossoms respectively. The following week the blossom count dropped significantly for each tree.

SEEDLING EMERGENCE

The germination test began on March 20, 1986 when the flats were removed from the cooler and brought into the propagation greenhouse. The first seedling emerged on April 4. Germination counts began April 9 and continued until termination on May 1, the end of the 45 day germination period.

Thirty-five seedlings were counted on the first count day of April 9 (Figure 3). For the next five count days there was an

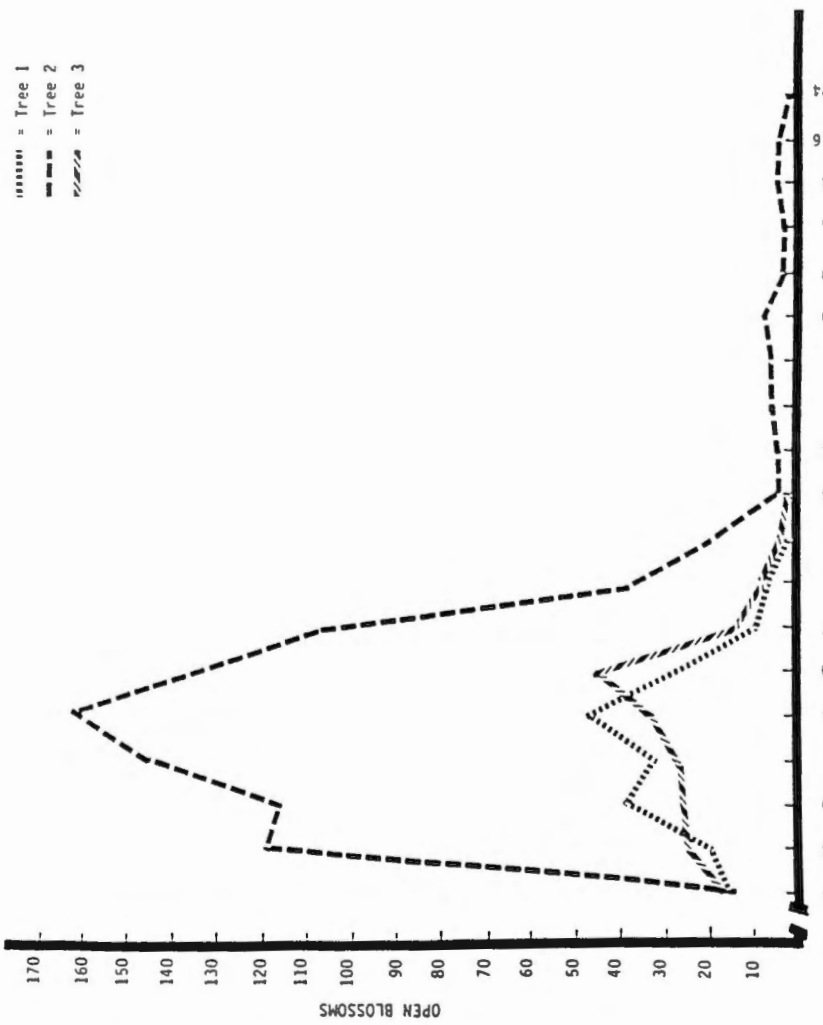


FIGURE 2. GRAPHIC REPRESENTATION OF PEAK BLOSSOMS IN 1985.

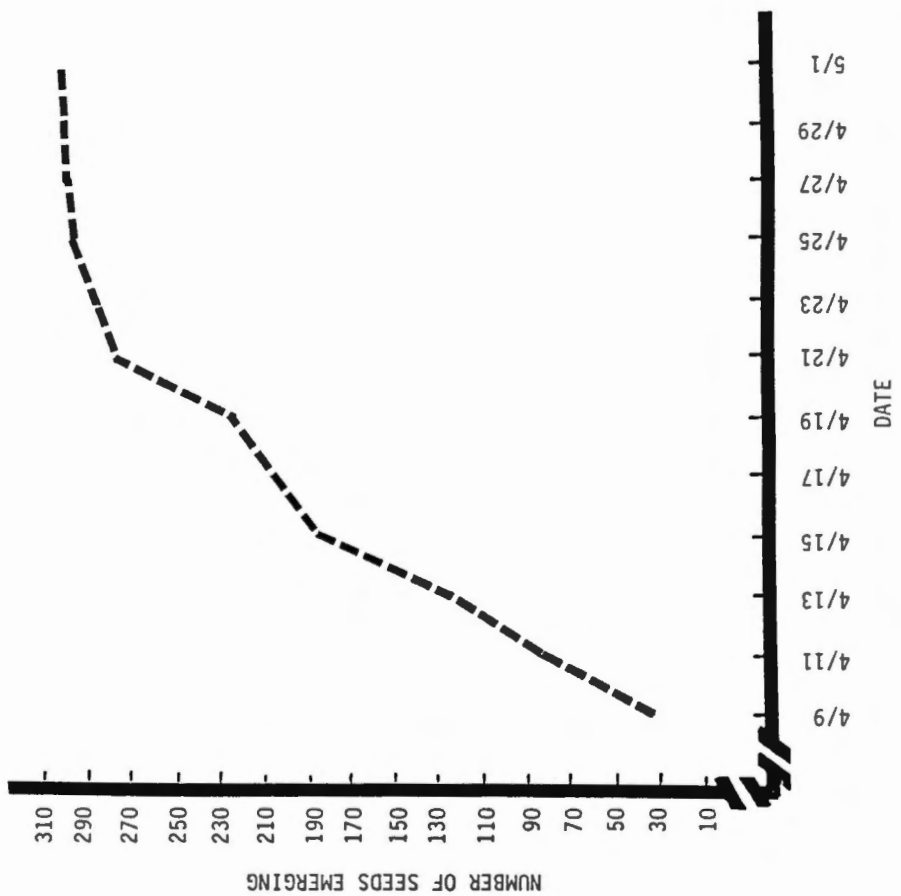


FIGURE 3. GRAPHIC REPRESENTATION OF SEEDLING EMERGENCE IN 1985.

increase of a minimum of 31 seedlings each day with the maximum increase occurring on the second count day. On that day 52 new seedlings had emerged. After the 27th day, April 23, the number of seedlings emerging decreased significantly.

TETRAZOLIUM TESTS

The seeds from each harvest period were stained with tetrazolium salt to compare seed viability with seed germination for each harvest period (Table 6). In each harvest period the percent viability was greater for each harvest period than the actual germination percentage. The last two harvest dates of November 21 and November 13 had the highest viability and germination percentages.

Many of the embryos analyzed had injured radicles. This would have resulted reduced in germination because Magnolia grandiflora radicle has a single root bud and it had been destroyed.

TABLE 6. Seed viability percentages of various harvest periods in 1985 of *Magnolia grandiflora*.

Harvest Periods	Viability Percentages	Mean Germination Percent
November 21	84.0%	22.3
November 13	78.3%	12.1
October 4	73.3%	8.1
October 24	57.1%	6.2
October 11	56.0%	8.9
November 1	52.2%	3.9
October 7	44.0%	5.5
October 15	35.3%	8.1
September 25	32.0%	2.5
September 30	19.2%	3.4

CHAPTER V

DISCUSSION AND CONCLUSIONS

The seeds of Magnolia grandiflora are diverse in weight, size and density; therefore, this study was undertaken to measure these physical parameters and to determine their relationship to germination. To further understand the germination percent for this season, tetrazolium salt tests were administered.

The weights of individual seeds were extremely variable but means were comparable and ranged from .07 to .08 grams. The specific weight group of the seed did not influence the percent of seed which germinated.

Seed density influenced germination percentage. Seeds with densities of .91 g/ml and 1.0 g/ml had significantly higher germination percentages than with densities <.78 g/ml or .78 g/ml. However, best germination occured in seeds of .91 g/ml density.

Harvest period significantly affected germination percentage. Seeds harvested November 21, 1985 had significantly higher germination percentage than those of all other harvest periods. Also, seeds collected from flowers of the peak bloom period (June 20) had significantly higher germination percentages.

The most significant difference between paired and non-paired seeds was the germination percentage. Paired seeds

had an overall germination percent of 42.1 compared with 10.6 percent for the non-paired .

In the analysis of apical and basal seeds there were no significant differences in weight, density or germination percentages. Also, there were no differences between seeds which came from different rows of the aggregate.

The correlations in each experiment were extremely low between the various parameters of density, weight, trees, bloom periods and harvest periods. Therefore, from these results it was determined that there was little relationship between these factors.

From this study, new information was gained about germination of Magnolia grandiflora seeds as affected by seed density, harvest date and bloom period. Magnolia seeds with a denstiy of .91 or 1.0 g/ml germinated significantly higher than seeds with densities of .78 and <.78 g/ml. Also, seeds harvested late (November 21) and seeds collected from fruits resulting from flowers that bloomed during the peak blossom period (June 20) had significantly higher germination. Further study is needed not only on M. grandiflora but on other woody ornamentals to determine techniques or procedures that might improve production efficiency and the quality of seedlings.

LITERATURE CITED

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1. Arndt, C.H. 1935. A Study of Some of the Factors That May Influence Cottonseed Germination and Seedling Growth. South Carolina Agricultural Experimentation Report 45: 46-49.

2. Association of Official Seed Analysts. 1981. Rules For Seed Testing. Journal of Seed Technology 6 (2).

3. Balls, W.L. 1910. The Effect of Seed Weight on the Field Germination of Cottonseed. Cairo Science Journal 4: 185-187.

4. Belcher, Earl W. 1975. Optimum Tetrazolium Staining of Longleaf Pine Seed. Proceedings of Off. Seed Analysts 65: 84-87.

5. Burk, L.G. 1965. Overcoming Dormancy in Nicotiana. Agronomy Journal 49: 461.

6. Chester, K.S. 1938. Gravity Grading, A Method of Reducing Seed Borne Disease in Cotton. Phytopath. 28: 745-749.

7. Copeland, L.O. and M.B. McDonald. 1985. Principals of Seed Science and Technology. Minneapolis, Minn.: Burgess Publishing Company.

8. Dirr, Micheal A. 1983. Manual of Woody Landscape Plants. Third Edition. Champaign, Illinois: Stipes Publishing Co.

9. Evans, C.R. 1933. Germination Behavior of Magnolia grandiflora. Bot. Gaz. 94: 729-754.

10. Eumes, Arthur J. 1961. Morphology of the Angiosperms. New York: McGraw-Hill Book Company.

11. Fergusion, D. and J. H. Turner. 1971. Influence of Filled and Unfilled Cottonseed on Emergence and Vigor. Crop Science 11: 713-715.

12. Fisher, W.D. and J.T. Presley. 1959. Increasing Yields Through Better Planting-Seed Process. Cotton Gin and Oil Mill Press 60(6): 50-51.

13. Grabe, Don F. 1959. Technique For Interpretation of Tetarazolium Tests. Proceedings Assoc. of Off. Seed Analysts 49: 131-133.

14. Guedes, Michel, 1979. Morphology of Seed Plants. Germany: Strauss and Cramer.

15. Hein, M.R. and L.R. Best. 1980. College Chemistry: An Introduction to Inorganic, Organic, and Biochemistry. Second Edition. Monterey, Calif.: Brooks/Cole Publishing Co.

16. Helmer, J.D. and M.S. Abdel-al. 1965. Some Aspects of Seed and Boll Maturation in Cotton. Proceedings of Assoc. Off. Seed Analysts 55: 154-162.

17. Hillier, H.G. 1981. Hillier's Manual of Trees and Shrubs. London: Newton Abbot.

18. Kreig, D.R. and S.N. Bartee. 1975. Cottonseed Density: Associated Germination and Seedling Emergence Properties. Agronomy Journal 67: 343-347.

19. Kunze, O.R., L.H. Wilkes and G.A. Niles. 1969. Field Emergence and Growth Response Related to the Physical Characteristics of Cottonseed. Transactions of the American Society of Agricultural Engineers 12(5): 608-610,613.

20. Leppik, E.E. 1975. Morphogenic Stagnation in the Evolution of Magnolia Flowers. Phytomorphology 25(4): 451-464.

21. McDonald, Miller B. Jr. 1975. A Review and Evaluation of Seed Vigor Tests. Proceedings of Assoc. Off. Seed Analysts 65: 109-133.

22. Mayer, A.M. and A. Poljakoff-Mayber. 1963. The Germination of Seeds. New York: The Macmillian Company.

23. Meyer, B.S., D.B. Anderson and R.H. Bohning. 1973. Second Edition. Introduction to Plant Physiology. D. Van Nostrand Company, Inc.

24. Moore, R.P.. 1964. Tetrazolium Testing of Tree Seed for Viability and Soundness. Proceedings of Assoc. Off. Seed Analysts 54: 66-72.

25. Moore, R.P. 1969. Seed deterioration Symptoms as Revealed by Tetrazolium and Growth Tests. Proc. Assoc. Off. Seed Analysts 58: 107-109.

26. Pauli, A.W. and B.L. Harriott. 1968. Lettuce Seed Selection and Treatment for Precision Planting. Agricultural Engineering 49: 18-22, 24.

27. Porterfield, J. and E.M. Smith. 1956. Characteristics and Field Performance of Mechanicaly Graded Acid-delinted Cottonseed. Oklahoma Experiment Station Bulletin T-60.

28. Sung, T.Y. and James C. Delouche. 1962. Relation of Specific Gravity to Vigor and Viability in Rice Seed. Proc. Assoc. Off. Seed Analysts 52: 162-165.

29. Switzer, G.L. 1959. Effects of Specific Gravity Separation on Some Common Indices of Loblolly Seed Quality. Journal of Forestry 57: 497.

30. Treseder, Neil G. 1978. Magnolias. Boston: Faber and Faber.

31. Tupper, G.R. 1969. Physical Characteristics of Cottonseed Related to Seedling Vigor and Design Parameters for Seed Selection. Ph.D. Dissertation. Texas A&M University, College Station, Texas.

32. USDA Forestry Service. 1974. Seeds of Woody Plants in the United States. Washington D.C.: U.S. Dept. of Agriculture.

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