# THE EFFECT OF STORAGE TREATMENT UPON GERMINATION OF PECAN NUTS, CARYA ILLINOENSIS (WANG.) K. KOCH CV. WESTERN

By

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THE EFFECT OF STORAGE TREATMENT UPON GERMINATION OF PECAN NUTS, CARYA ILLINOENSIS (WANG.) K. KOCH CV. WESTERN

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# CHAPTER I

## INTRODUCTION

Pecan is an important source of valuable wood and a very desirable wildlife food. Since this species usually does not form pure stands, and its natural regeneration consists mainly of scattered individuals, establishment of stands for management would require an artificial regeneration by direct seeding of nuts or planting of seedling trees.

Studies on the germination of pecan nuts are of great importance to nurserymen propagating pecan trees. It is generally assumed that pecan nuts have no well-defined rest period and will germinate at any time after harvest. In fact, preharvest sprouting is not uncommon for several cultivars (1, 17, 28). Under greenhouse conditions, pecan nuts begin to germinate one to two months after planting and may continue to germinate over two to four month period or even longer (28, 38, 39). Irregular germination which produces seedling plants of different physiological age makes it most difficult to conduct studies due to the lack of plant uniformity. Few nurserymen stratify pecan before planting. They plant the nuts in late winter or early spring after they have been soaked in water for a week to ten days, prior to planting. Unfortunately, the seedlings do not all emerge at the same time. If they all come up together, it would simplify grafting and cultivation, as the plants would all be of the same size (18, 19, 25, 28).

Practically all nuts are stored for a period of time after harvesting. This is true whether they are to be planted for propagation, or whether they are to be used for food. Nuts for planting should be stored in a moderately dry, cool, dark place, and protected from mold, insects, rodents and rancidity. Nuts for planting should not be held for more than four to six months, and should not be completely dried or heated. Nuts that are moldy, rancid or broken are unsuitable for planting. Nuts kept at room temperature for more than one year will not germinate. Pecans that are not utilized by the beginning of warm weather inevitably begin to deteriorate unless they are properly stored. Nuts kept in cold storage will germinate slowly unless stratified (21, 23, 30, 33, 35, 37, 39).

Nuts to be used in growing stocks should be fully matured. They should be of good size for the variety, and should be gathered only from healthy, vigorous trees. Large pecan nuts will produce larger seedling than will smaller nuts (22, 23, 26).

As a result of practices followed by the nurserymen, there is a lack of uniformity in tree size in pecan nursery plantings. This lack of uniformity and the fact that researchers have had difficulties in obtaining response in nutritional studies etc., has stimulated an interest in uniform germination, and uniform root stocks. Adopting suitable procedures would give quicker and uniform germination and thus could give earlier and more uniform size graftable stock.

Advantages of more uniform germination would result in greater orchard uniformity, tree-spacing, tree size, growth of seedlings, and uniform root system for controlled research (22, 26, 42).

# CHAPTER II

# REVIEW OF LITERATURE

The primary objective in designing the current experiments was to obtain sufficient information about the prompt and uniform germination of the pecan nuts, so that further studies, if any, could be conducted conveniently on uniform growing seedlings. These studies consisted of determination of the effect of storage temperatures; the occurrence of rancidity under different storage conditions and its relation to germination; the duration of germinability of mature nuts; and the effect of storage conditions on germination period.

There have been many reports associated with the effects of different methods of storage of pecan nuts on germination (17, 33, 37, 45, 46). Stratification of the nuts under cold temperatures have been reported effective in rapid and uniform germination (3, 20, 23, 28, 30, 39, 42, 43).

## Nuts Stratification in Moist Media

The object of stratification is to have the nuts gradually absorb sufficient moisture to insure the bursting of the shell by the swelling kernel, which usually occurs during the warm weather of spring. In many cases it may be necessary and more convenient to stratify the nuts in damp sand, placed in a cool, shady location prior to planting in spring (12, 23, 33). Several workers (7, 16, 32, 33, 34, 36) have

reported that pecan seeds may be planted soon after harvest or early in the spring. Fall planting does away with the need of stratifying the seed, but involves the risk of considerable loss of nuts from mice or other rodents.

McHatton and Woodroof (30) tried different methods of storing pecans and found that those stored in a refrigerator or stratified, germinated more rapidly than those stored at room temperature. Plantings were made in the field after storage.

According to Bailey and Woodroof (3) pecans held through the winter, buried in soil, germinated readily in the spring, and gave the highest percentage germination and the most vigorous seedlings. The second best results were obtained from nuts stored in a refrigerator at a temperature just above freezing in a humid atmosphere.

Barton (4) reported that pre-treatment for two to four months at low temperature in a moist medium was necessary for seedling production in Juglans cinerea and Juglans nigra. When a sufficiently long period at low temperature (about $3^{o}$C.) was preceded by one to four months at higher temperature ($21^{o}$C.), germination was hastened. Seedling production of Carya ovata was improved by pre-treatment in moist soil for one to five months at $3^{o}$C. or $10^{o}$C. Others (31) recommended the storage of nuts of several species of Juglans in moist peat at 1 to $3^{o}$C. for five to six months to give good germination.

Haut (20) reported that pecan nuts can be planted in the nursery row in the fall, or the seed could be stratified during the winter or held in a cool, dry place at room temperature, or somewhat cooler, and planted out in the early spring. Nuts germinate successfully, but do not germinate quite as rapidly as where they have been stratified in

the open or in a cool, moist place. Pecans not soaked in water will not germinate as rapidly.

It has been shown by Gossard and Crane (17) that no difference was found in the percentage of germination of Moore, Stuart and Waukeenah varieties, but nuts of low kernel percent and low specific gravity had poor germination. Good stands of seedling trees can be expected only when nuts with well-filled plump kernels are planted. They also reported that the nuts should be placed in cold storage soon after harvest or, otherwise, they will become rancid and will lose their viability. The development of rancidity was found to be in direct relation to the temperature at which the nuts were stored.

According to McDanniel (29) the carpathian strain of Persian walnuts (Juglan regia) behaved, in general, similarly to the Carya species and hybrids while small numbers of the Wright heart nut and one Asiatic hazel gave no germination when planted at different times from late fall of 1955 to early spring of 1956. It was also indicated in these studies that although Persian walnuts, pecans, shagbarks, shellbarks, and hicans all lack the resting period, it must not be concluded that stratification treatments are of no value with seed nuts of these species and hybrids.

Hinrichs (22) found that large pecan nuts of the Western cultivar produced significantly larger seedlings than did smaller nuts of the same cultivar. He reported that pecans soaked in water prior to planting usually are hastened in germination but in this test there was no difference in germination between the dry and soaked seed. This may, in part, have been due to the more favorable environment for the germination of nuts in the greenhouse.

Davis (15) recommended over-winter stratification of Persian walnut seed in a well drained site in a container about 3 to 4 inches below the surrounding area, particularly in the northern part of the United States where the ground freezes to considerable depth. He suggests planting of the nuts as early in the spring as the ground can be worked and rows lined out. He reported that nuts stratified in this manner germinate quickly and this method works equally well on all hard shelled nuts.

Jaynes (24) reported that chestnuts mixed with nearly dry peatmoss and stored in polyethylene bags at 35-36°F were still viable after 3½ years. This long-term storage is not recommended as a general practice, but chestnut seed held for 18 months, until the second planting season after harvest, appears to be practical.

As found by Berry (5), Chinese chestnut seeds need an after ripening cold treatment for at least six to eight weeks at a temperature of 30°-32°F. The germination was more rapid as the periods of cold treatment were extended to 40 weeks. Woodroof (44) suggested storage of chestnut seed at 32°-40°F. for commercial purposes.

Madden et al. (27) suggest that seeds may be soaked in water for 4 or 5 days prior to planting, usually March in Texas, or they may be stratified until they show the first sign of sprouting for planting. After stratification, nuts held at 85°-90°F. will begin to sprout from 11 to 14 days. He (26) further reported that pre-harvest sprouting in the shuck (germination on the tree) for several cultivars was found to be associated with moisture between the shuck and the shell of the nut. There is a close association between the extent of vegetativeness of the tree and the amount of the early season germination. The same

authors (28) found that many of the northern seeds do not germinate without chilling. When seeds of Major and Peruque cultivars were planted without prior treatment the time required for 80 percent emergence of seedlings was 195 and 160 days, in contrast to 26 and 47 days respectively, for seeds stratified and chilled for 12 weeks before being planted. When seeds of Riverside cultivar were planted without prior treatment the time required for 80 percent seedling emergence was 90 days, but when nuts were stratified and chilled for 12 weeks, 80 percent of the seedlings emerged within 20 days. They found that the influence of both stratification and chilling (stratified in moist peatmoss and chilled at 32-36$^{o}$F) and chilling (chilled only at 32-36$^{o}$F in plastic bags) alone were more pronounced as the periods of treatments were prolonged, from 0 to 12 weeks. Giles, although considered as a northern cultivar, responded, in germination, like Riverside. This is a reminder that seedlings from clones are highly variable, and that the classification into northern and southern varieties is arbitrary. Seeds of southern origin were found to germinate and grow more uniformly when stratified at 32-34$^{o}$F for 6 to 12 weeks.

Brison (8) reported that nuts for planting may be soaked for 7 to 10 days in running water or water which is changed daily. Another method, he suggests, is to stratify the nuts until they show that germination is eminent, indicated by separation of the two carpels of the shell at the apex, and that such nuts germinate more uniformly when planted in the nursery rows.

Sparks et al. (39) found that stratification promoted earlier germination, more uniformity of germination and, in general, a higher

percentage of germination. The maximum effects for initial germination, 50 percent germination and the total germination period, occurred with the longest time of stratification (10 weeks). As stratification time was increased from 8 to 10 weeks, time to initial germination, 50 percent germination, and the total germination period continued to decrease. This investigation suggests that for maximum enhancement of germination, the stratification period should exceed 10 weeks, because the minimum stratification period needed for maximum enhancement is not known.

## Nuts Stored Dry at Low Temperature

Most workers agree that all kinds of nuts should be stored at low temperatures if they are held over for spring planting. At the same time, the usual recommendations are that nuts be stratified in moist sand or peatmoss to obtain more uniform germination and tree size for propagation.

As reported by Reed (35), Schley and Stuart cultivars of pecans can be held over from one season to another in perfectly marketable condition by storing the nuts at $32^{o}$F., and having that temperature uniformly maintained. Others (37) concluded that cold storage can be relied upon to preserve seed pecans from one year to the next in a reasonable viable condition.

Gossard and Crane (17) reported that the development of rancidity was found to begin in late May or early June when nuts were stored in a heated laboratory. Soon afterwards rancidity was found to develop in nuts that were stored in the shed. Nuts stored at $45^{o}$F. were next to the last to become rancid, and those stored at $32^{o}$F. were the last. These results indicate that $32^{o}$F. was the best temperature to store

nuts for germination. To determine whether pecan nuts have a rest period, the nuts from the Stuart and Moore cultivars, used in the pre-harvest germination test were, immediately after harvest placed at room temperature and in cold storage at 32°F. Germination tests were made at weekly intervals from harvest, October 20 to January 6. There was no marked difference between the mean percentages of germination of the two varieties at any time. In no case was there any indication that the nuts had a rest period which required a post-harvest treatment before they would germinate. In these studies germination tests of the nuts from cold storage (45° and 32°F.) were continued from early June each year until September of the second year following harvest. They found that the percentage of nuts of both varieties that germinated, decreased as the time in storage increased. They also found 32 to 60 percent germination of nuts stored at 45° and 32°F. respectively, in early May of the second spring after harvest.

In still another study, Woodroof and Heaton (45) suggest that pecans should be stored under refrigeration within a month after harvest. It is recommended that only those nuts with good color, texture, flavor, and high oil content be stored for more than one year. The ill effects from improper storage are cumulative and irreversible.

Worthington (2) conducted a demonstration on cold treatment and planting of nuts. He concluded from the results that the nurserymen and growers will not benefit by using the cold treatment.

Tedder et al. (42) reported that 75 percent germination was obtained 43 days after planting if the pecans were previously soaked in water for one week, removed, placed in polyethylene bags and refrigerated at 1°C. They found that this method did not produce

seedlings as rapidly and consistently as was needed for future experiments.

In a study, Sparks et al. (39) compared the germination of cold stored (45°F.) Stuart pecan nuts to those stratified in moist sand and stored at the same temperature. They found that if nuts are held in cold storage prior to planting but were not stratified, relatively high germination percentages (84 percent of nuts cold stored compared to 89-98 percent from stratified nuts) were possible, but germination was delayed. Once germination began it extended over a long time period. In contrast, the stratification promoted early germination and greatly alleviated delayed germination.

According to Madden and Tisdale (28) chilling alone had little or no effect on earliness or uniformity of germination. Chilling for 2, 4, 6 and 8 weeks, in most cases, had an inverse relationship effect on earliness and uniformity of seed germination. They also concluded that nuts of northern cultivars could be planted in the south satisfactorily if given a stratification and chilling treatment. Nuts of southern cultivars germinated earlier and more uniformly when given a stratification and chilling treatment. When the nuts were planted using the procedure used by most nurserymen (soak in water for 3 days and plant), germination extended for 1 to 6 month period.

## Dry Storage of Nuts at Room Temperature

Pecans that are not utilized by the beginning of warm weather begin to deteriorate unless they are properly stored. In no case should seed nuts be allowed to become dry enough to impair their vitality. Nuts kept at room temperature and room humidity until

January or February should be soaked 36 to 72 hours before planting (7, 34, 35).

It has been found by McHatton and Woodroof (30) that green nuts "forced" to dry out at temperatures of 70°, 60°, 50°, failed to germinate and the nuts that were excessively dried at any temperature gave very poor germination and poor seedling growth. They pointed out that nuts to be planted should not become either very dry or warm, but storage conditions should approximate those which exist when a nut falls to the ground at maturity and remains covered with moist leaves until spring. Drying or heating the nuts at any time before planting was detrimental in proportion to the intensity or duration of the treatment (3).

Wright (46) reported that in the northern part of the country the commercial nut crop, including most kinds, is generally held in common or warehouse storage throughout the fall and winter following harvest when the prevailing temperature conditions are usually favorable for this kind of storage. As warm, humid weather approaches either kernels or nuts in the shell that are to be kept through the summer should go into cold storage at a temperature of 32°F. with a relative humidity of about 80 percent. In some sections of the country this transfer to cold storage may be made as late as March but in the South, pecans are not safe in common storage much after February. During this investigation some kinds of nuts were tested for germination after a year in storage and it was found that all Persian walnuts, almonds, chestnuts and pecans held in common storage failed to germinate. From storage at 40°F., 25 to 26 percent germinated while at 32°F. storage, 28 to 73 percent germinated. It is evident from these results that the viability of

nuts held in common or warehouse storage is much less than for nuts held at 32°F.

Smith et al. (37) reported that nuts of Burkett and Stuart cultivars held over one season in cloth bags at a temperature ranging from 0° to 5°C. showed good viability, whereas no germination was secured from comparable nuts held at room temperature. On the other hand, fresh nuts which had been kept less than four months (Oct. 18 to Feb. 1) in a warm room germinated satisfactorily. In another study (17) it was found that nuts to be used for growing seedlings could be held from time of harvest until early May in sheds or even heated rooms without serious loss in viability. It was also found that the development of rancidity was directly proportional to the storage temperature. Bilan and Foster (6) concluded that where facilities for stratification were not available, the nuts stored at room temperature will germinate satisfactorily if planted before the spring months.

# CHAPTER III

## MATERIALS AND METHODS

The object of this experiment was to obtain information on germination of pecan nuts stored under different conditions and planted at different periods of time.

Pecan nuts of the 'Western' cultivar were harvested November 5, 1974, at the Pecan Research Station located near Sparks, Oklahoma, and brought to the Pecan Laboratory, Department of Horticulture, Oklahoma State University, Stillwater, Oklahoma.

These nuts were divided into three equal lots on November 12, 1974. In one lot, the nuts were placed in a wooden box and stratified in a moist peatmoss and stored at 1.66°C. The second lot was stored dry at 1.66°C. and the third lot was stored dry at room temperature (21.11°-23.88°C.) in the pecan laboratory.

Nuts were planted in one gallon Zarn No. 450, green plastic containers which were 8½ inches high with 7½ inches top diameter, 5½ inches bottom diameter and 245.87 cubic inches in volume. The pots were washed with Clorox (1 part Clorox and 10 parts water) before use. Perlite and Canadian sphagnum peatmoss were mixed in equal parts and used as the potting soil.

Nuts stored at room temperature and those stored dry at 1.66°C were soaked in water for 24 hours before each planting date. Nuts of all three treatments were transferred immediately from the laboratory

to the greenhouse for planting. Pots were filled with the soil mix and nuts planted 2 inches deep. Each pot was labeled for identification of the treatment. There were 10 nuts planted per pot and each treatment replicated five times. The pots were placed on the bench in the greenhouse and watered twice a week. The temperature in the greenhouse averaged from 15.55°-18.33°C. at night and 21.11°-32.22°C. during the daytime.

Nuts of each treatment were planted at weekly intervals on November 19, November 26, December 3, December 10, December 17, December 24, December 31, 1974, January 7, January 14, and January 21, 1975. After January 21, the nuts were planted at 4 week intervals on February 18, March 18, April 15, May 13, and June 10, 1975. In addition, nuts stored dry at 0° to 1.66°C from the years of 1970, 1971, 1972, and 1973, were included in the study, planted November 19, 1974. Germination was recorded every other day for all treatments. A nut was considered germinated when the emerging plumule protruded through the soil.

The total percent germination, the mean daily percent germination, and Czabator's peak values[1] were computed. Germination value, which is the composite expression of both speed and completeness of germination was then computed by multiplying peak value by mean daily germination.

Statistical significance of experimental results was determined by analysis of variance on number of days for a sample to achieve 80 percent germination. Least Significant Difference (LSD) was determined in significance tests between treatments on each date. This

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[1]Peak value is the largest of the quotients derived by dividing cumulative germination percent on each day by the number of days to reach this percent.

experimental design had no valid error term for testing dates. On each date, pots were randomly positioned within a single location in the greenhouse. However, a different location was used on each date. Thus, location effects would be confounded with dates.

## CHAPTER IV

## RESULTS AND DISCUSSION

Pecans of Western cultivar stored under different conditions and planted at various intervals varied greatly in the degree of germination. Nuts stratified in moist peat and perlite at 1.66°C had the best overall germination as shown in the Figures 1 to 15.

The total percent germination, days to initial germination, germination period, mean daily germination, peak values and germination values for individual treatment on each date of planting are presented in Table I. The results of the analysis of variance for number of days to 80 percent germination are reported in Table II and graphically represented in Figure 16 of the Appendix. There was no significant difference between treatments planted one and two weeks after the storage (Figure 1 and 2). On the third week of planting nuts at room temperature (RMT)[1] and stratified (S 1.66°C)[2] behaved similarly, but dry cold nuts (N 1.66°C)[3] required more days to achieve 80 percent germination (Prob > F 0.0671 Table II). In this particular planting the S 1.66°C treatment started to germinate more rapidly (Figure 3) than the other treatment and achieved 100 percent germination in

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[1] RMT = Nuts stored dry at room temperature.

[2] S 1.66°C = Nuts stratified in moist peatmoss and stored at 1.66°C.

[3] N 1.66°C = Nuts stored dry at 1.66°C.

# TABLE I

## EFFECT OF LENGTH OF STORAGE OF PECAN NUTS UNDER DIFFERENT TREATMENTS; ON THE TIME TO INITIAL AND TOTAL GERMINATION PERIOD, AND PERCENT GERMINATION

| Date | Week of planting after storage | Treatment | Total percent germi-nation | Days to initial germi-nation | Germi-nation period (days) | Mean daily germi-nation | Peak Value | Germi-nation Value |
|---|---|---|---|---|---|---|---|---|
| Nov. 19, 1974 | 1 | S 1.66°C. | 96 | 46 | 168 | 0.57 | 0.73 | 0.42 |
| | | RMT | 100 | 46 | 174 | 0.57 | 0.71 | 0.40 |
| | | N 1.66°C. | 94 | 44 | 182 | 0.52 | 0.66 | 0.34 |
| Nov. 26, 1974 | 2 | S 1.66°C. | 98 | 35 | 167 | 0.59 | 0.59 | 0.35 |
| | | RMT | 98 | 43 | 171 | 0.57 | 0.57 | 0.32 |
| | | N 1.66°C. | 98 | 41 | 167 | 0.59 | 0.63 | 0.37 |
| Dec. 3, 1974 | 3 | S 1.66°C | 100 | 36 | 164 | 0.61 | 0.61 | 0.37 |
| | | RMT | 98 | 34 | 170 | 0.58 | 0.59 | 0.34 |
| | | N 1.66°C. | 96 | 38 | 166 | 0.58 | 0.58 | 0.34 |
| Dec. 10, 1974 | 4 | S 1.66°C. | 100 | 17 | 147 | 0.68 | 1.10 | 0.75 |
| | | RMT | 94 | 29 | 161 | 0.58 | 0.59 | 0.34 |
| | | N 1.66°C. | 92 | 31 | 161 | 0.57 | 0.57 | 0.32 |
| Dec. 17, 1974 | 5 | S 1.66°C. | 96 | 28 | 82 | 1.17 | 1.17 | 1.37 |
| | | RMT | 96 | 34 | 154 | 0.62 | 0.71 | 0.44 |
| | | N 1.66°C. | 98 | 46 | 152 | 0.64 | 0.64 | 0.41 |
| Dec. 24, 1974 | 6 | S 1.66°C. | 100 | 29 | 73 | 1.37 | 1.37 | 1.88 |
| | | RMT | 90 | 45 | 145 | 0.62 | 0.62 | 0.38 |
| | | N 1.66°C. | 92 | 59 | 147 | 0.63 | 0.63 | 0.40 |
| Dec. 31, 1974 | 7 | S 1.66°C. | 100 | 22 | 70 | 1.43 | 1.45 | 2.07 |
| | | RMT | 92 | 40 | 140 | 0.66 | 0.66 | 0.44 |
| | | N 1.66°C. | 88 | 38 | 140 | 0.63 | 0.63 | 0.40 |
| Jan. 7, 1975 | 8 | S 1.66°C. | 96 | 23 | 63 | 1.52 | 1.65 | 2.51 |
| | | RMT | 94 | 37 | 135 | 0.70 | 0.70 | 0.49 |
| | | N 1.66°C. | 90 | 43 | 135 | 0.67 | 0.67 | 0.45 |
| Jan. 14, 1975 | 9 | S 1.66°C. | 100 | 18 | 52 | 1.92 | 2.00 | 3.84 |
| | | RMT | 94 | 44 | 126 | 0.75 | 0.75 | 0.56 |
| | | N 1.66°C. | 92 | 38 | 128 | 0.72 | 0.72 | 0.52 |
| Jan. 21, 1975 | 10 | S 1.66°C. | 94 | 17 | 51 | 1.84 | 2.15 | 3.96 |
| | | RMT | 94 | 37 | 121 | 0.78 | 0.78 | 0.61 |
| | | N 1.66°C. | 94 | 37 | 119 | 0.79 | 0.79 | 0.62 |
| Feb. 18, 1975 | 14 | S 1.66°C. | 98 | 17 | 37 | 2.65 | 3.11 | 8.24 |
| | | RMT | 96 | 45 | 107 | 0.90 | 0.90 | 0.81 |
| | | N 1.66°C. | 96 | 37 | 107 | 0.90 | 0.93 | 0.84 |
| Mar. 18, 1975 | 18 | S 1.66°C. | 100 | 17 | 25 | 4.00 | 4.00 | 16.00 |
| | | RMT | 98 | 41 | 95 | 1.03 | 1.06 | 1.09 |
| | | N 1.66°C. | 98 | 39 | 83 | 1.18 | 1.18 | 1.39 |
| Apr. 15, 1975 | 22 | S 1.66°C. | 100 | 13 | 23 | 4.35 | 5.53 | 24.06 |
| | | RMT | 66 | 33 | 105 | 0.63 | 0.67 | 0.42 |
| | | N 1.66°C. | 96 | 23 | 51 | 1.88 | 1.91 | 3.59 |
| May 13, 1975 | 26 | S 1.66°C. | 98 | 11 | 17 | 5.76 | 5.76 | 33.18 |
| | | RMT | 18 | 51 | 77 | 0.23 | 0.23 | 0.05 |
| | | N 1.66°C. | 96 | 23 | 49 | 1.96 | 2.26 | 4.43 |
| June 10, 1975 | 30 | S 1.66°C. | 98 | 9 | 17 | 5.76 | 6.00 | 34.56 |
| | | RMT | 12 | 35 | 69 | 0.17 | 0.17 | 0.03 |
| | | N 1.66°C. | 96 | 17 | 33 | 2.91 | 3.36 | 9.78 |

TABLE II

AVERAGE NUMBER OF DAYS, WHEN 80 PERCENT OF THE NUTS HAD GERMINATED

| Date of Planting | Week(s) | Average Number of Days Treatment | | | Observed Significance Level** (Prob > F) |
|---|---|---|---|---|---|
| | | S 1.66°C | RMT | N 1.66°C | |
| Nov. 19, 1974 | 1 | 107.6 a | 106.4 a | 122.8 a | 0.3209 |
| Nov. 26, 1974 | 2 | 101.4 a | 103.4 a | 107.0 a | 0.8446 |
| Dec. 3, 1974 | 3 | 87.2 a | 118.0 a | 128.4 b | 0.0671 |
| Dec. 10, 1974 | 4 | 65.4 a | 119.8 b | 125.0 b | 0.0536 |
| Dec. 17, 1974 | 5 | 71.2 a | 111.6 b | 122.0 b | 0.0030 |
| Dec. 24, 1974 | 6 | 59.0 a | 122.6 b | 129.4 b | 0.0004 |
| Dec. 31, 1974 | 7 | 47.2 a | 110.0 b | 132.0 c | 0.0002 |
| Jan. 7, 1975 | 8 | 46.6 a | 114.6 b | 127.8 c | 0.0001 |
| Jan. 14, 1975 | 9 | 35.6 a | 115.6 b | 120.0 b | 0.0001 |
| Jan. 21, 1975 | 10 | 35.8 a | 110.2 b | 112.6 b | 0.0001 |
| Feb. 18, 1975 | 14 | 26.2 a | 91.4 b | 89.8 b | 0.0001 |
| Mar. 18, 1975 | 18 | 21.4 a | 72.6 b | 68.2 b | 0.0001 |
| Apr. 15, 1975 | 22 | 15.0 a | * | 42.2 b | 0.0012 |
| May 13, 1975 | 26 | 15.4 a | * | 35.8 b | 0.0010 |
| June 10, 1975 | 30 | 13.8 a | * | 25.4 b | 0.0020 |

Means within a row followed by the same letter are not significant by the LSD procedure at 0.05 significance level.

*Nuts with less than 80 percent germination were not statistically analyzed.

** Observed significance level for testing the hypothesis of no difference among treatment means.

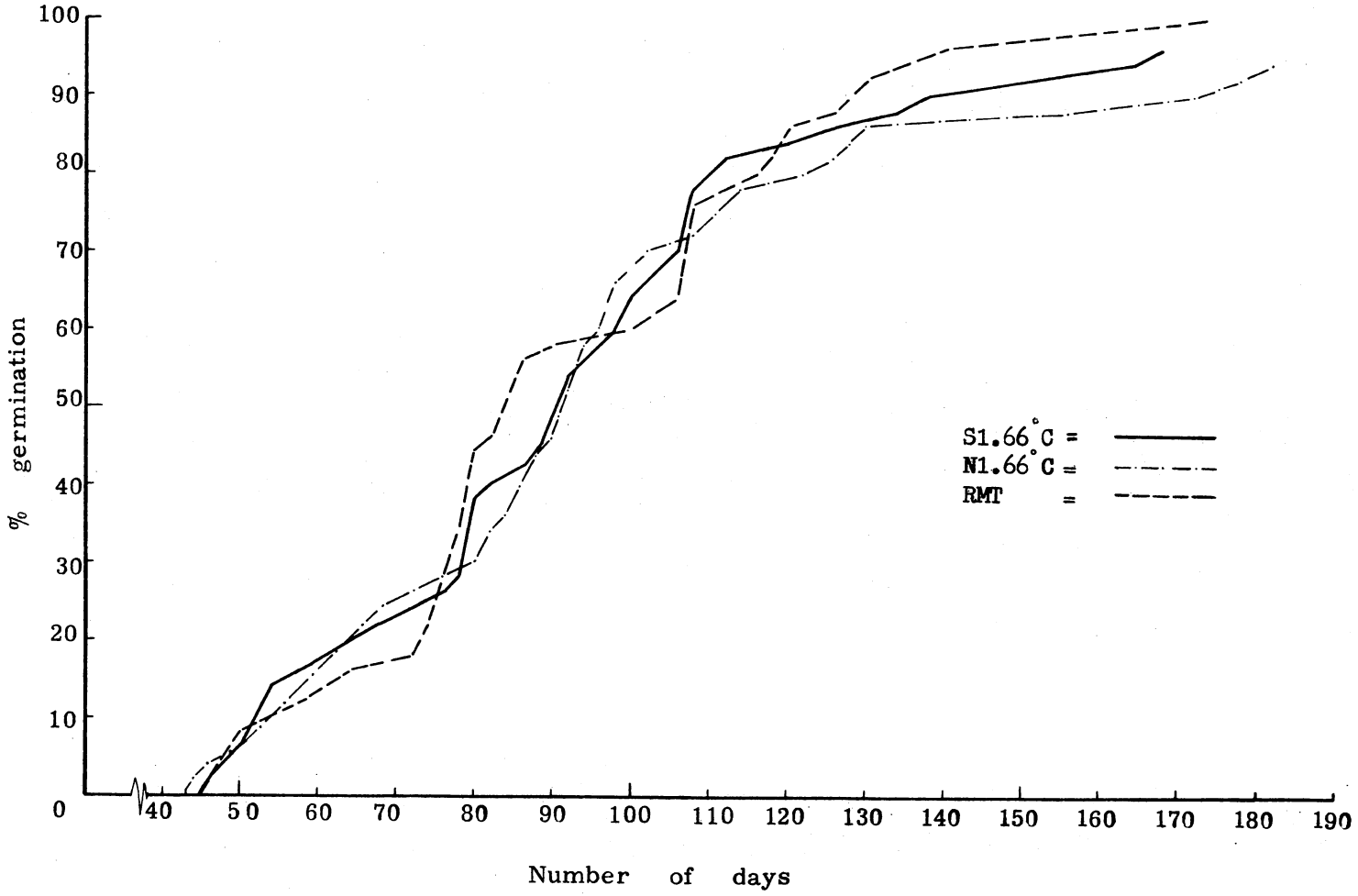


Figure 1. Effect of Different Methods of Storing Pecan of the Western Cv. on Germination (Nuts Planted November 19, 1974)

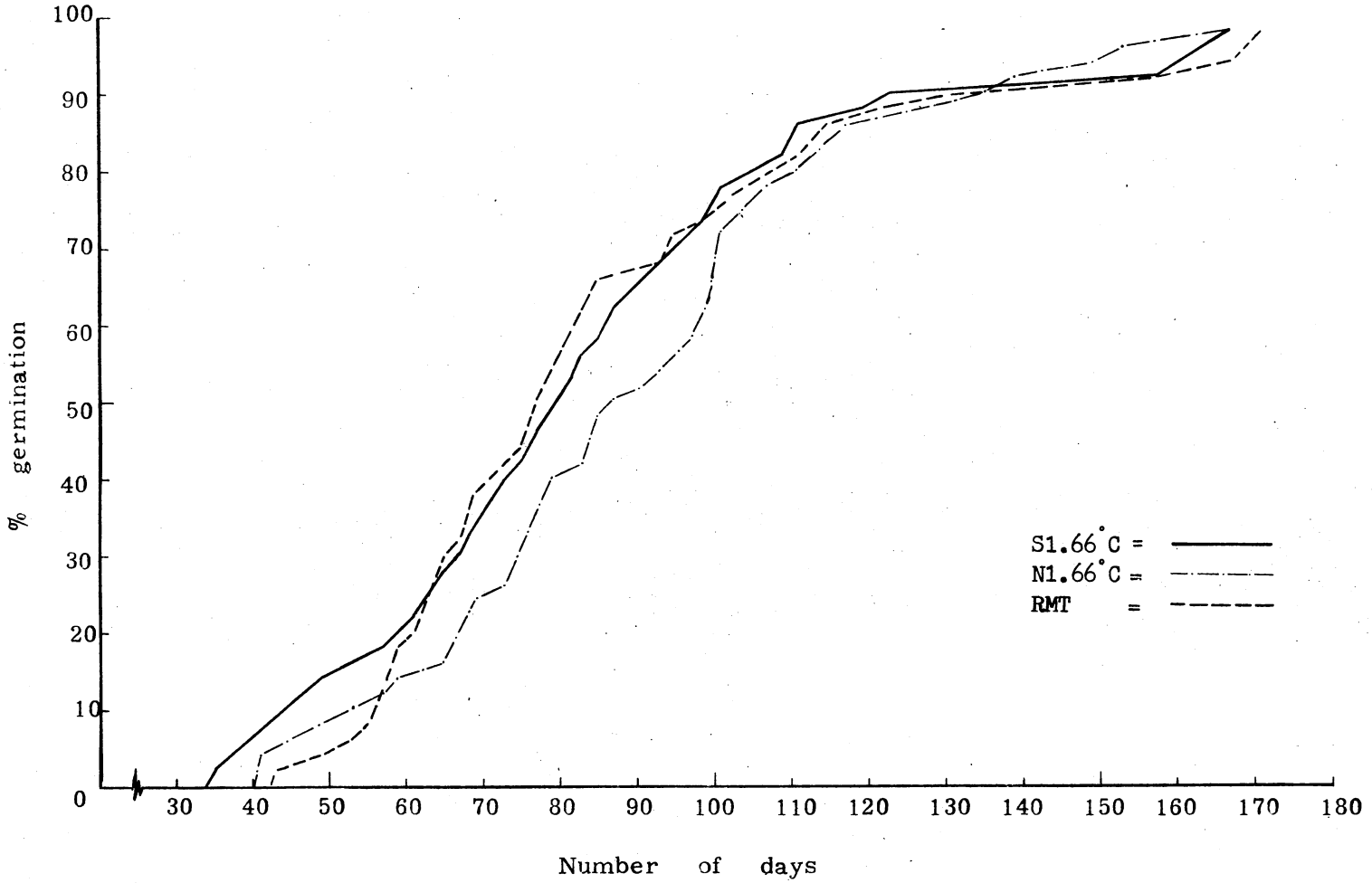


Figure 2. Effect of Different Methods of Storing Pecan of the Western Cv. on Germination (Nuts Planted November 26, 1974)

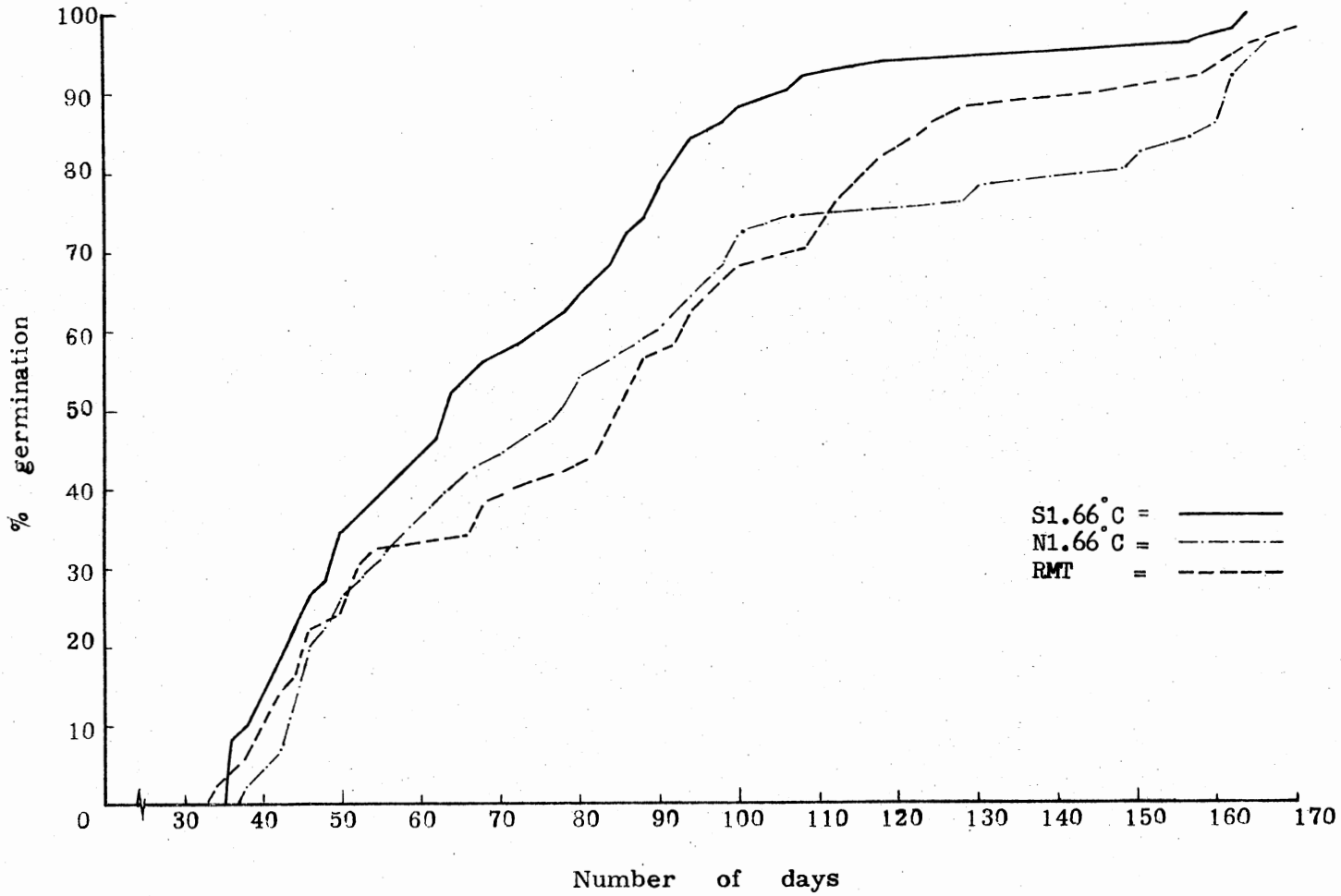


Figure 3. Effect of Different Methods of Storing Pecan of the Western Cv. on Germination (Nuts Planted December 3, 1974)

164 days compared to RMT and N 1.66°C which gave 98 and 96 percent germination in 170 and 166 days respectively. The percent germination of S 1.66°C treatment is a little higher than that of the other two treatments (Table I). On the fourth week of planting (December 10, 1974), treatment S 1.66°C was significantly different (Prob > F 0.0536) from the other two treatments. Average days for 80 percent germination were 65.4 for the S 1.66°C treatment while it required 119.8 and 125.0 days for treatment RMT and N 1.66°C respectively (Table II). The peak value and germination value were twice as high for the S 1.66° as compared to RMT and N 1.66°C treatments (Table I). During the fifth and sixth week of planting, S 1.66°C treatment showed highly significant difference (Prob > F 0.003 and Prob > F 0.0004) from the other two treatments. There was no significant difference between the other two treatments on these dates (Table II). There was 96 percent germination in 82 days for S 1.66°C treatment; 96 percent germination in 154 days for RMT; 98 percent germination in 152 days from N 1.66°C treatment for nuts planted December 17, 1974 (Figure 5 and Table I). Nuts planted December 24, 1974, gave 100 percent germination in 73 days for S 1.66°C treatment with 90 percent germination in 145 days for RMT; and 92 percent germination 147 days for N 1.66°C (Figure 6). The germination value increased rapidly for S 1.66°C in the fifth and sixth weeks of planting as shown in Table I. From the seventh week of planting (December 31, 1974) 100 percent germination was recorded in 70 days for S 1.66°C; 92 percent in 140 days for RMT and 88 percent in 140 days for N 1.66°C (Figure 7 and Table I). Germination percentages of the nuts planted January 7, 1975, were 96, 94, and 90 in 63, 135, 135 days for S 1.66°C, RMT and N 1.66°C respectively (Figure 8 and Table I). Mean

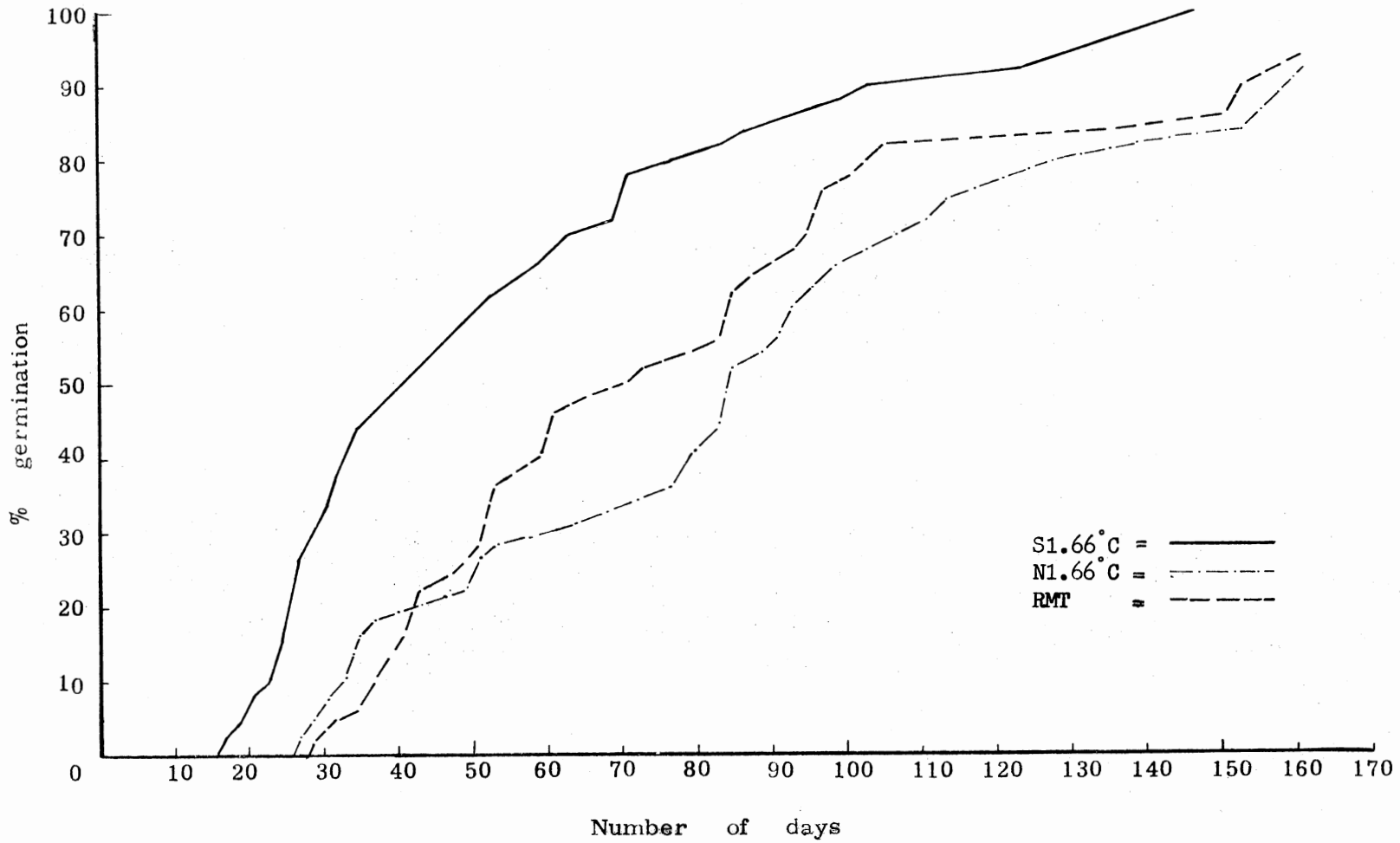


Figure 4. Effect of Different Methods of Storing Pecan of the Western Cv. on Germination (Nuts Planted December 10, 1974)

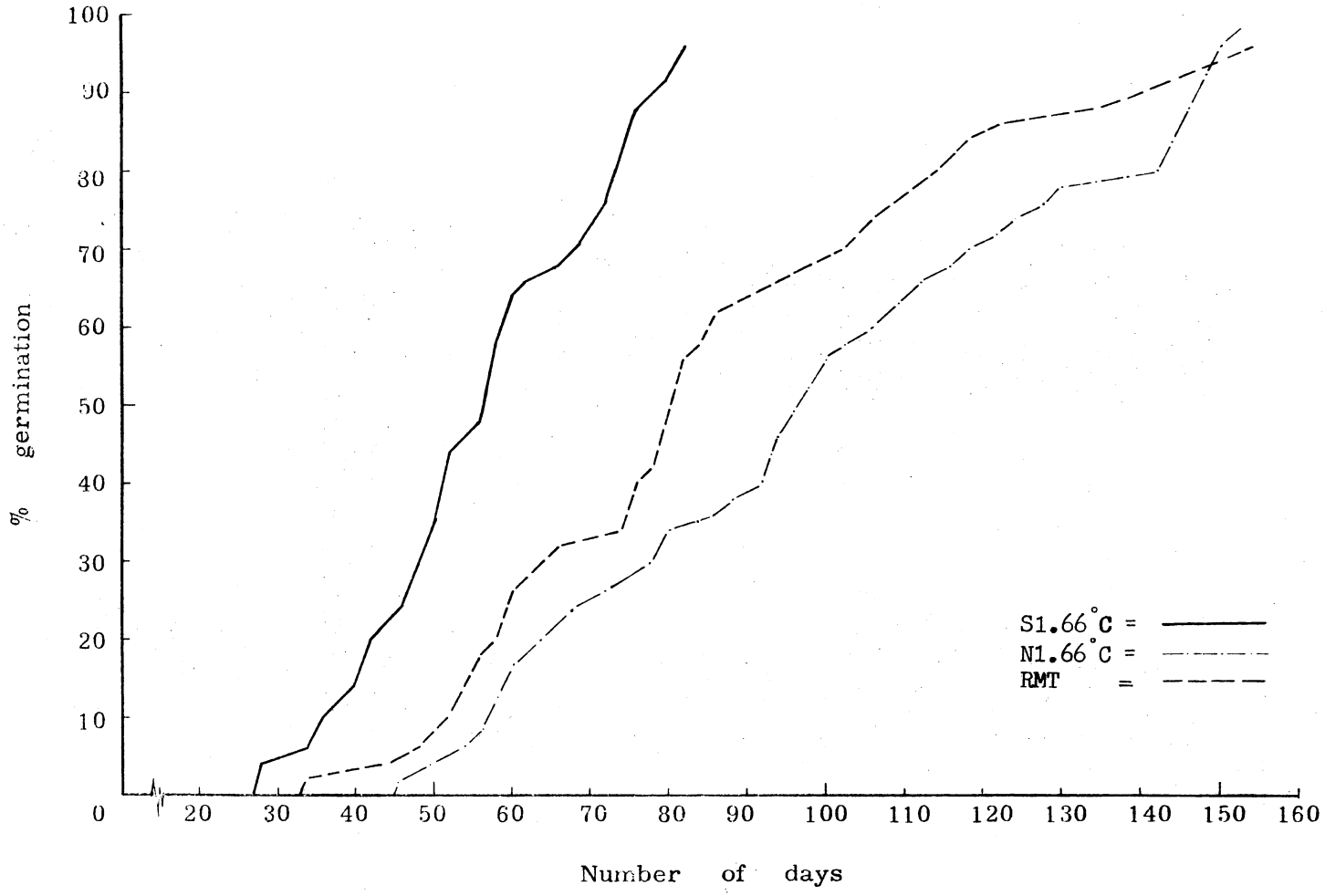


Figure 5. Effect of Different Methods of Storing Pecan of the Western Cv. on Germination (Nuts Planted December 17, 1974)

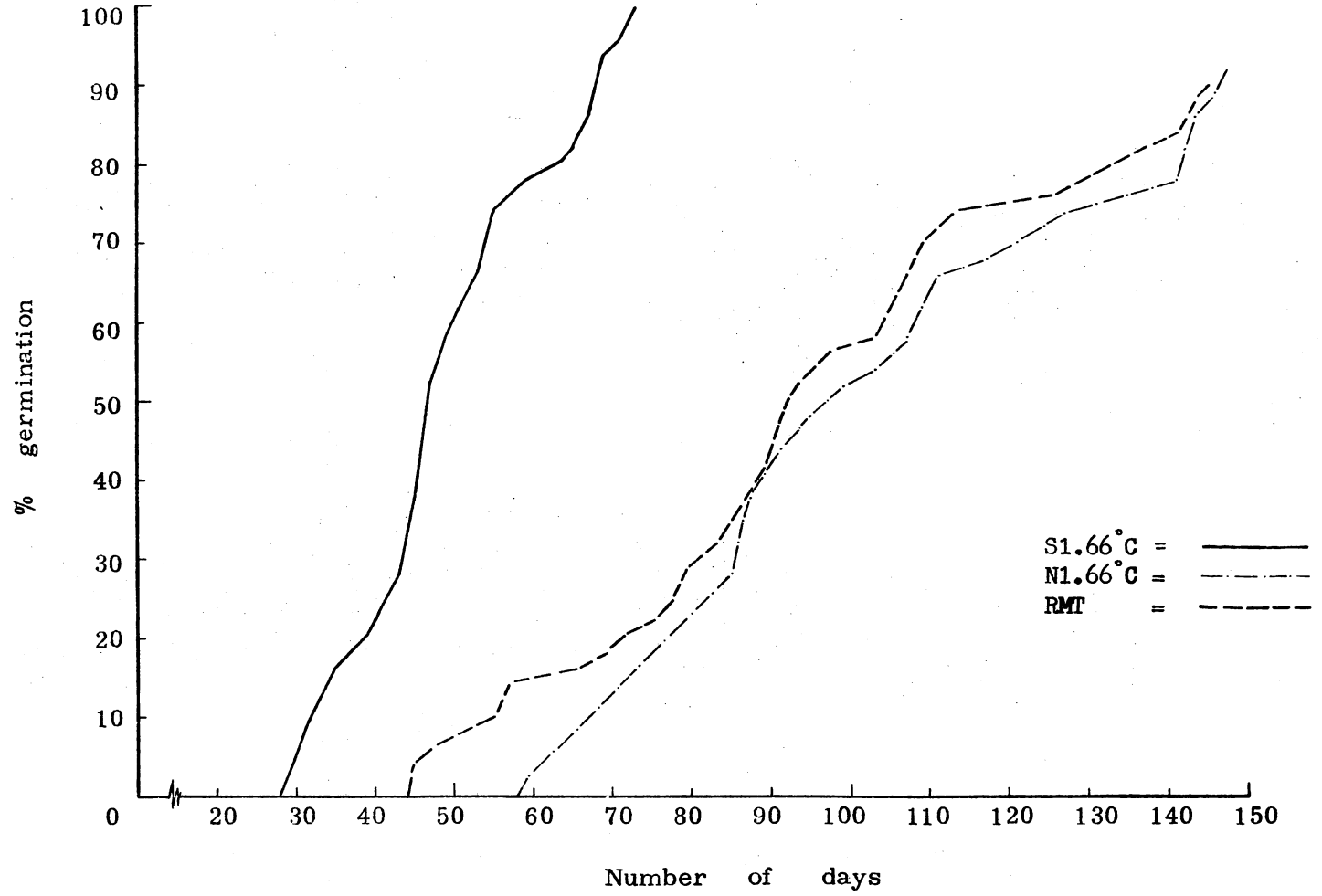


Figure 6. Effect of Different Methods of Storing Pecan of the Western Cv. on Germination (Nuts Planted December 24, 1974)

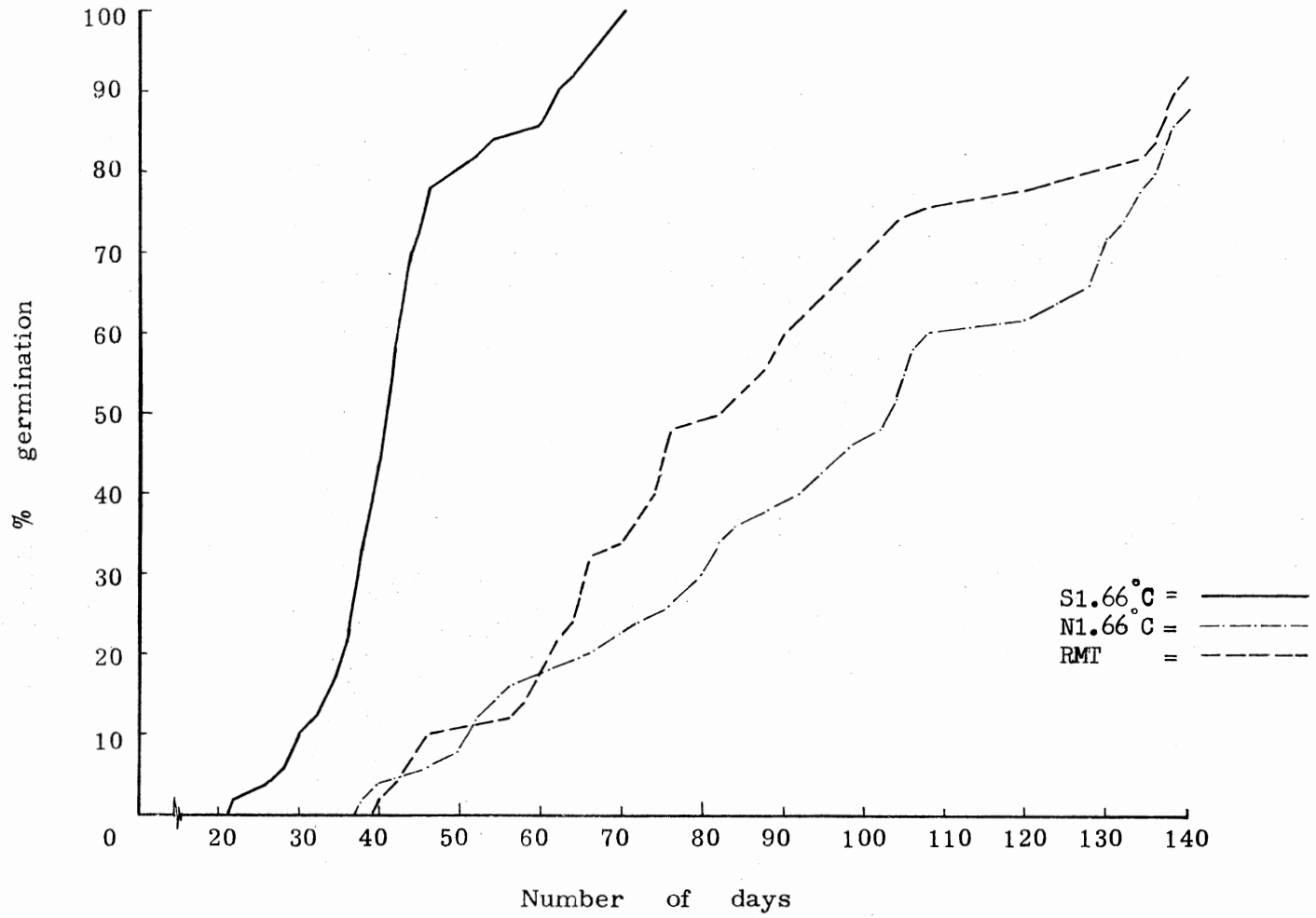


Figure 7. Effect of Different Methods of Storing Pecan of the Western Cv. on Germination (Nuts Planted December 31, 1974)

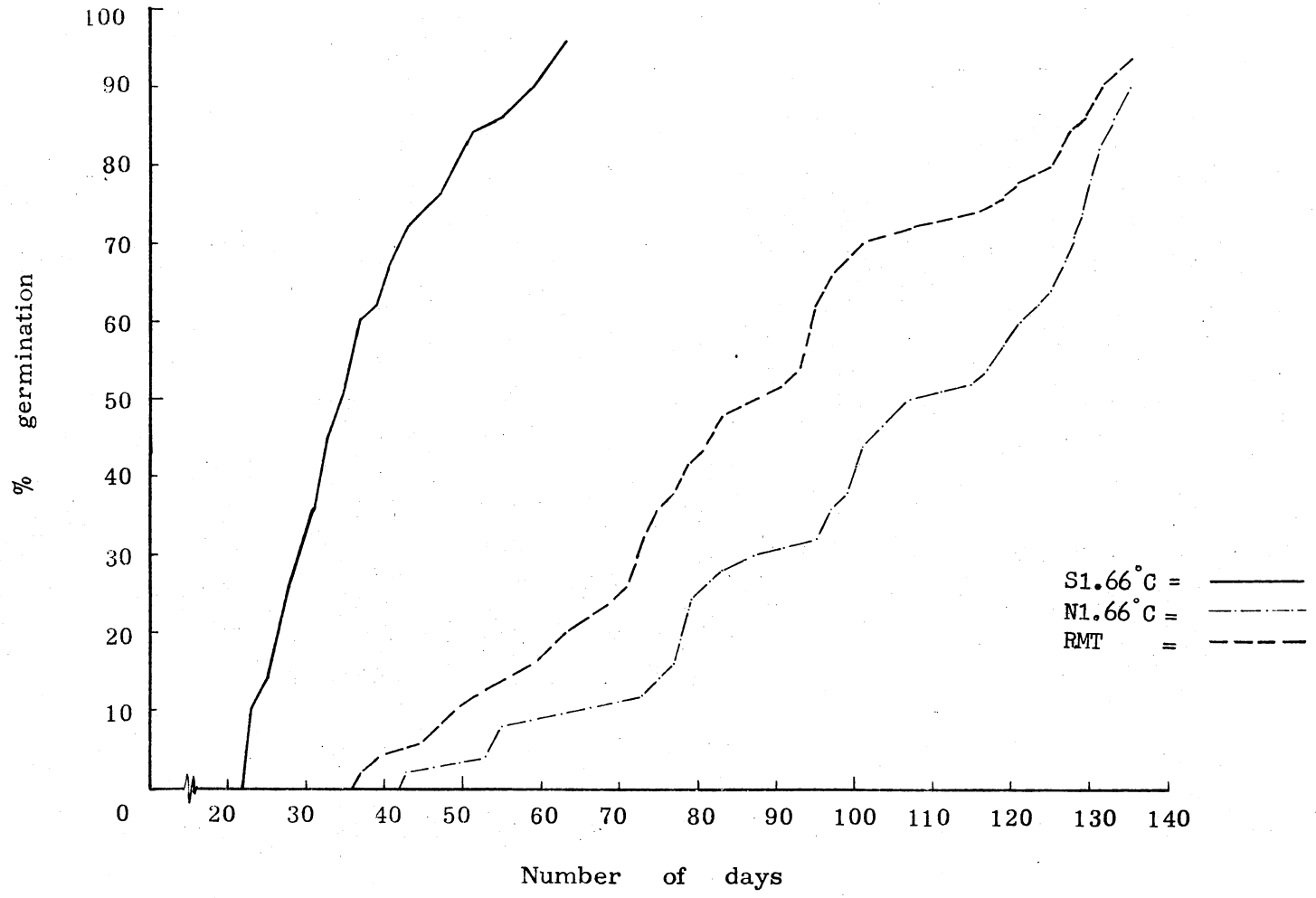


Figure 8. Effect of Different Methods Storing Pecan of the Western Cv. on Germination (Nuts Planted January 7, 1975)

daily germination, peak value and germination value continued to increase for the S 1.66°C treatment (Table I). On the seventh and eighth weeks of planting treatment S 1.66°C was highly significant (Prob > F 0.0002 and Prob > F 0.0001) from the other two treatments and there was a significant difference between N 1.66°C and RMT treatments. The N 1.66°C treatment required more days to reach 80 percent germination (Table II). The low temperatures in dry storage delayed the germination.

From January 14, 1975 to March 18, 1975, S 1.66°C treatment was highly significant from the RMT and N 1.66°C treatments. At this time, there was no significant difference between RMT and N 1.66° treatments (Table II). Rancidity began to develop in the nuts stored at room temperature. Nuts planted 18 weeks after storage (Figure 12) took 12 days more for RMT than N 1.66°C treatments to reach 98 percent germination (Table I). As rancidity increased, the percent germination was decreased i.e., 66, 18, and 12 percent respectively (Table I) and took a longer time when planted 22, 26, and 30 weeks after storage of the nuts at room temperature (Figures 13, 14, and 15).

These results showed that nuts should not be stored in the heated rooms for more than 18 weeks for germination purposes. Nuts stored dry at 1.66°C will take more time for acceptable germination than nuts stratified and stored at 1.66°C (Table II). These studies revealed that pecan nuts should be stratified in moist peatmoss after harvest and stored at 1.66°C for prompt and uniform germination at the onset of the warm weather of spring, preferably from the middle of February to the middle of April (Table II).

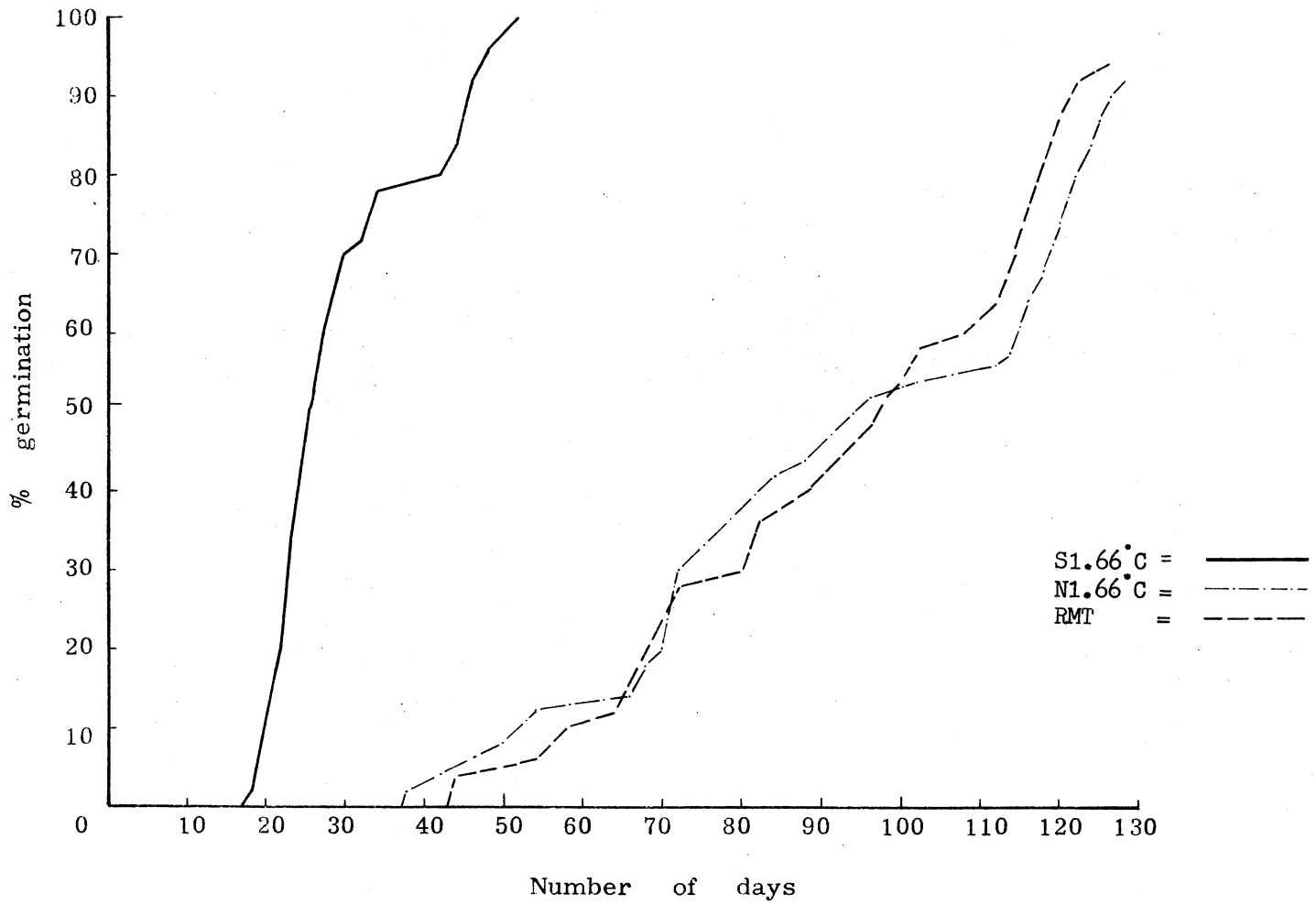


Figure 9. Effect of Different Methods of Storing Pecan of the Western Cv. on Germination (Nuts Planted January 14, 1975)

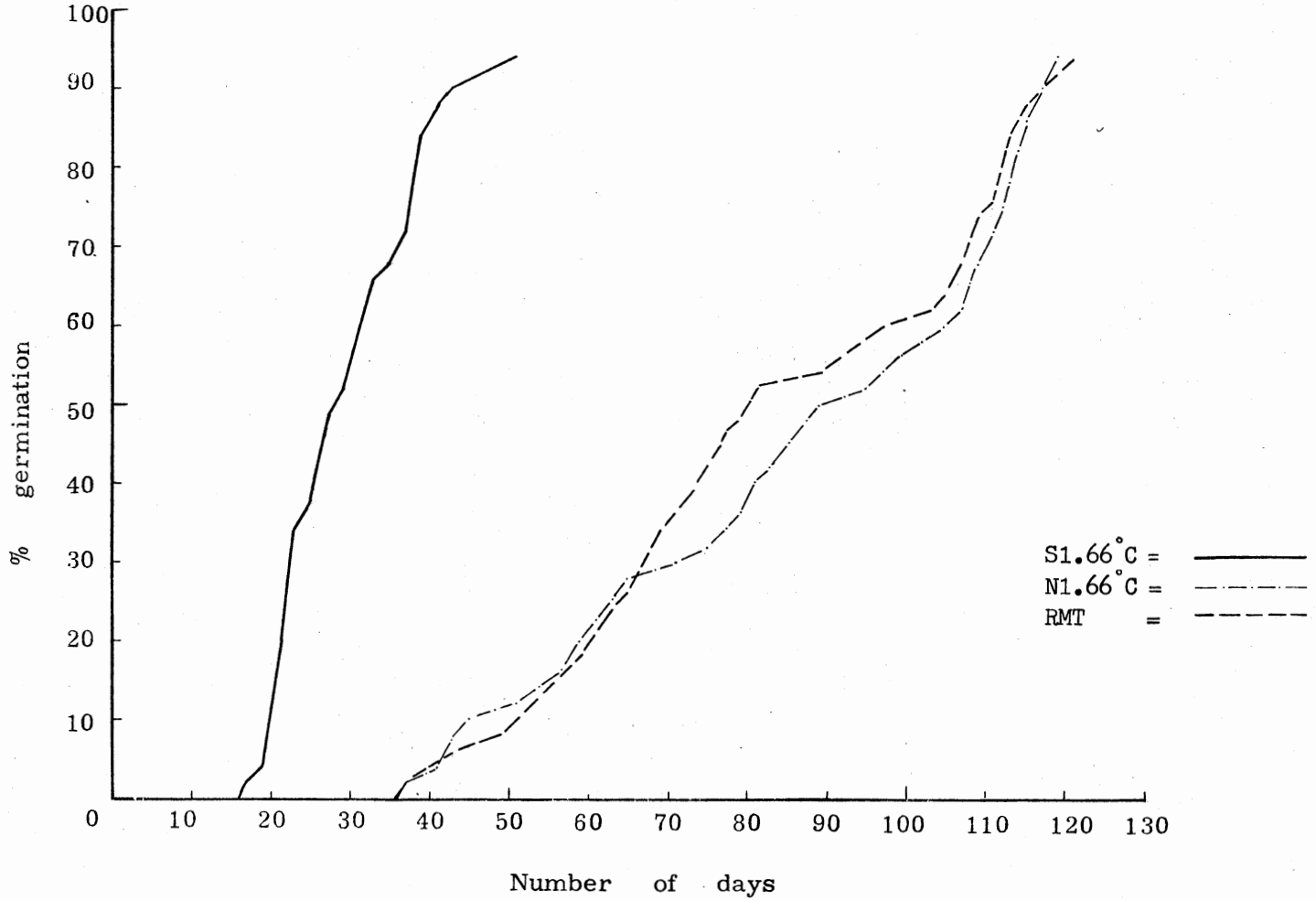


Figure 10. Effect of Different Methods of Storing Pecan of the Western Cv. on Germination (Nuts Planted January 21, 1975)

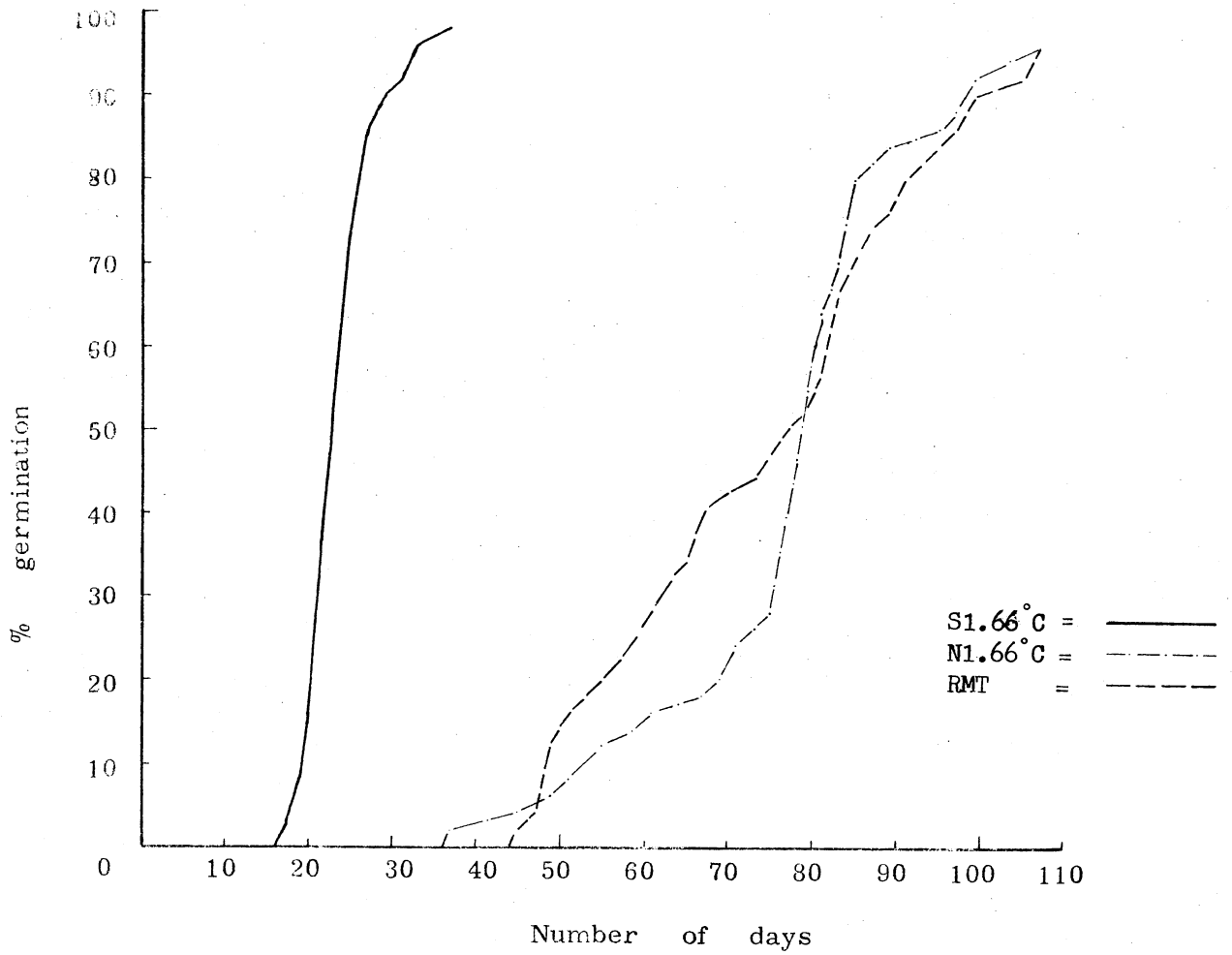


Figure 11. Effect of Different Methods of Storing Pecan of the Western Cv. on Germination (Nuts Planted February 18, 1975)

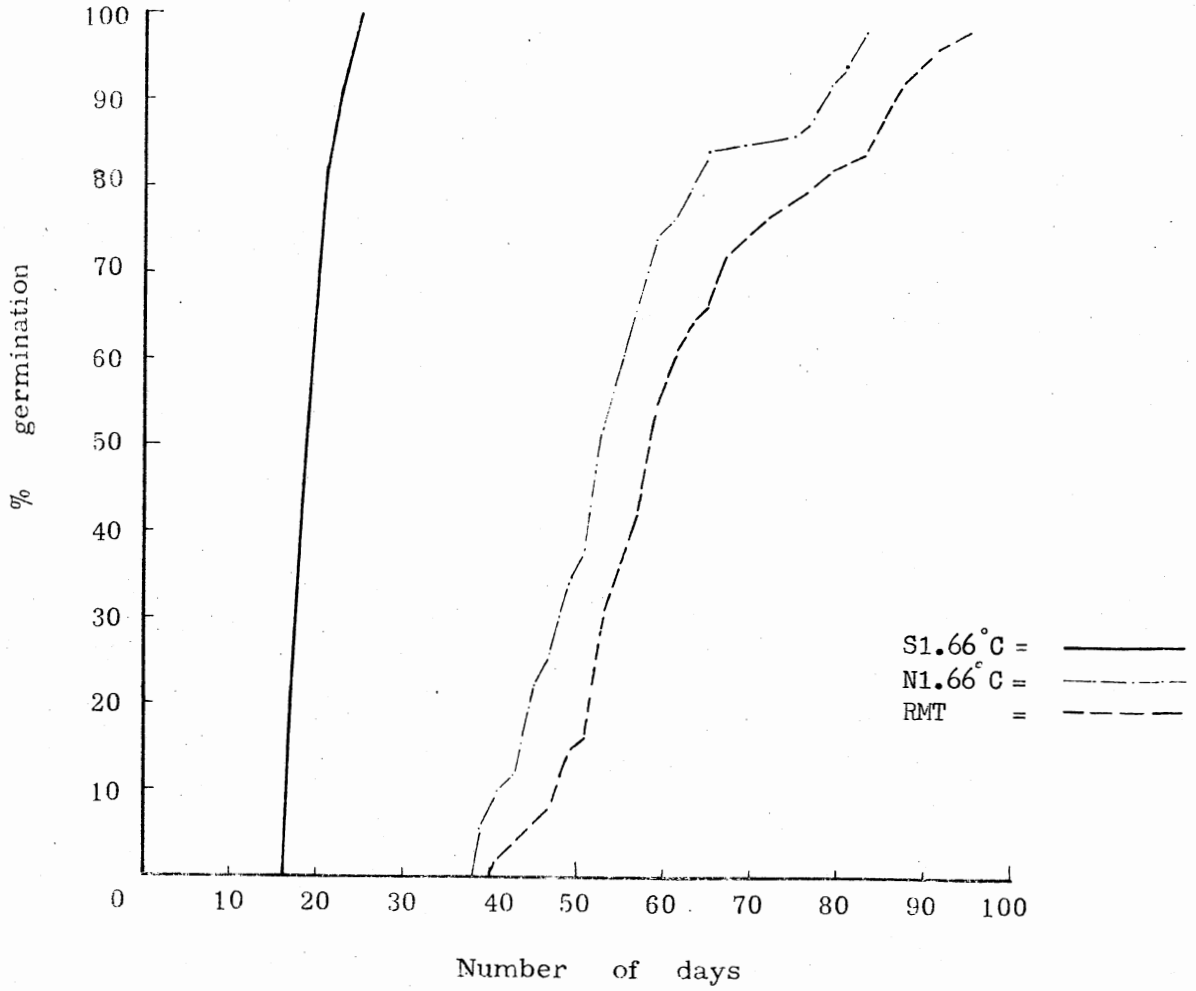


Figure 12. Effect of Different Methods of Storing Pecan of the Western Cv. on Germination (Nuts Planted March 18, 1975)

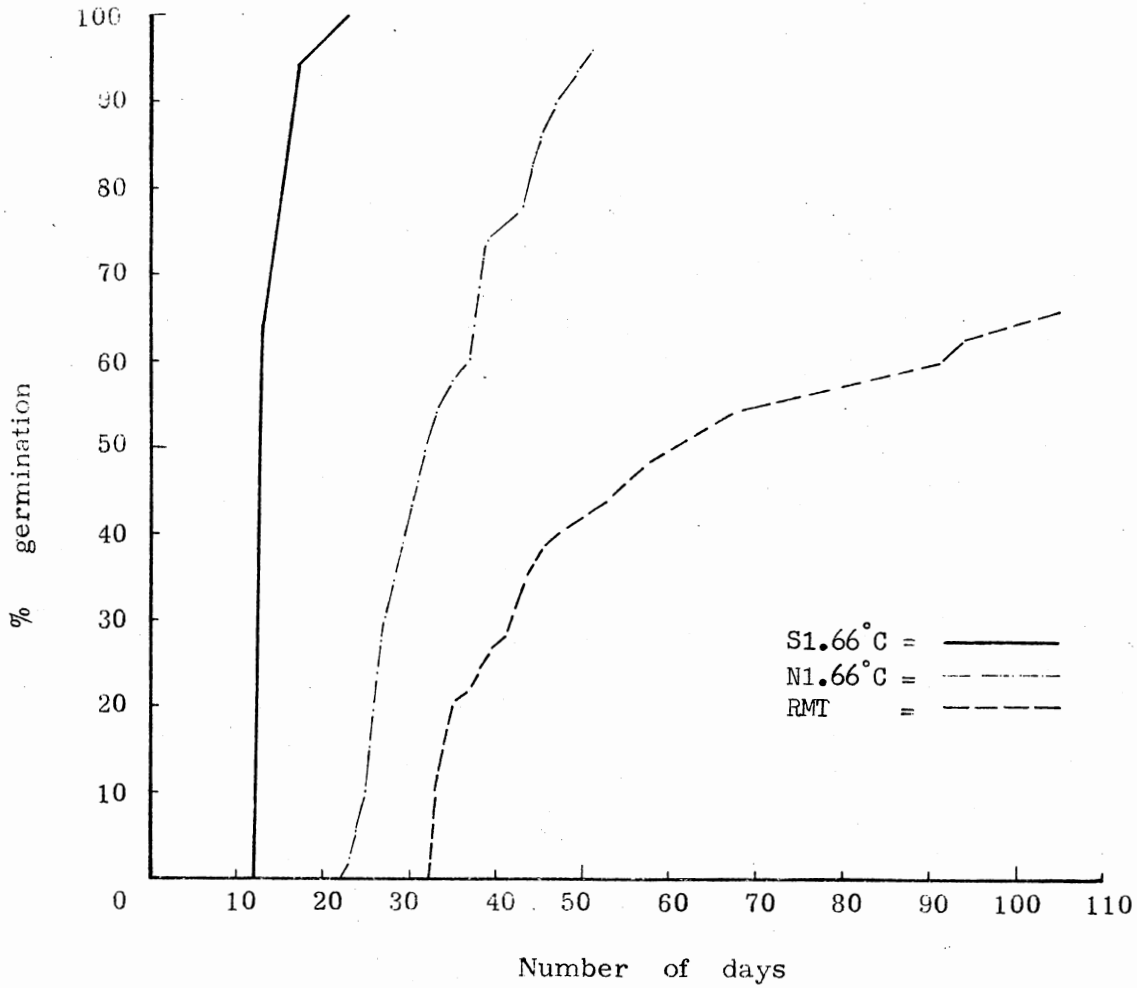


Figure 13. Effect of Different Methods of Storing Pecan of the Western Cv. on Germination (Nuts Planted April 15, 1975)

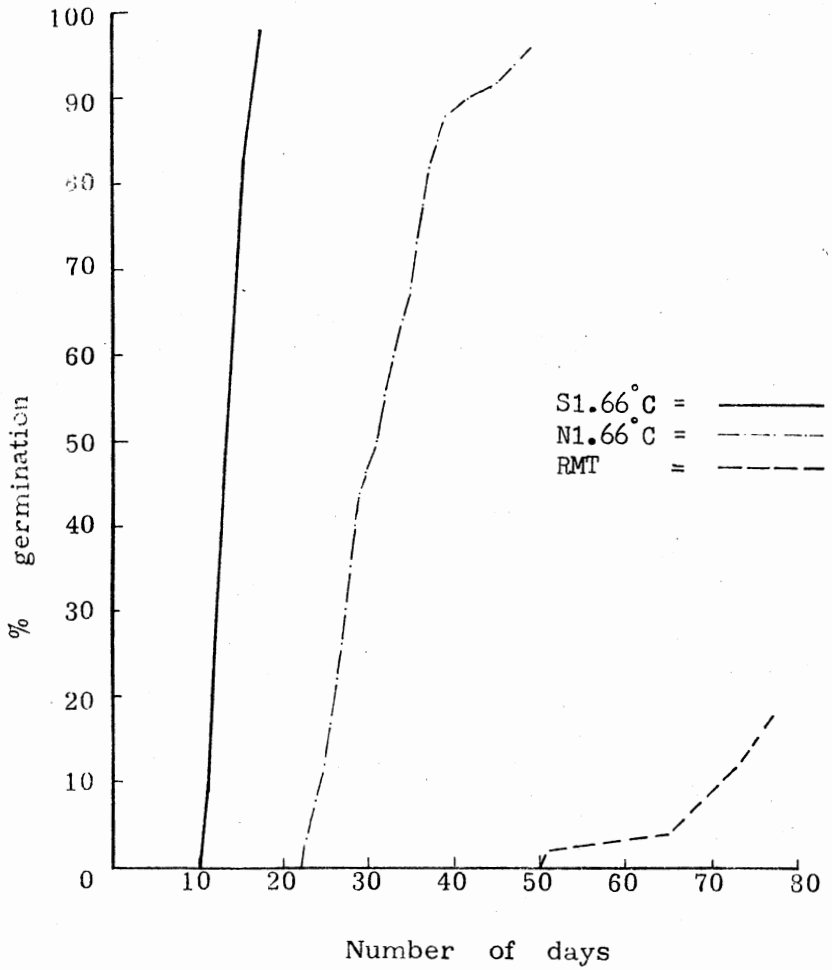


Figure 14. Effect of Different Methods of Storing Pecan of the Western Cv. on Germination (Nuts Planted May 13, 1975)

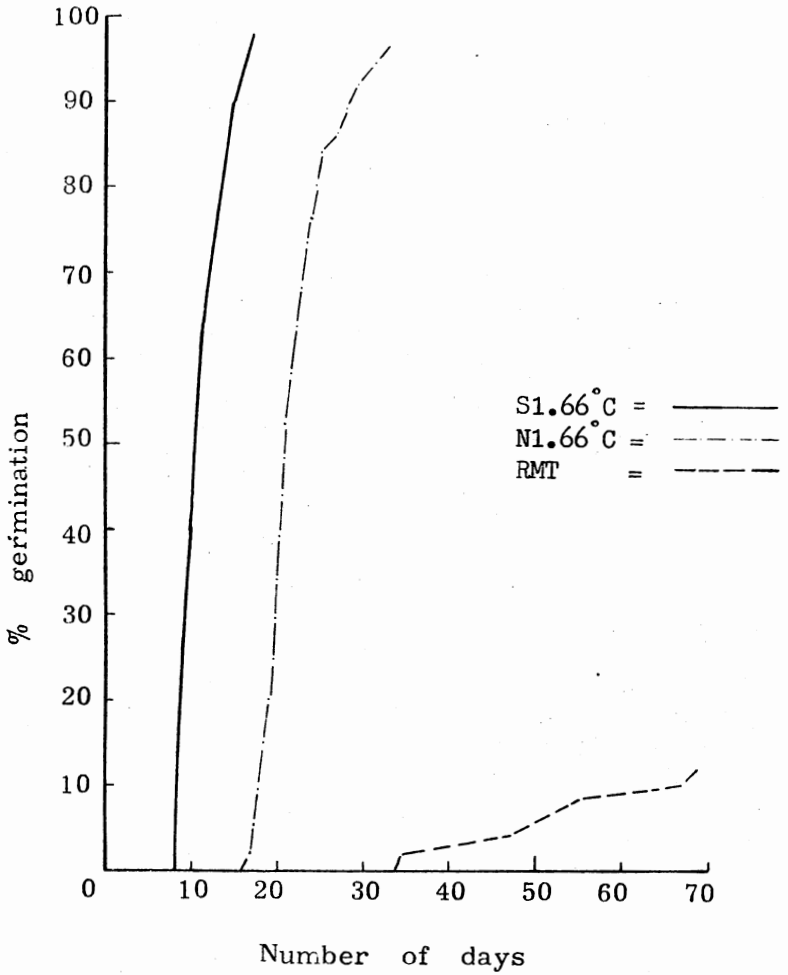


Figure 15. Effect of Different Methods of Storing Pecan of the Western Cv. on Germination (Nuts Planted June 10, 1975)

Nuts stored dry at 0 to 1.66°C from the years 1970, 1971, 1972 failed to germinate. Pecans from the 1973 crop had an average of 88 percent germination in 87.2 average days and 80 percent of the nuts germinated in 80.4 average days (Table III). This study demonstrates that nuts stored dry at 0 to 1.66°C for more than two years did not germinate.

TABLE III

GERMINATION STUDIES ON PECAN NUTS* STORED DRY FOR 1-4 YEARS AT 0-1.66°C

| Year of Storage | Average Percent Germination | Average Number of Days to Average Percent Germination | Average Number of Days to 80% Germination |
|---|---|---|---|
| 1970 | ** | ** | ** |
| 1971 | ** | ** | ** |
| 1972 | ** | ** | ** |
| 1973 | 88 | 87.2 | 80.4 |

*Nuts were planted November 19, 1974.
**No germination.

# CHAPTER V

## SUMMARY AND CONCLUSIONS

The study reported herein relates to the effect of different methods of storage of pecan nuts on germination for the current crop of 1974 and from 1970, 1971, 1972, and 1973 crops. Germination was variable over a long period of time from nuts planted 1 to 3 weeks after storage. There was no significant difference between the treatments. Dry cold stored nuts required more time to germinate than did the other two treatments to achieve 80 percent germination. Stratified nuts stored at 1.66°C responded significantly different from nuts either stored dry at room temperature or stored dry at 1.66°C when planted 4 weeks after storage. Promptness and uniformity of germination increased with length of stratification period, up to 30 weeks. Stratified nuts required 26.2, 21.4, 15.0, 15.4, and 13.8 average days to 80 percent germination when these nuts were planted at 14, 18, 22, 26, and 30 week periods respectively after storage. Dry stored nuts at 1.66°C required slightly more time to achieve 80 percent germination than did nuts stored at room temperature when planted about 10 weeks after treatments were used. Rancidity began to develop in nuts stored at room temperature when planted 22 weeks after storage. At 22, 26, and 30 week periods these nuts lost viability very rapidly having 66, 18, and 12 percent germination respectively. Pecan nuts

stored dry at 0 to 1.66°C for one year germinated satisfactorily, but there was no germination from nuts stored for 2 to 4 years.

It is concluded from these studies that pecan nuts harvested during the fall should be stratified and stored at 1.66°C. These nuts should be planted during the start of the warm season of the following spring for more prompt and uniform germination. Nuts should not be stored for more than 18 weeks at room or higher temperatures.

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# APPENDIX

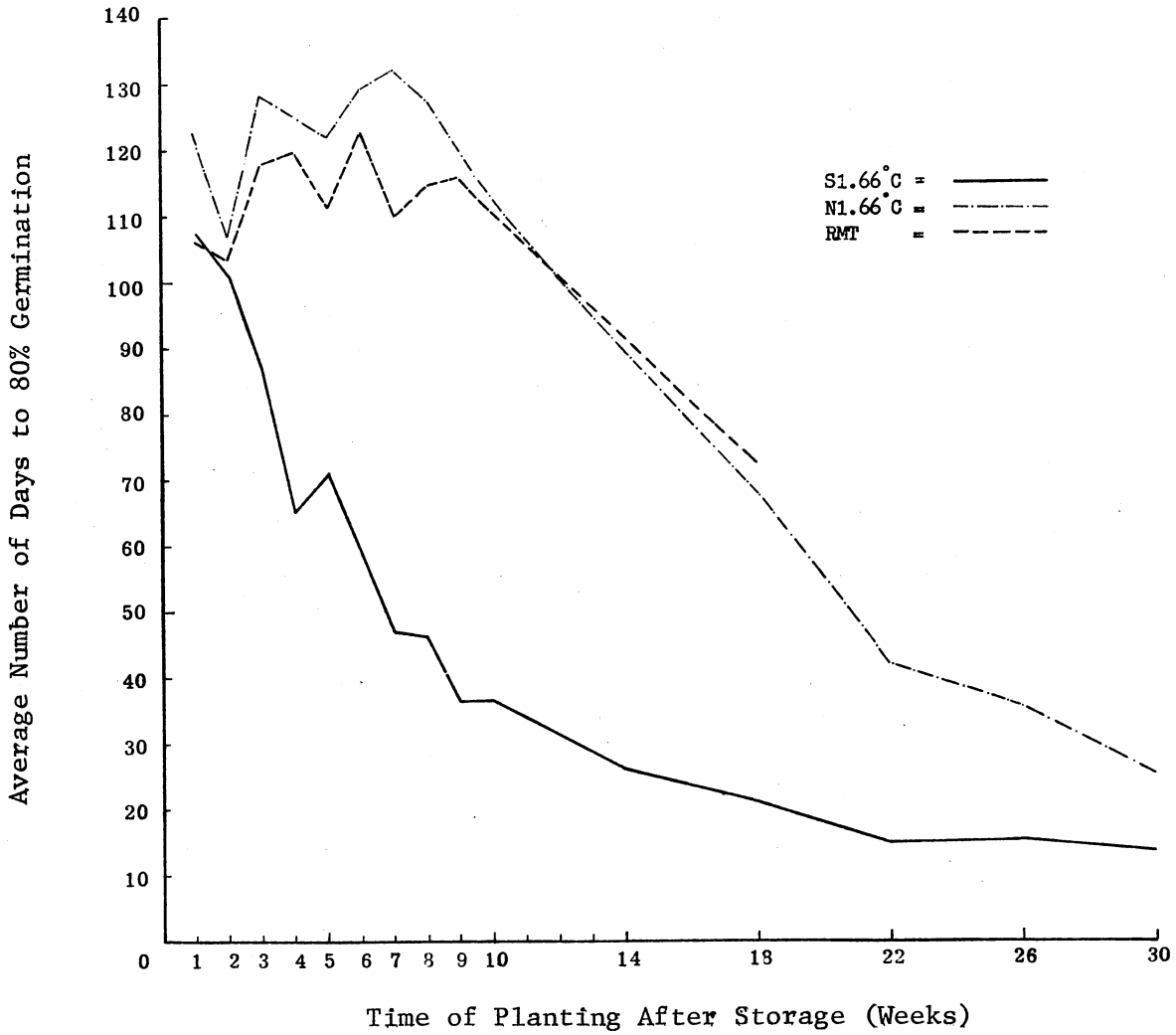


Figure 16. Time of Planting (Weeks) Versus Average Number of Days to 80 Percent Germination

# VITA

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Master of Science

Thesis: THE EFFECT OF STORAGE TREATMENT UPON GERMINATION OF PECAN NUTS, CARYA ILLINOENSIS (WANG.) K. KOCH CV. WESTERN

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