EFFECT OF IBA AND CUTTING DATES ON THE ROOTING OF 4 TILIA SPECIES

BY

MICHAEL DEAN KLAHR

B.S., Kansas State University, 1976

A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Horticulture

Kansas State University

Manhattan, Kansas

1978

Approved by: Steven M. Stall

Major Professor

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LITERATURE REVIEW

Tilia species are excellent street and shade trees (5,8,9,18). Lindens are adapted to a wide range of climates and soils. They are often selected because of their foliage density and color, good branch and crotch development, disease and insect resistance, overall growth rate, and their attractive, fragrant flowers.

Nearly every method has been attempted for propagating Tilia. Yet to date no reliable method has been found. Each has several drawbacks.

Propagation by seed is a complex, unreliable process (9). Seeds of T. americana have a tough pericarp which surrounds an impermeable seed coat and a dormant embryo (12). Thus the seeds germinate very slowly and irregularly. The pericarp must be removed either mechanically or by soaking in nitric acid for nearly two hours followed by a thorough rinsing and drying. Seeds must then be soaked in concentrated sulfuric acid for 15 min to etch the seed coat. Stratification is also required, for four months at 35° F (2°C). If this does not work, it may be necessary to use warm stratification (60° to 80°F) (16° to 27°C) for five months, followed by five months at 35° (2°C) to 40°F (4°C). An alternative method is to collect seeds from the tree when seed coats are brown, but before they drop, followed by immediate planting (12). Even after complex seed treatments, Tilia seed often do not germinate. Average germination for treated T. americana seed is 31 per cent, compared to 33 per cent for treated T. cordata seed (5). The irregular germination usually results in seedlings of treated seeds emerging slowly over a 2 or 3 year period (5). Also much seedling variation occurs when propagating by seed (12).

Air-layering is an impractical method of propagation of Tilia. An apparent problem with any type of layering is the limited number of new plants that can be reproduced each year from each stock plant. Blake and Pauley (4) had problems with air-layering of T. americana. Roots which were produced were very brittle.

Grafting of Tilia is usually discouraged, since grafted plants are often stunted or show indifferent growth. An unsightly swelling also occurs in mature specimens of grafted plants (16).

Budding of Tilia suffers from poor bud take (17). Budding and grafting also have other disadvantages, including the increasing shortage of skilled labor, up to 5 years to produce a saleable product, and certain disease problems.

Rooting Tilia species from hardwood cuttings has been achieved with variable success (1). Ashby (2) reported no rooting on hardwood cuttings made in November from T. americana seedlings, although cuttings appeared viable for several months. Dormant hardwood cuttings taken from a 4-year-old T. americana on December 24 failed to root, although some shoot growth was observed (3). Some hardwood cuttings of T. euchlora and T. petiolaris DC. have rooted, but no rooting percentages were reported (17). These cuttings were taken in February and March and given a 5-second dip of 2500 and 5000 ppm IBA.

Research with softwood cuttings has shown more success. Peterson, et. al. (15) obtained 22 to 47 per cent rooting on T. americana cuttings taken in June and July from stump sprouts. Morsink and Smith (14) have achieved 60% rooting of softwood T. americana cuttings taken from June to

September and dipped in 5,000 and 10,000 ppm IBA. Cuttings were from saplings 6-12 years of age. T. platyphyllos Scop. has been rooted from July cuttings using a mixture of IBA and NAA. Rooting took 58 days (13).

At the Arnold Arboretum (10), March 11 cuttings of T. americana were treated with Hormodin No. 3 after wounding. Ten of 27 cuttings rooted. Also, 2 out of 2 T. a. macrophylla Rehd. cuttings rooted from July 28 to October 21 after treatment with Hormodin Rooting Compound. No research has been done at the Arnold Arboretum on T. cordata, T. euchlora, or T. e. 'Redmond' propagation by cuttings.

Indole-3-butyric acid has been shown to be more effective than IAA or NAA for rooting cuttings of T. americana (14). Significant increases in root growth occurred only with IBA treatments. Buds and shoots did not develop with NAA treatment. Only IBA-treated cuttings overwintered well with few losses, whereas cuttings treated with IAA or NAA failed to set buds and did not overwinter well.

Shoot growth of T. americana is usually limited to a few weeks in the spring (3). Rooting response is related to maturity and hardening of the stem wood. Apparently, rooting ability is highly dependent on cutting date with late spring or early summer being best. Rooting response also varies with different clones (15). Ashby and Cummins (3) have related the formation of roots on leafy cuttings and not on leafless ones to a rooting stimulus from the leaves.

The most favorable time to take most softwood cuttings is when the base of the current season's growth has begun to ripen, since this denotes a favorable carbohydrate-nitrogen relation. A high carbohydrate content plus a reasonable amount of nitrogenous compounds in the tissues is the

best for high quality root and shoot production on cuttings. There is usually decreased rooting ability if flower buds are present on the cuttings (7).

Members of the Tiliaceae family contain a tough, inner bark (6) and are high in fibers. Plants containing abundant fibers in the wood seldom respond from cuttings, as in the case of Fagus (11).

Morsink and Smith have shown that root growth is greater if larger cuttings are used (14). This is probably related to larger reserves of carbohydrates, and larger leaves present would mean a larger photosynthetic area.

LITERATURE CITED

1. Anonymous. 1973. Report for 1972. United Kingdom East Malling Research Station. Maidstone.

2. Ashby, W. C. 1962. Root growth in American basswood. Ecology 43:336-339.

3. Ashby, W. C. and J. N. Cummins. 1968. Root growth and rooting of basswood. Bot. Gaz. 129:327-333.

4. Blake, G. M. and S. S. Pauley. 1960. The vegetative propagation of basswood by air-layers. Minnesota Forestry Notes, no. 85.

5. Brinkman, K. A. 1974. Tilia L. p. 810-812. In C. S. Schopmeyer (ed.) USDA For. Ser. Agr. Handbook 450. Wash., D.C.

6. Brockman, C. F. 1968. Trees of North America. Golden Press, New York. p. 228-229.

7. Chadwick, L. C. 1955. The choice of shoot; a consideration of the influence of source factors on regeneration. p. 215-221. In J. P. Nieuwstraten (ed.) Fourteenth International Horticultural Congress--1955. H. Veenman and Zonen, Wageningen, Netherlands.

8. Chapin, R. R. and P. C. Kozel. 1975. Shade tree evaluation studies at the Ohio Agr. Res. and Devel. Center. OARDC Res. Bul. 1074. Wooster, Ohio.

9. Dirr, M. A. 1977. Manual of Woody Landscape Plants. Stipes Pub. Co., Champaign, Ill. p. 447-454.

10. Dirr, M. A. 1978. Personal Communication.

11. Hanger, F. B. W. 1952. Recent developments in plant propagation, including the after-treatment of seedlings. Paper presented at 13th Internat. Hort. Congress, London.

12. Hartman, H. T. and D. B. Kester. 1975. Plant Propagation: Principles and Practices. 3rd. ed., Prentice-Hall, Inc., Englewood Cliffs, N. J.

13. Komissarov, D. A. 1968. Biological basis for the propagation of woody plants by cuttings. Israel Program for Scientific Translations. Jerusalem.

14. Morsink, W. A. G. and V. G. Smith. 1974. Root and shoot development on cuttings of basswood (Tilia americana L.) as affected by auxin treatments and size of cuttings. Can. J. For. Res. 4:246-249.

15. Peterson, D. W., G. M. Blake, and S. S. Pauley. 1960. Propagation of American basswood by cuttings. University of Minnesota Forestry Note 86.

16. Sheat, W. G. 1965. Propagation of Trees, Shrubs and Conifers. Macmillan & Co. Ltd. New York. p. 380-382.

17. Ward, S. 1974. The rooting of hardwood cuttings. Agr. in Northern Ireland. 49:66-69.

18. Wyman, Donald. 1977. Trees for American Gardens. MacMillan Pub. Co., New York. p. 450-455.

MANUSCRIPT

This manuscript is written in the style of and for publication in HortScience.

Effect of IBA and Cutting Dates on the Rooting of 4 *Tilia* Species.[1]

M. D. Klahr and S. M. Still[2]

Department of Horticulture

Kansas State University, Manhattan, Kansas 66506

Additional index words: *T. americana*, *T. cordata*, *T. euchlora*, *T. euchlora* 'Redmond'.

Abstract. Softwood and semi-hardwood cuttings of 4 *Tilia* species were taken at different dates and treated with high levels of IBA. Rooting varied according to species and cutting dates. Greatest number of roots on *Tilia americana* L. occurred on cuttings taken May 19 and June 1. Cuttings of *Tilia cordata* Mill. showed no significant difference in rootability when taken May 19, June 22 or July 13, although rooting was significantly less on August 3 cuttings. *Tilia euchlora* Koch cuttings did not root; *Tilia euchlora* Koch 'Redmond' cuttings taken May 19 or June 22 rooted 100 per cent. A 5-sec basal dip of IBA significantly stimulated rooting, especially in the range of 20,000 to 35,000 ppm.

---

[1]Received for publication
Contribution No. , Department of Horticulture, Agricultural Experiment Station, Kansas State University, Manhattan, KS 66506

[2]Graduate Student and Research Horticulturist, Ornamentals.

The landscape qualities of the various species and cultivars of Tilia have been described by many plantsmen (2,4,5,13). In a recent urban tree evaluation (4), several cultivars of T. cordata received excellent ratings for foliage density and color, branch and crotch development, disease and insect resistance, and overall growth rate. For these reasons, Tilia are quite popular with the gardening public. However, the propagation techniques of Tilia are varied and often troublesome which makes nursery production difficult (1,2,5,7,10,12).

Several methods of propagation have been attempted with Tilia. Seed propagation is complex and unreliable (5). Average germination for T. americana is 31%, and for T. cordata, 33% (2). Even with successful germination, undesirable seedling variation can occur (7). Tilia propagation by layering is limited to the low number of plants that can be reproduced each year from a single stock plant. Budding and grafting remain the most common methods of propagation. However, they are not without disadvantages which include the need for skilled propagators (12).

Attempts in rooting Tilia species from hardwood cuttings have been only mildly successful (1,10,12). There are a few reported attempts to propagate Tilia from softwood or semi-hardwood cuttings. However, this research has been with American Linden and not the more popular cultivars of Crimean or Littleleaf Linden. Peterson et al. (10) reported 22 to 47% rooting on T. americana cuttings taken in June and July from stump sprouts. Sixty percent rooting of the same species was achieved when cuttings taken from 6-12 year old trees were treated with 5,000 to 10,000 ppm IBA. Nearly all previous research used cuttings obtained from pollarded or juvenile trees (9,10). Since little information is available

on cutting propagation of Tilia from mature trees, an experiment was designed to study the possibility of rooting cuttings taken from mature trees of 4 different Tilia species. Additional factors included in the experiment were the effects on rooting of cutting dates and high levels of IBA.

Cuttings were taken from mature trees (15 to 20 m tall) of 4 Tilia species. The species were T. americana (American), T. cordata (Littleleaf), T. euchlora (Crimean), and T. euchlora 'Redmond'. In 1978, cuttings 15-25 cm in length were taken from terminal growth. Cutting dates for T. americana were May 19, June 1, June 22, and July 13. Cutting dates for the other three species were May 19, June 22, July 13, and August 3.

Cuttings were treated with 0, 10,000, 20,000, 25,000, 30,000, or 35,000 ppm IBA dissolved in 50% water and 50% ethyl alcohol (95%). Cuttings were dipped in the treatment solution for 5 sec and then stuck in a 7:3 perlite-peat medium. A randomized, split-split plot statistical design was used. Intermittent mist was applied for 6 sec every 3 min. Evaluations of rooting were made after 30 days. Per cent rooting, quality rank, and overall-rooting-value were the average of 3 replications, each replication being the average of 7 cuttings. Per cent rooting was a measurement of the % of cuttings that initiated roots while quality rank was based on the number of roots per cutting, as described by Swanson (11). Overall rooting value is the average product of 3 replications' "% Rooting x Quality Rank".

For T. americana, there was no difference among the cutting dates

on % rooting (Table 1). Cuttings taken on June 22 had the highest average of 75% rooting. The quality rank of 6.2 for cuttings taken May 19 and 5.4 for cuttings taken June 1 were better than the quality rank of cuttings taken later in the season. The overall rooting value of 515 for May 19 cuttings was better than that for June 22 or July 13 cuttings, but it was not better than the 470 value for June 1.

Data of T. americana in Table 1 show that for % rooting, quality rank and overall rooting value, all IBA treatments are generally better than the control but do not differ among themselves.

Data in Table 1 indicate that the number of roots (quality rank) and the overall rooting value of T. americana cuttings taken June 1, June 22 and July 13 increase as IBA concentration increases, except that it may decrease for June 1 and June 22 at the highest IBA concentration.

Per cent rooting, quality rank, and overall rooting value of T. cordata cuttings (Table 2) were higher for cuttings taken May 19, June 22 and July 13 than those taken Aug. 3. IBA did not affect per cent rooting.

IBA treatment had no effect on per cent rooting of T. cordata, but IBA benefited quality rank. For example, for cuttings taken May 19, 0 IBA treated cuttings had 81% rooting but the quality rank was only 1.3 (1-5 roots/cutting); cuttings treated with 10,000 ppm IBA had 61% rooting, but the quality rank was 7.3. The overall rooting value for the 0 ppm IBA treatment was 105 compared to 467 for the cuttings treated with 10,000 ppm IBA. This comparison indicates the importance of looking at more than one measurement of rooting.

The highest % rooting among the different species occurred with T. e. 'Redmond' (Table 3). Except for the Aug. 3 sample date, average rooting was above 88% with rooting exceptionally good on cuttings taken May 19, because of the IBA treatments. One-hundred % rooting was achieved for at least one IBA treatment on May 19, June 22 and Aug. 3 cuttings and 95% on July 13 material. For 0 ppm IBA treatments, the May 19 and Aug. 3 cuttings rooted poorly, but June 22 and July 13 cuttings had a high % rooting. Cuttings taken May 19, Juen 22, and July 13 had quality ranks of 6.2 to 7.8. Overall rooting values above 700 were obtained for cuttings of May 19 and June 22. After May 19, the overall rooting values dropped progressively with time. All IBA treatments were generally better than the control on May 19. They were no better than the control for June 22 or July 13 cuttings. By Aug. 3, higher IBA concentrations more effectively stimulated rooting, and 100% rooting occurred at 35,000 ppm.

In considering the effect of IBA treatments on the overall rooting value of T. e. 'Redmond' (Table 3), one should note that all IBA treatments on May 19 cuttings resulted in values over 730. The highest overall value was 781 (out of 800 maximum possible). This occurred at 30,000 ppm IBA.

The treatment averages of T. americana (Table 1) and T. euchlora 'Redmond' (Table 3) indicate that, for overall rooting value, the four higher IBA treatments are significantly better than 0 or 10,000 ppm IBA. The treatment averages of T. cordata (Table 2) show that all IBA treatments are significantly better than the control for overall rooting value, but there is no difference among treatments.

Cuttings of T. euchlora had almost no rooting at any sample date. The best rooting occurred at 0 ppm and low ppm IBA concentrations. Highest % rooting occurred on June cuttings treated with 0 or 10,000 ppm IBA, 29 and 24% respectfully. No rooting occurred on Aug. 3 cuttings at any treatment. Quality ranks averaged 2 or lower.

The overall rooting value of cuttings from American (T. americana) and Redmond Linden (T. e. 'Redmond') was higher than Crimean (T. euchlora) or Littleleaf (T. cordata). Morsink and Smith (9), in work with leafy T. americana softwood cuttings, have shown that root growth is greater if larger cuttings are used. Although all cuttings in this experiment were approximately the same length, Redmond and American Linden are by nature of a greater stem diameter and have larger leaves. Greater stem thickness should be related to larger reserves of carbohydrates; the larger leaves would represent a larger photosynthetic area (9). Thus, one might expect American and Redmond Linden to root more readily than the smaller leafed and stemmed Crimean and Littleleaf Linden. And indeed, this is the case if one looks at the total rooting response and the average trt. avg. of the different species.

There are 2 possible other reasons for poor rooting of T. euchlora cuttings. Hanger (6) has reported that cuttings from plants containing abundant fibers in the wood seldom root, as in the case of Taxus. Crimean Linden may be higher in fibers within the inner bark (near the region of root initiation). It is known that members of the Tiliaceae family do contain tough, inner bark (3) and are high in fibers. A second and perhaps more probable reason is that Crimean Linden lacks a rooting cofactor or organic substance necessary for rooting. Hess (8)

has suggested that the failure of cuttings to respond to synthetic auxins when an ample supply of nutritive substances are available may be due to a shortage of one or more of the rooting cofactors. Redmond, listed as a cultivar of T. euchlora, is supposedly a cross between Crimean and American Linden (5) and it appears that the ability of Redmond cuttings to root so easily is a function of the American Linden parentage and not Crimean Linden.

As can be observed from Fig. 1, the four higher IBA treatments were significantly better than 0 or 10,000 ppm IBA for % rooting and overall rooting value of T. americana. It is possible that as the tissue matured, a greater concentration of auxin (IBA) was necessary to promote root initiation. Rooting of T. cordata, T. euchlora, and T. e. 'Redmond' tended to decrease during August treatments.

The time of rooting (30 days) in this experiment was considerably faster than that reported by Peterson, et al (10). In their experiment T. americana cuttings required 91 days in the propagation bench for successful rooting. This longer period was probably due to the use of "Rootone" powder instead of higher IBA concentrations. The 30-day period of rooting achieved with high IBA concentrations here means less tie-up of bench space for the nursery propagator.

Of special significance in this experiment was the exceptionally high rooting percentage compared to those obtained by other researchers. For example, Redmond Linden cuttings taken May 19 (Table 3), had 100% rooting at all IBA treatments. Among June 22 cuttings, 10,000 20,000 and 35,000 ppm IBA each yielded 100% rooting. Other researchers have not obtained such high rooting values. Even with supposedly

easier-to-root stump sprout cuttings, Peterson, et. al. reported only 22-47% rooting (10). Softwood cuttings from young seedlings have yielded 60% rooting (9).

This experiment indicates that softwood and semi-hardwood cuttings taken from mature Tilia trees can be induced to initiate roots with high applications of IBA. We have shown the optimum cutting date and IBA concentration vary with species. The data indicate that overall root quality of cuttings of these 3 species was best when cuttings were taken in May to mid-June. Cuttings taken at later dates required higher IBA treatments for comparable results. Our results indicate that propagation of T. euchlora should not be attempted by softwood or semi-hardwood cuttings.

LITERATURE CITED

(1) Ashby, W. C. 1962. Root growth in American basswood. Ecology 43:336-339.

(2) Brinkman, K. A. 1974. Tilia L. p. 810-812. In C. S. Schopmeyer (ed.) USDA For. Ser. Agr. Handbook 450. Wash., D.C.

(3) Brockman, C. F. 1968. Trees of North America. Golden Press, New York. p. 228-229.

(4) Chapin, R. R. and P. C. Kozel. 1975. Shade tree evaluation studies at the Ohio Agr. Res. and Devel. Center. OARDC Res. Bul. 1074. Wooster, Ohio.

(5) Dirr, M. A. 1977. Manual of Woody Landscape Plants. Stipes Pub. Co., Champaign, Ill. p. 447-454.

(6) Hanger, F. E. W. 1952. Recent developments in plant propagation, including the after-treatment of seedlings. Paper presented at 13th Internat. Hort. Congress, London.

(7) Hartman, H. T. and D. E. Kester. 1975. Plant Propagation: Principles and Practices. 3rd ed., Prentice-Hall, Inc., Englewood Cliffs, N. J.

(8) Hess, C. E. 1968. Internal and external factors regulating root initiation. p. 42-53. In W. F. Whittington (ed.) Root Growth. Plenum Press, New York.

(9) Morsink, W. A. G. and V. G. Smith. 1974. Root and shoot development on cuttings of basswood (Tilia americana L.) as affected by auxin treatments and size of cuttings. Can. J. For. Res. 4: 246-249.

(10) Peterson, D. W., G. M. Blake, and S. S. Pauley. 1960. Propagation of American basswood by cuttings. University of Minnesota Forestry Note 86.

(11) Swanson, B. T., Jr. 1974. Ethrel as an aid in rooting. Proc. Int. Plant Prop. Soc. 24:351-361.

(12) Ward, S. 1974. The rooting of hardwood cuttings. Agr. in Northern Ireland 49:66-69.

(13) Wyman, D. 1977. Trees for American Gardens. MacMillan Pub. Co., New York. p. 450-455.

Table 1. Effects of cutting dates and IBA treatments on % rooting, quality rank[z], and overall rooting value[y] of Tilia americana cuttings.

Trt. x 1000 ppm IBA	% Rooting Cutting Date May 19	June 1	June 22	July 13	Trt. Avg.	Quality Rank Cutting Date May 19	June 1	June 22	July 13	Trt. Avg.	Overall Rooting Value Cutting Date May 19	June 1	June 22	July 13	Trt. Avg.
0	0c	10k	52b	19k	20g	XX	1.0m	1.6b	1.0m	1.2g	XX	29n	121b	29m	66g
10	81ab	71j	61ab	71j	71f	3.6c	4.3k	2.9b	1.8m	3.1f	305b	305mn	152b	133km	224f
20	100a	100j	85ab	76j	90e	7.0ab	6.0jk	4.8a	5.0k	5.7e	695a	595jk	414a	367jk	518e
25	76ab	67j	81ab	81j	76ef	7.8a	5.4jk	5.6a	5.3jk	6.0e	586a	376km	462a	438j	465e
30	95ab	95j	95a	76j	90e	6.8ab	6.7j.	5.7a	5.8jk	6.2e	648a	643j	538a	452j	570e
35	61b	91j	71ab	85j	77ef	5.6b	6.3j	5.3a	6.8j	6.0e	343b	576jk	419a	595j	483e
Avg.	69p	72p	75p	68p	71	6.2p	5.4p	4.5q	4.5q	5.1	515p	470pq	365q	354q	422

Mean separation within rows and columns by Duncan's Multiple Range Test, 5% level.

[z]Ranking system for number of roots per cutting:

Rank	Number of Roots
1	1-5
2	6-10
3	11-15
4	16-20
5	21-25
6	26-30
7	31-35
8	>35

XX=No assigned value due to no rooting at this treatment.

[y]Overall rooting value is the average of the products of 3 repetitions' "% rooting x quality rank".

Table 2. Effects of cutting dates and IBA treatments on % Rooting, quality rank, and overall rooting value[Y] of *Tilia cordata* cuttings.

Trt. x 1000 ppm IBA	% Rooting Cutting Date					Quality Rank Cutting Date					Overall Rooting Value Cutting Date				
	May 19	June 22	July 13	Aug. 3	Trt. Avg.	May 19	June 22	July 13	Aug. 3	Trt. Avg.	May 19	June 22	July 13	Aug. 3	Trt. Avg.
0	81ab	71j	86a	43j	70e	1.3b	2.0m	1.7b	1.3km	1.6f	105b	148k	148b	62k	115f
10	61ab	71j	100a	43j	69e	7.3a	5.4jk	4.9a	2.6jk	5.0e	467a	386jk	490a	110k	363e
20	61ab	61j	85a	52j	65e	6.6a	4.0km	5.6a	5.0j	5.3e	390a	248k	476a	386j	374e
25	85a	61j	67a	52j	67e	6.2a	6.3jk	6.2a	3.0jk	5.4e	529a	386jk	400ab	224jk	385e
30	48b	76j	85a	43j	63e	6.7a	6.7j	4.6a	4.1j	5.5e	319ab	510j	414a	176jk	355e
35	91a	43j	71a	24j	57e	5.8a	6.8j	5.9a	3.3jk	5.5e	519a	290jk	429a	86k	331e
Avg.	71p	64p	83p	43q	65	5.7p	5.1p	4.8p	3.1q	4.7	388p	328p	393p	161q	320

Mean separation within rows and columns by Duncan's Multiple Range Test, 5% level.

[Y] Overall Rooting Value is the average of the products of 3 repetitions' "% rooting x quality rank".

Table 3. Effects of cutting dates and IBA treatments on % rooting, quality rank, and overall rooting value[Y] of *Tilia euchlora* 'Redmond' cuttings.

Trt. x 1000 ppm IBA	% Rooting Cutting Date					Quality Rank Cutting Date					Overall Rooting Value Cutting Date				
	May 19	June 22	July 13	Aug. 3	Trt. Avg.	May 19	June 22	July 13	Aug. 3	Trt. Avg.	May 19	June 22	July 13	Aug. 3	Trt. Avg.
0	38b	91j	85a	29m	61g	1.0b	2.5m	1.4c	1.1m	1.5h	38b	224m	119c	50k	113g
10	100a	100j	95a	24m	80f	7.3a	4.6k	3.9c	1.6m	4.6g	733a	426k	376b	57k	439f
20	100a	100j	91a	71k	90e	7.4a	6.8j	4.5bc	4.1jk	5.7f	738a	681j	419ab	295j	533e
25	100a	95j	86a	71k	88ef	7.6a	7.4j	5.9a	3.5jk	6.1ef	757a	710j	505ab	271j	561e
30	100a	95j	86a	67k	87ef	7.8a	7.1j	6.2a	4.9j	6.5e	781a	671j	538a	314j	576e
35	100a	100j	86a	100j	96e	7.7a	7.1j	5.4ab	3.4k	5.9ef	767a	705j	467ab	338j	569e
Avg.	90p	97p	88p	60q	84	6.5p	5.9p	4.6q	3.3r	5.1	636p	575p	404q	242r	471

Mean separation within rows and columns by Duncan's Multiple Range Test, 5% level.

[Y]Overall Rooting Value is the average of the products of 3 repetitions' "% rooting x quality rank".

FIGURE 1: Rooting of July 13 *Tilia americana* cuttings after 30 days in the propagating bench.


0
10
20
25
30
35
IBA 1000's
AMERICAN

APPENDIX

Table 4. Effects of cutting dates and IBA treatments on % rooting, quality rank[z], and overall rooting value[y] of *Tilia euchlora* cuttings.

Trt. x 1000 ppm IBA	% Rooting Cutting Date					Quality Rank Cutting Date					Overall Rooting Value Cutting Date				
	May 19	June 22	July 13	Aug. 3	Trt. Avg.	May 19	June 22	July 13	Aug. 3	Trt. Avg.	May 19	June 22	July 13	Aug. 3	Trt. Avg.
0	19a	29j	5a	0j	13e	1.0a	1.0j	1.0a	XX	1.0e	57a	29j	14a	XX	31e
10	14ab	24j	10a	0j	11e	1.0a	1.3j	1.5a	XX	1.3e	43a	43j	21a	XX	34e
20	5ab	5k	0a	0j	2f	1.0a	2.0j	XX	XX	1.5e	14a	29j	XX	XX	21e
25	5ab	0k	0a	0j	1f	1.0a	XX	XX	XX	1.0e	14a	XX	XX	XX	14e
30	0b	5k	0a	0j	1f	0	1.0j	XX	XX	1.0e	XX	14j	XX	XX	14e
35	0b	0k	0a	0j	0f	0	xx	XX	XX	XX	XX	XX	XX	XX	XX
Avg.	7pq	10p	2pq	0.0q	5	1.0p	1.2p	1.3p	XX	1.2	32p	31p	19p	XX	29

Mean separation within rows and columns by Duncan's Multiple Range Test, 5% level.

[z]Ranking system for number of roots per cutting.

Rank	Number of Roots
1	1-5
2	6-10
3	11-15
4	16-20
5	21-25
6	26-30
7	31-35
8	>35

XX=No assigned value due to no rooting at this treatment.

[y]Overall Rooting Value is the average of the products of 3 repetitions' "% rooting x quality rank".

ADDITIONAL LITERATURE SEARCHED

Albert, L. S. 1975. Physiology of roots. Comb. Proc. Int. Plt. Prop. Soc. 25:392-399.

Ashby, W. C. 1960. Seedling growth and water uptake by Tilia americana at several root temperatures. Bot. Gaz. 121:229-233.

Ashby, W. C. 1962. Bud break and growth of basswood as influenced by daylength, chilling, and gibberellic acid. Bot. Gaz. 123:162-170.

Basu, R. N., T., Bose, B. N. Roy and A. Mukhopadhyay. 1969. Auxin synergists in rooting of cuttings. Physiologia Plantarum 22:649-652.

Beakbane, A. B. 1969. Relationships between structure and adventitious rooting. Conb. Proc. Int. Plt. Prop. Soc. 19:192-201.

Burridge, L. O. W. 1973. Growth effects of nonionic wetting agents. The Plant Propagator 19 (3):11-16.

Fordham, R. 1972. Observations on the growth of roots and shoots of tea (Camellia sinensis, L.) in Southern Malawi. J. Hort. Sci. 47:221-229.

Friedberg, S. H. and D. Davidson. 1971. Cell population studies in developing root primordia. Ann. Bot. 35:523-533.

Heslop-Harrison, Y. 1959. Natural and induced rooting of the stem apex in Rubus. Ann. Bot. 23:307-318.

Howard, B. H. 1973. Research at East Malling points way to replacing traditional shield budding with chip budding for ornamental trees. The Grower. July, pp. 84-86.

Kains, M. G. and L. M. McQuesten. 1947. Propagation of Plants. Orange Judd Publishing Company, Inc., New York.

Kaminek, M. 1967. Root formation in pea stem sections and its inhibition by kineten, ethionine and chloramphenicol. Biologia Plantarum 9 (2):86-91.

Khan, M. A. A., R. L. Banik and M. M. Rahman. 1969. Physiological studies on the adventitious root formation in jute plants. Pakistan J. Sci. Res. 21 (3, 4):81-87.

Klasova, A., J. Kolek, and J. Klas. 1971. A statistical study of the formation of lateral roots in Pisum sativum L. under constant conditions. Biologia Plantarum 13 (4):209-215.

Krul, W. R. 1968. Increased root initiation in pinto bean hypocotyls with 2,4-Dinitrophenol. Plant Physiol. 43:439-441.

Lathrop, J. K. and R. A. Mecklenburg. 1971. Root regeneration and root dormancy in Taxus spp. J. Amer. Soc. Hort. Sci. 96 (1):111-114.

Looney, N. E. and D. L. McIntosh. 1968. Stimulation of pear rooting by pre-plant treatment of nursery stock with indole-3-butyric acid. Amer. Soc. Hort. Sci. 92:150-154.

Lovell, P. H., A. Cobb, and K. G. Moore. 1971. The control of root initiation and development in detached cotyledons of Sinapis alba L. and Raphanus sativus L. Ann. Bot. 35:501-509.

Macleod, R. D. 1976. The development of lateral root primordia in Vicia faba L. and their response to colchicine. Ann. Bot. 40:551-562.

Macleod, R. D. and S. M. McLachlan. 1975. The development of large primordia in Vicia faba L.: Some cytological and anatomical changes. Protoplasma 85:291-304.

Mallory, T. E., S. Chiang, E. G. Cutter, and E. M. Gifford, Jr. 1970. Sequence and pattern of lateral root formation in five selected species. Amer. J. Bot. 57 (7):800-809.

Mishra, D. and G. C. Pradhan. 1968. Formation of adventitious roots in tomato seedlings by CCC treatment. Curr. Sci. 37 (9):263.

Rice, P. F. 1970. Some biological effects of volatiles emanating from wood. Can. J. Bot. 48:719-735.

Sawhney, V. K. and L. M. Srivastava. 1974. Cytochalasin-B-Induced inhibition of root-hair growth in lettuce seedlings and its reversal by Benzyladenine. Planta 119:165-168.

Schnitzer, M. and P. A. Poapst. 1967. Effects of a soil humic compound on root initiation. Nature 213:598-600.

Thornley, J. H. 1972. A balanced quantitative model for root:shoot ratios in vegetative plants. Ann. Bot. 36:431-441.

Welch, H. J. 1973. Mist Propagation and Automatic Watering. Faber and Faber, London.

Went, F. W. 1938. Specific factors other than auxin affecting growth and root formation. Plt. Phys. 13:55-80.

ACKNOWLEDGEMENTS

I would like to take this opportunity to express by sincere appreciation to my major Professor, Dr. Steven M. Still, Department of Horticulture, for his guidance, patience, and encouragement throughout my graduate study.

Sincere appreciation is also extended to Robert J. Campbell, Carl D. Clayberg, Ray A. Keen, and Charles D. Long in the Department of Horticulture for their advice as members of my academic committee.

I wish to acknowledge the financial support provided by the Department of Horticulture.

Finally, I am forever indebted and grateful to my wife and my parents, whose encouragement and sacrifice made my graduate studies possible.

EFFECT OF IBA AND CUTTING DATES ON THE ROOTING OF 4 TILIA SPECIES

BY

MICHAEL DEAN KLAHR

B.S., Kansas State University, 1976

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Horticulture
Kansas State University
Manhattan, Kansas

1978

Softwood and semi-hardwood cuttings of 4 Tilia species were taken at different dates and treated with high levels of IBA. Rooting varied according to species and cutting dates. Greatest number of roots on Tilia americana L. occurred on cuttings taken May 19 and June 1. Cuttings of Tilia cordata Mill. showed no significant difference in rootability when taken May 19, June 22 or July 13, although rooting was significantly less on August 3 cuttings. Tilia euchlora Koch cuttings did not root; Tilia euchlora Koch 'Redmond' cuttings taken May 19 or June 22 rooted 100 per cent. A 5-sec basal dip of IBA significantly stimulated rooting, especially in the range of 20,000 to 35,000 ppm.