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The propagation and culture of Mitchella repens L.

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THE PROPAGATION and CULTURE of Mitchella Repens L.

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The Propagation and Culture of *Mitchella repens* L.

by

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To My Mother

whose gracious living and loving ways
have always been a light unto my feet,
who first taught me to love the out-of-
doors, to find peace in the living God.

PREFACE

Not many investigations on a graduate level could ever be undertaken at a collegiate institution without the understanding and thoughtful cooperation of others interested in a study of this sort. The author gratefully acknowledges the use of the laboratories and facilities of the Departments of Botany, Agronomy, Floriculture and Landscape Architecture and the assistance and helpful suggestions which the staffs of these departments, particularly the members of his thesis committee, have offered during this investigation.

The writer also wishes to thank Miss Esther Carlson of Boston University and Mr. Robert Landry of Loyola University for assistance in Swedish and Latin translations; Miss Esther Thayer, formerly of Boyce Thompson Institute, for obtaining experimental data from that institution; Dr. Bernice G. Schubert of the Gray Herbarium for suggestions and aid in obtaining historical research data; Messrs. Ralph W. Donaldson and Frederick A. McLaughlin of the Extension Service and the Experiment Station, respectively, of the University of Massachusetts for testing soil

samples and *Mitchella* seed; Mr. Joel Giddens and his staff of the Soil Testing Service of the University of Georgia for further testing samples and making suggestions; Dr. Theodore A. Bancroft of Iowa State College for reviewing the statistical data of this experiment and recommending future experimental procedures; Dr. Wilbur H. Duncan of the University of Georgia for assistance in formulating a program for gathering distribution data; the many curators and their assistants who so graciously gave of their time in obtaining herbaria data and in answering correspondence in regard to partridgeberry distribution; and to my wife and mother who gave encouragement and helped assemble data during the course of this project. Were it not for these and many others who so kindly exchanged information and discussed problems of mutual interest many of the pleasures of fellowship in research would be greatly lacking.

The experimental portion of this investigation was conducted at the University of Massachusetts from July, 1944 through March, 1946. Other research and the preparation of the manuscript was carried on

intermittently at various institutions in such time as the author could spare from his teaching and administrative duties.

Mr. Robert L. Coffin made the black and white photographs of the rooted cuttings of the partridge-berry. All colored photographs were made by the author with a Kine Exacta camera equipped with a Zeiss Tessar 1:2.8 lens having a 5 cm. focal length. The photographs were taken in natural light without supplementary illumination. Eastman Kodak daylight type Kodachrome film (K135) was used and processed in the concern's Rochester laboratories. The Koda-chrome prints were made in the same laboratories from positives which were selected for illustrating this thesis.

The general organization and form of this thesis, with the major exception of the method of citing literature, is that given in the Manual of Thesis Writing for the Graduate School, Alabama Polytechnic Institute, and prepared by Theodore C. Hoepfner, Assistant Professor of English at that institution.

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I. INTRODUCTION

The use of native plants in landscape planting has always been a subject of keen interest to the author. In this respect, however, indigenous ground covers seem to be neglected generally. Very few nurseries (32)[1] in the New England area offer this native type of plant for sale. From personal observation it has been noted also that not many gardening enthusiasts use collected plants for ground cover purposes. It was thought, therefore, that the study of one of these trailing plants would reveal a sufficiently large knowledge of its habits and culture to stimulate a greater interest in native ground covers among the gardening public.

It has also been observed by the author that after using root-inducing substances in propagating plants by cuttings some species seem to vary considerably in the amount of subsequent growth which they develop. It seemed to the writer that it would be a good idea to look into this matter in an attempt to arrive at some conclusions

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[1]Numbers in parentheses throughout this thesis refer to literature cited. See page 105.

concerning this observation.

Mitchella repens L. was selected for this study because it is evergreen; it has attractive, small, often fragrant (40), twin flowers in spring; and it bears bright red, edible (35) berries in the autumn. Besides these appealing characteristics the plant appears to grow under a variety of conditions. These may be wet or dry, in wooded areas or open glades, either in mixed hardwood or in evergreen stands. The plant is creeping in its habit and under optimum environmental conditions forms a dense ground cover to the exclusion of almost all competing herbaceous plants.

In addition the plant has many uses, the greatest number of which A. D. Taylor has listed in one of his publications (33). Mitchella makes an excellent undergrowth planting in wooded and wild garden areas, under large trees and in heavily shaded situations on lawns; it thrives among rhododendrons and azaleas, in wall crevices and rock gardens; and, obligingly, makes not only a splendid plant for boggy situations but also seems adapted for growing on slopes which are always somewhat dry.

Not the least among its virtues is its contri-

bution to wildlife conservation where Mitchella rates highly as a game cover plant in which the buds, blossoms, foliage and fruit are used by at least nine species of birds including our Eastern bobwhite, Eastern ruffed grouse and Canadian spruce grouse. It has been also observed that the fruit is frequently eaten by the red fox (36).

A. Statement of problem

The problem was to determine the most economical method of propagating Mitchella repens from the nurseryman's viewpoint, to determine the best cultural requirements under which the plant may be grown, and to note particularly the relationship between the rooting of treated cuttings in various media and the subsequent growth of these cuttings.

B. Purpose of investigation

The purpose of this study was threefold:

1. To find an economical means of propagating Mitchella repens so that its sale may be profitable commercially if sufficient interest in the plant creates a demand for this ground cover;

2. To correlate this method of propagation with the environmental conditions under which the

plant naturally grows;

3. To conduct an exploratory experiment to determine whether or not the relationship between root-inducing substances and subsequent plant growth warrants further study.

C. Preview of organization of body of thesis

An extended treatment of the facts and findings of the above study will be found in the body of the thesis (pp. 37 - 100) where there are also detailed results of the investigation and an analysis of the findings. Tabular and graphical presentation of data is included also along with illustrations and such explanations as were thought necessary. The summary and conclusions are presented last.

Here, in this introduction, follows a review of literature, a statement concerning sources of data, an account of materials and equipment used in the investigation and a description of the method of procedure.

D. Review of literature

The review of literature is discussed under four separate headings: A history of Mitchella

repens, information concerning the propagation of the plant, the culture of and, lastly, the ornamental uses for Mitchella repens.

1. History of Mitchella repens L.

Mitchella repens was named after John Mitchell, a scholarly account of whose life is found in the Dictionary of American Biography (24). Mitchell was an English doctor who resided for a while in America and, who, together with a number of others, contributed so much to American botany in the first half of the eighteenth century.

It is anyone's guess as to when Mitchella repens was first discovered, by whom, and where. In all the literature the writer has been able to peruse no mention has been made of this information. If we accept the date of 1700 as the year most likely that Mitchell landed upon these shores then it may be assumed that he first found the plant growing along the Rappahannock. If, on the other hand, we accept Martin's statement that "...he could not have emigrated to Virginia until 1721 or 1725 at the earliest...." (24) then possibly someone else discovered Mitchella growing in Virginia before

Dr. Mitchell did.

John Bartram (25), born in 1699, was our first native American botanist and had a passion for botany from the time he was ten years old; John Clayton came to Virginia in 1705 and lived on the Piankatauk River (26), 10 to 15 miles southwest of the Rappahannock and parallel to it; Mark Catesby sent back to England many seeds and plants which he collected while he was in Virginia from the years 1712-1719 (6). Any of these men could easily have run across the plant but probably Clayton should have the credit for discovering Mitchella first.

It was Clayton's herbarium specimens and botanical observations which formed the basis for Dr. Gronovius' Flora Virginica (12). Since this is the first published record we have of Mitchella repens having been collected, this is sufficient evidence for most people that Clayton first discovered the plant. As Asa Gray wrote:

> ...Mitchell had sent as early as the year 1740 to Collinson a paper in which 30 new genera to Va. plants were proposed. This Collinson sent to Trew of Nuremburg, who published it in the Ephemerides Acad. Naturae Curiosorum for 1748: but in the meantime most of the genera had been already published with other names by Linnaeus or Gronovius....(11)

In addition Bartram in the year 1742 waited "...for the publication of Dr. Mitchell's book on the plants of Virginia before he went ahead with his own....(8)

> ...Among Mitchell's new genera was one which he called Chamaedaphne. This Linnaeus referred to Lonicera, but the elder (Bernard) Jussieu in a letter dated 2-19-'51, having shown him that it was very distinct from both Lonicera and Linnaea, and having in fact belonged to a different natural order, he afterward named it Mitchella....(11)

With all the material being sent from Virginia by the collectors in the early 18th century it was not earlier than 1761 that a living specimen of Mitchella repens was sent to Europe. In that year John Bartram introduced it to Kew where it flowered in June (27).

2. Propagation of Mitchella repens L.

Mitchella repens has never been extensively used from a commercial standpoint except when "...small berried specimens in glass bowls are featured by the florists at Christmas time...." (29). For this reason, perhaps, no particular attention has been given to its propagation and very little is mentioned about such matters in the literature concerning the plant. As Bailey says, the plants

may be propagated by division or collected (2). This is probably sufficient information for the average person who desires only a small quantity of the plant material. The most frequently mentioned means of propagation, however, was that of the creeping stems rooting at the joints (35). Even Loudon's Encyclopedia of 1855 mentions this characteristic habit by stating that the plant is propagated by layers (22).

Since the fruit, a berry-like drupe, usually contains eight nutlets (34), it should be expected also that Mitchella may be propagated by seed. In all the literature read, however, only one mention was made of propagation by this means (4). In this case it was determined at the Boyce Thompson Institute that Mitchella repens must undergo an after-ripening period before it will germinate. In 1935 and 1936 Miss Barton of that Institute was able to germinate Mitchella seed successfully in two ways. In the first method she placed seed in bottles of peat in controlled temperature ovens; in the second seed was planted in flats.

The best results (98%) for the first treatment were obtained by placing the seeds in moist peat

for two months at 25° C., then four months at 5° C. and then brought to 20° C., at which temperature they germinated. With the second method 80% germination was obtained after the seeds, sown in flats, were placed in the greenhouse after six months at 5° C. Low germination after only five months at 5° C. showed that after-ripening was just beginning to be completed. Another method which Miss Barton suggested was that of outdoor plantings in the fall, the plantings being mulched so that the seeds would not be heaved out of the soil.

3. Culture of Mitchella repens L.

Before selecting an area for a field study a further survey of the literature concerning the culture of the partridgeberry (14)[1] was made. The writer wanted to acquaint himself with as many different kinds of conditions under which Mitchella grew as possible. In the limited available literature no conditions were described, however, which the author had not observed in or around Amherst. Cassell's Dictionary (40) states that the plant

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[1] All common names used in this thesis are quoted from Standardized Plant Names, 1942.

"...is not particular as to soil, as long as it is light and moist...." Loudon's Encyclopedia mentions only soil of sandy peat (22). Another reference also mentions "...moist woods, about the roots of trees...." (35). In writing of southeastern conditions Small (31) states that Mitchella grows in "...damp woods, sandy hammocks, and shaded banks, often in acid soil...." while Aiken (1) indicates that the plant isn't too particular as to plant associations doing equally well "...under both hardwoods and conifers...." The most extensive discussion of this sort which the author found, however, was that of the culture of partridgeberry under Florida conditions.

Crevasse (7) states

> ...In the wild condition the partridgeberry is found growing in the deep shade of the hammocks.[1] Under cultivation it demands the same conditions, being unable to grow and thrive in full sunlight. It prefers hammock soils containing an abundance of leaf mold. An acid reaction ranging from pH 4.0 to 6.5 is to its liking. It is hardy throughout most of the United States, and thus may be used without danger of frost damage. This plant will endure

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[1] "...Southern United States colloquialism, a fertile tract abounding in hardwood vegetation...." The Winston Dictionary (19).

> a limited amount of tramping, and since a good covering will seldom exceed 1 or 2 inches in height, no mowing or shearing is required. Being a slow grower, a good cover cannot be developed in less than six months at least unless good-sized sods are used in setting.

4. Ornamental uses of partridgeberry

Again, as has been previously indicated, little information is available concerning the ornamental uses of the partridgeberry. Most all references already cited mention a word here and there about the use of this plant but mostly as a natural ground cover or a wild garden plant growing under partially shaded conditions.

The ornamental uses of the partridgeberry outdoors and in bowls and terrariums has already been noted earlier in this study. Aiken's Nurseries, Putney, Vermont state in their many illustrated catalogues that Mitchella is the very best plant for this use and that they fill and sell partridgeberry bowls by the thousand at Christmas. For those who wish to fill a bowl of their own this concern sends out a printed paper of instructions.

Van Rensselaer (37) states that "Attractive evergreen ground-covers are always in demand among

progressive gardeners and park administrators...." While the partridgeberry does not lend itself to extensive park use because of its very small scale, "...it is especially adapted to small or restricted areas...." (7). In this respect Bailey (2,3) writes that it is "...attractive in half-shaded spots...in rockeries...." and also "...useful...as a ground-cover beneath trees...."

Most authorities mention somewhere in their cultural descriptions the matter of open shade for the partridgeberry in northern habitats and more densely shaded conditions for plants growing farther south. In an article on the "Wild Garden" in The Garden Dictionary (18), this writer found the only notice that the partridgeberry "...can be acclimated to either sun or shade...." As to the use of this plant in sunny situations the writer can only point with emphasis to the fact that the study of the growth of all the propagated partridgeberry plants was conducted in the French Hall greenhouses with only the very small amount of moving shade the structure of the house provides. The splendid and rapid growth of plants in the sun in good, well-watered, garden soil speaks for itself.

In his article, "Living Mulches for Garden Roses", Chadwick (5) presents an interesting idea for the use of ground-cover plants. While it is thought that the fine texture and low carpet formed by Mitchella would be of insufficient contrast with medium- and large-sized rose bushes, the following notes taken from Chadwick's article do suggest the usefulness of the partridgeberry in association with plants of smaller scale.

> The possible use of living mulches for garden roses is intriguing. The bareness of a soil cover and the unattractive character of many of the common mulch materials are conditions which it would be well to overcome.
>
> A low growing cover would add much to the attractiveness of many rose beds. A green foliage color is much more pleasing than the browns and grays of most mulches. In addition to the foliage, small flowers, particularly at the time when there is little rose bloom, would not detract from the value of the rose, but instead it would enhance the value of the rose bed in the landscape picture.
>
> ...With living mulches no cultivation is required. Even with the common mulches, some stirring of the mulch is advisable to prevent crusting.
>
> It is possible that the use of living mulches will bring about a better soil structure. It is generally conceded that a soil impregnated with many fine roots will be of excellent structure. This condition cannot be accomplished with the ordinary mulches. Living mulches will prevent soil compaction, possibly increase the nutrient content of the soil and aid

> in the maintenance of favorable moisture and temperature relations.
>
> Living mulches also aid in the prevention and control of black spot by increasing the vigor of plant growth and hindering the distribution of fungus spores. There is little experimental evidence to bear out this statement but several rose gardeners have expressed this opinion.
>
> It is understood that any plant used as a live mulch should not be a rank grower, should be fairly permanent, either living over or developing from self sown seed, and such that rose bloom production is not reduced....

E. Sources of data

The data for this thesis were obtained from the available literature on the subject, through original inquiry and experimental work, by means of a questionnaire and by a combination of these methods.

As far as could be determined no previous investigation of the asexual propagation of the partridgeberry has been undertaken nor has the subsequent growth of plants after root-inducing treatments been studied. Only those references that were thought to be especially significant for the problem chosen were cited in the text. Others actually consulted and made use of while conducting the study and during the preparation of the thesis are listed separately.

To gain experience in making a botanical dot map and to determine accurately the natural range of Mitchella repens, a questionnaire was sent out to at least one herbarium in each state and province within the given range and outlying areas. A ninety per cent reply was received from this inquiry which was sent to seventy institutions including museums, botanical gardens and universities.

F. Laboratory, materials and equipment used in investigation

An area was selected for field study from which a large quantity of Mitchella material could be obtained easily for propagation purposes. The Tuxbury lot was chosen because it was close by and was representative of a greater variety of conditions under which the partridgeberry grows than any area within the immediate vicinty of Amherst. The lot,[1] owned by the University, is bounded on the south by Eastman Lane and on the east and across the northeast corner by a small stream originating in the Wildwood Cemetery property and flowing into

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[1]Refer to Figure 1, a portion of the Mt. Toby quadrangle sheet, edition of 1941, prepared by the United States Geological Survey.

Fig. 1. Location of Tuxbury Lot, University of Massachusetts, Amherst.

Mill River.

There is about a fifty-foot difference of elevation within the bounds of the area which slopes gently from the southeastern corner to the northwest. The lot is approximately 18.25 acres in area, is of mixed hardwood with a few large individual evergreen trees and contains some small groups of Canada hemlock along the moist banks of the stream. Besides some original open glades the wooded area is rather open as a result of some necessary clearing which had to be undertaken after the hurricane of 1938 blew down many of the large trees. Most of the area is rather dry and well-drained, a small portion of the northeast corner remaining quite moist even in dry periods during the summer months.

The Tuxbury lot is found on the northern end of the Mount Pleasant drumlin extending from a point just north of Triangle Street, past the Fisher Laboratory, through the university woods to Eastman Lane. To this local thickening of the glacial drift, analogous to a sand bar in a stream (20), was added the Pleistocene fresh-water Lake Hadley. According to Emerson (9), this drumlin was "...a great island in the lake...." the shore line follow-

ing approximately what today is the 300-foot contour. "...The work of the lake water along the west side of the Mount Pleasant block of hills...consisted mainly in the concentration of a coarse, well-washed and well-rounded beach gravel out of the till...." The Tuxbury lot rests upon this beach. (9).

The larger portion of the Tuxbury lot is composed of the brown phase of Wethersfield soil, a small strip along the brook and the area to the north being known as Cheshire sandy loam. In most areas these are well-drained and aerated soils, not very inferior, and fairly well adapted to agriculture.

The brown phase of Wethersfield loam occurs on low smoothly-rounded hills or drumlins in scattered areas throughout the Connecticut valley. It is derived from Triassic shale and sandstone and takes its color from this rock material, ranging from mildly acid to neutral.

> ...Following is a description of a typical profile of Wethersfield loam observed in a forested area one-fourth mile southeast of Feeding Hills: From 0 to 2 inches, dark-brown mellow loam of granular structure; from 2 to 5 inches, reddish-brown mellow loam; from 5 to 20 inches, reddish-brown firm but friable loam...The till extends to a depth rang-

> ing from 20 to 30 feet. The entire profile contains some gravel but little stone...Wethersfield loam, brown phase, occupies similar positions but is not so red as typical Wethersfield loam. Most areas of this soil have a lighter-textured A horizon, and the upper part of the C horizon is a tightly compacted layer, similar to a hardpan, which holds the moisture above to the extent that faint mottlings occur in the lower part of the B horizon. Wethersfield loam, brown phase, ranges from loam to fine sandy loam in texture and in places carries much stone, consisting of mixed Triassic sandstone and conglomerate, also some erratic granite and trap boulders....(16)

To convey some idea of the pH values and mechanical analyses of Wethersfield loams, the following two tables are included in this thesis.

TABLE 1

pH values of profile samples of Wethersfield loam and Wethersfield loam, brown phase (16)

Wethersfield loam*			Wethersfield loam, brown phase**		
Sample number	Depth (Inches)	pH	Sample number	Depth (Inches)	pH
131105	0- 2	5.17	131189	0-10	4.80
131106	0- 5	4.92	131190	10-20	5.29
131107	5-20	4.80	131191	20-28	4.22
131108	20-30	4.90	131192	28-36	6.23
131109	30-36	5.02			

* Taken from a forested area.
** Taken from an abandoned field.

TABLE 2

Mechanical analyses of Wethersfield loam (16)

Sample number	Depth	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
	(")	(%)	(%)	(%)	(%)	(%)	(%)	(%)
131106	2- 5	6.1	9.1	5.1	15.9	14.4	38.0	11.4
131107	5-20	4.0	10.9	5.8	20.4	15.6	30.8	12.5
131108	20-30	5.3	12.0	5.5	16.9	16.7	34.5	9.1
131109	30-36	2.2	9.0	5.5	18.1	20.0	32.0	13.2

Table 2 gives the results of the analyses of samples taken from a representative area 1¼ miles southeast of Feeding Hills. From the results it will be noted that the hardpan usually existing at the C horizon has been broken by weathering and that moisture easily penetrates the material below.

Cheshire sandy loam is weathered from Triassic conglomerate, is not so red as the Wethersfield soils but has a somewhat red cast throughout its entire profile. Cheshire fine sandy loam is the most important farming soil of the hill soils of the valley. Cheshire sandy loam on the other hand is less productive although its drainage is more thorough. A typical profile probably would have these layers: From 0 to 3 inches, dark-brown mellow sandy loam; from 3 to 12 inches, yellowish brown

firm but friable sandy loam; from 12 to 24 inches, pink coarse sandy loam loose in structure; and from 24 to 36 inches, red sandy till of the same structure as the layer above and containing some pieces of red sandstone (16). Some indication of the pH values of Cheshire soils may be obtained from the following table.

TABLE 3

pH values of profile samples of Cheshire fine sandly loam (16)

Forested area			Cultivated field		
Sample number	Depth (Inches)	pH	Sample number	Depth (Inches)	pH
131105	0- 3	4.67	131143	0- 6	5.73
131106	3-12	4.52	131144	6-12	4.70
131107	12-24	5.02	131145	12-24	4.73
131108	24-36	5.35	131146	24-36	5.02

The climate of the valley is humid, long cold winters prevailing and short warm summers. These climatic conditions over much of the area favor the accumulation of a moderate amount of raw humus on the surface of the predominating brown soils. Under forest conditions this surface covering of leaf mold, or duff, becomes an inch or more thick. Owing to the summer heat in the valley, however,

the organic matter is more rapidly disintegrated and disappears from the surface soil at a faster rate than elsewhere in the area. (See Table 4 for data concerning these climatic conditions as observed in Amherst.)

The experimental portion of this project was conducted in the horticultural and plant propagation units of the French Hall greenhouses. The propagation unit was run at a night temperature from 42° to 45° F. and the horticultural unit from 65° to 68° F. Daytime temperatures were maintained at an average of 10 degrees F. more.

The soil used to grow the rooted cuttings was obtained from that which the Departments of Floriculture and Olericulture composted annually. The base soil for this composting was a sandy loam which was obtained from the land behind the Curry S. Hicks Physical Education Building.

Leafmold used was obtained from that stored by the Department of Floriculture. This leafmold had accumulated for a period of some twenty years in the old chemistry building cellar hole. The Building and Grounds Department had dumped the fallen autumn leaves in this hole after gathering

TABLE 4

A selected list of average meterological conditions for Amherst, Massachusetts

(Figures based on observations made from 1889 to 1938 at the Massachusetts Agricultural Experiment Station, Amherst, and taken from the station's Meterological Series Bulletin No. 672.)

Air Temperatures in degrees F.

Highest	95.7
Lowest	-12.2
Mean	47.4
Mean maximum	57.8
Mean minimum	36.5

Precipitation, in inches

Precipitation	43.70
Snow	47.78
Number of days with .01 or more	124

Wind, in miles

Mean hourly velocity	5.8
Maximum velocity	39.5

Wind, direction

Prevailing direction	W

Weather

Mean relative humidity, percent	67.6
Mean cloudiness	51.7
Number of clear days	116
Number of fair days	123
Number of cloudy days	126
Number hours bright sunshine	2,353
Percent of possible hours of bright sunshine	52.8
Last snow	April 15
First snow	Nov. 6
Last frost	May 14
First frost	Sept. 21

them from the campus each year. The leaves which formed the leafmold were principally maple.

A good quality, medium-textured, washed sand generally used for construction purposes was obtained from a local supply house. Sphagnum moss peat, commercial grade and granulated, also came from the same source. The mechanical analysis, pH rating, percentage of organic matter, water holding capacity and chemical analysis of all the above material may be found in Table 5.

Hormone powder treatment by means of indolebutyric acid in talc was given to certain cuttings in this experiment. This material was sold under the trade names of Hormodin No. 1, Hormodin No. 2 and Hormodin No. 3 by Merck & Company, Rahway, N. J. and contained at the time of the experiment 1, 3 and 8 mg., respectively, of indolebutyric acid per gram of talc (1,000, 3,000 and 8,000 p.p.m.).

A pH Electrometer, Model 3, manufactured by the Coleman Electric Company, Maywood, Illinois was used in determining the relative acidity of soils and media, Hilgard cups were used for determining water holding capacities, and Bouyoucos cups and equipment for determining mechanical analyses.

TABLE 5. Analyses of Soil Samples, Rooting and Growing Media used in the propagation and culture of *Mitchella repens* L.

Media		pH	Organic Matter (%)		WHC (%)	Mechanical Analysis (%)			Chemcial Analysis				
Proportion	Use		Method 1*	Method 2**		Sand	Silt	Clay	NO_3	P_2O_5	K_2O	MgO	CaO
1 sa, 1 p	Rooting	4.12	9.2	3.13	62.8	93.2	4.4	2.4	M	M	L	L	ML
2 sa, 1 lm	Rooting	6.52	6.2	2.62	38.9	98.0	2.0	0.0	VH	VH	M	VH	VH
1 sa	Rooting	6.43	0.38	0.00	24.0	94.2	3.4	2.4	L	H	VL	L	L
1 sa, 1 so, 1 lm	Growing	6.15	11.5	3.80	46.8	76.0	20.5	3.5	VH	M	VH	H	VH
1 sa, 1 so, 1 p	Growing	4.70	7.9	4.04	40.8	76.0	20.0	4.0	VH	M	VH	M	H
1 sa, 2 so	Growing	6.30	17.9	2.75	59.1	66.0	29.0	5.0	VH	M	EH	H	VH
1 sa, 3 so, 1 lm, 1 p	Growing	5.91	22.4	4.00	51.4	68.0	26.5	5.5	VH	M	EH	H	VH
1 so	Base	6.24	14.7	3.60	66.2	47.0	46.0	7.0	VH	M	EH	H	VH
1 lm	Base	6.26	30.4	7.24	80.6	75.2	19.4	5.4	VH	M	EH	VH	VH
Soil Samples from	Station												
Tuxbury Lot	1	4.6	25.12	6.48***	92.6	60.0	34.7	5.3	–	M	VL	L	VL
	2	4.9	16.88	4.36***	73.4	86.5	13.5	2.5	M	M	VL	M	VL
	3	4.6	13.57	3.51***	60.6	53.6	42.3	4.1	–	L	VL	L	--
	4	5.1	21.33	5.23***	80.2	52.2	44.6	3.2	VL	L	--	L	--
	5	5.0	36.40	9.41***	120.6	51.2	45.2	3.6	L	–	L	L	--
	6	4.1	39.45	10.18***	137.5	57.2	39.6	3.2	–	L	--	VL	--
	7	4.4	41.54	10.73***	140.2	61.2	36.6	3.2	L	L	VL	L	--
	8	5.5	17.20	4.44***	63.0	55.2	41.6	3.2	VL	L	M	L	--
	9	4.8	23.80	6.14***	99.0	43.2	53.6	3.2	VL	M	M	VL	--
	10	4.6	24.89	6.43***	94.3	45.2	51.0	4.8	VL	M	VL	L	--
	11	4.8	19.70	5.08***	100.1	43.2	55.0	1.8	VL	L	M	M	--
	12	5.0	18.77	4.85***	96.7	41.2	54.8	4.0	VL	M	L	M	--
	13	4.7	14.59	3.77***	71.9	43.2	53.6	3.2	VL	M	L	VL	--

Legend:

WHC – Water holding capacity
* – Estimation by burning
** – Modified Walkley and Black
*** – Estimated
sa – Sand
so – Composted soil
lm – Leafmold
p – Sphagnum peat

-- – Trace
VL – Very Low
L – Low
M – Medium
H – High
VH – Very High
EH – Exceptionally High

Alundum crucibles and Bunsen burners were employed in estimating the organic matter of soils and rooting media.

G. Methods of procedure

As previously mentioned a questionnaire was mailed to many herbaria to obtain data for determining the exact natural range of Mitchella repens. The data were returned on forms (see next page) which accompanied the letters of inquiry. From these data the actual collection stations of the partridgeberry were located by dots placed on base maps purchased from McKnight and McKnight, Bloomington, Illinois.

These base maps of North America at a scale of 1:15,000,000 were the best the writer was able to obtain to show the overall distribution of the partridgeberry and at the same time indicate state and provincial boundary lines. However, since these maps did not show the distribution in sufficient detail two other maps at the scale of 1:7,500,000 were prepared from the same data. The United States map was obtained from the U. S. Coast and Geodetic Survey, the map of Canada from the Hydrographic

Collections of *Mitchella repens* L. on deposit in the Herbarium of _____

_____

State	County	(1) Locality	(2) State of development	Date collected	Collector

(1) Such as "3 mi. S.E. of Athens."
(2) Indicate in flower (Flr.), with fruit (Fr.), or sterile (S).

Fig. 2. Reproduction of 8½" by 11" form used to obtain distribution data for Mitchella repens L.

Office of the Surveyor General. Unfortunately, maps of the same projection could not be obtained in maps at the above scale.

The completed dot maps were then reduced and reproduced by lithography, copies being sent to all who so kindly contributed data. (See Section II for these maps and the Appendix for a list of herbaria which contributed location data concerning the partridgeberry.)

Thirteen stations where the partridgeberry grows within the Tuxbury lot were selected for study. These locations were selected because they represented the greatest variety and what appeared to be the most typical conditions under which the plant grows. A survey was made of the plant associations around each one of these stations for a radius of fifteen feet. The trees forming the mixed hardwood group as well as the shrubs and herbaceous material were noted.

Soil samples were taken from these stations, also, the duff on the forest floor not a part of the topsoil being set aside first. The samples were placed on newspapers in the laboratory to air dry for two months and then sent to the extension

agronomist at the University of Massachusetts for testing. Samples of rooting and growing media were also tested in the same way by the Universal Soil Testing System.

TABLE 6

Scale used in Universal Soil Testing System
(parts per million)

		VH	H	MH	M	L	VL
Nitrate	(NO_3)	15	10	6	3	2	1
Ammonia	(NH_3)	25	15	10	5	3	2
Phosphorus	(P_2O_5)	3	2	1	0.5	0.3	0.2
Potassium	(K_2O)	60	50	40	30	20	15
Calcium	(CaO)	400	300	200	100	75	50
Magnesium	(MgO)	40	20	10	5	3	2

A number of attempts were made to measure the average amount of light the partridgeberry receives while growing in its natural environment. Not much in the way of literature was found for guidance in this particular undertaking. Neither the work of Shirley (30) nor the information by Klugh (15) shed much light on ways and means of handling the problem.

A Weston II Universal Exposure Meter, Model 735, was used in attempting to measure the amount of light reflected from the surface of the leaves. In measuring the light the meter was placed a distance of six inches above the plants in such a manner

that the meter did not cast a shadow upon the leaves. The development of the plant at the various stations, the constant changing of sunlight and shadow throughout the days and seasons, the variations in the canopy of trees and shrubs overhanging the forest floor - all these factors were such that attempts to compare the measurement of light at different stations or to come to some definite conclusions were abandoned.

Manning's Plant Buyers Index (23) lists only one concern handling Mitchella seed. Correspondence with this establishment revealed that there was no 1943 seed available for purchase. Only six berries of the 1943 crop were found during July and August, 1944 on the Tuxbury plot. These were sown as soon as found in two-inch standard pots in a medium made up of equal parts of sand, leafmold and composted soil. The pots were plunged up to their rims in the propagation bench in which the sand varied in temperature from 19° to 27° C.

300 berries of Mitchella repens were gathered from the Tuxbury plot in early September, 1944. These were weighed and placed in a beaker at room temperature and allowed to dry for one month. The

seeds were separated from their fleshy coverings and allowed to dry in a beaker at room temperature for another month. Then the seeds were divided into five groups of 200 each for treatment. In early January, 1945 the remaining seed was sent to the Seed Testing Laboratory of the Massachusetts Agricultural Experiment Station for a germination test.

The report states that 100 seeds were tested for 76 days and were divided into three groups for the following treatments: 20° to 30° C. daylight, 20° C. dark, and 20° to 30° C. dark.

In late November, 1944 four lots of 200 seeds each were sown in six-inch seed pans which contained a medium of equal parts of sand, sphagnum peat and composted soil. One pan was placed in the greenhouse on the bench and the other three were placed in the Floriculture Department's refrigerator at 5° C. for one, two and three months, respectively. During the treatment the medium was kept in a damp condition by occasional watering. At the end of each treatment the pans were brought to the greenhouse bench.

A lot of 200 seeds kept at room temperature

for four months was soaked for 24 hours in tap water and then sown in a six-inch seed pan as were the other four lots of seed. The same medium was used as above and the pan was placed in the greenhouse along with the others. All were watered daily and given the same treatment that would be accorded flats with germinating seed.

For the portion of the experiment in which the partridgeberry was propagated by cuttings, three rooting media were prepared. The first was of sharp, washed sand of medium texture; the second was composed of two parts sand and one part leaf-mold; the third of one part sand and one part sphagnum peat. All media were screened through a one-quarter inch mesh, thoroughly mixed, and firmly packed six inches deep in the propagation bench. The sash was kept over the bench with two inches of air, the media kept moist at all times, and the temperature of the media maintained at as near 24° C. as was possible.

On July 8 cutting material was gathered from the Tuxbury lot and 225 cuttings prepared from this material using only the strongest terminal growth. The cuttings were measured and given five different

kinds of treatment. The first were a group of cuttings untreated for a check; the second, third and fourth groups were dipped in Hormodin numbers 1, 2 and 3, respectively; and the fifth group was soaked in tap water for 24 hours. The last type of treatment was undertaken to note if cuttings treated in such a manner would withstand soaking in liquid root-inducing solutions. 25 cuttings with each type of treatment were placed in the three rooting media and kept watered. As the cuttings rooted they were lined out in a coldframe in the nursery for observing growth and percentage of survival under such conditions.

On July 8 also, another group of the same number of cuttings was treated as above. As these rooted, however, they were potted and placed on the greenhouse bench as later described. Other batches of cuttings were taken and similarly treated on August 9, September 10, October 31 and December 17, 1944 and on April 8, May 24 and June 11, 1945.

Weekly observations were made on the progress of the cuttings in rooting. Most of the cuttings were potted at the end of three weeks after having been placed in the bench as this was the time when

the largest percentage of cuttings had rooted. At weekly periods thereafter rooted cuttings of each lot were potted in 2½" rose pots, the pots labeled and the length of the cuttings measured above the soil line. The pots were closely packed in rows on

Fig. 3. Potted Mitchella repens cuttings French Hall greenhouse. Photo taken April 2, 1945

the greenhouse bench and kept watered as needed. Nine months after the cuttings were taken the total length of stem growth of each plant was measured, the average length of growth for each lot determined and the results tabulated.

For the July 8 group of cuttings a growing medium of one part sand, one part soil, and one

part leafmold was selected; for the August 9 group a medium composed of one part sand, one part soil, and one part sphagnum peat was used; one part sand and two parts soil made up the growing medium for the September 10 group of cuttings; and for the group started October 31, one part sand, three parts soil, one part leafmold, and one part sphagnum peat. The other groups of rooted cuttings were grown with the medium used in the September test.

After a period of several months it was noted that the veins of the leaves of the plants propagated in August began to have a decided yellow cast. The new leaves were smaller than usual. During the late winter months the chlorotic condition became quite advanced. Later whole leaves turned a lemon yellow. Symptoms pointed to a nitrogen deficiency (17).

Three pots of each of the fifteen treatment combinations showing the most advanced stages of chlorosis were selected for treatment. These pots were divided into three groups, one pot of each combination being in each group, and each group given a different nutrient solution. Before being treated, however, each pot was numbered and a note made of the plant's propagation combination. The

total length of the stem growth and the chlorotic condition of each plant was also observed. The first lot of plants were fed Knop's solution (21); the next group a 1-gram-per-liter solution of potassium chloride; and the third a solution of calcium nitrate at a strength of 2 grams per liter. The rose pots used had a 120 cc. capacity when filled to the rim. The pots were three-fourths full of soil so that 30 cc. of each solution was given to the plants daily during the period of treatment from June 7 through August 6.

II. RESULTS OF INVESTIGATION

In the same order as the methods of procedure were described, the detailed results of the investigation follow:

As shown on the accompanying distribution maps, the western limits of the range of Mitchella repens follow a natural floral area (10) bounded by the 95th meridian from Canada to the Gulf of Mexico. South of the Arkansas River in Oklahoma one station has been established just west of the 95th meridian and in southern Texas several plants collected between the 95th and 97th meridians. In Mexico one station was established between the 100th and the 101st meridians in the State of San Luis Potosi by Ehrenberg in December, 1839. Most recently Dr. A. J. Sharp of the University of Tennessee established five other stations in the same country between the 97th and 99th meridians in Hidalgo, Puebla, and Vera Cruz in 1944 and 1945. Steyermark in making some studies of the Flora of Guatemala collected specimens in two places in the Sierra de las Minas, just northwest of the city of Zacapa, in 1939 and 1942.

From the southernmost stations between the


50
40
30
20
DISTRIBUTION OF Mitchella repens L.
Dots represent the locations of known collected material
Limit of Wisconsin glaciation
Limit of Pleistocene glaciation
Inner margin of Atlantic coastal plain
Eastern margin of Osage plains
of Greenwich
100
90
SAMUEL P. SNOW
NOVEMBER, 1949

Figure 4

15th and 16th parallels the range extends northward to Cape Ray on the southwestern tip of Newfoundland, approximately 59° west longitude, 48° north latitude. In between there are many areas in which the plant evidently has not been collected. Some of these may not be suitable as areas of natural habitat for the partridgeberry. Even so, there are apparently two major reasons for these gaps on the distribution maps: One, that certain regions have not been explored or have only been superficially covered by collectors; second, that in some areas the plant is so common that it has not been collected at all.

To illustrate these points, the reply to the inquiry sent to the Alabama Polytechnic Institute, which has only a very small herbarium, simply quoted Mohr's Plant Life of Alabama by stating that the partridgeberry grows all over the State in dry shaded woods and banks. The University of Georgia is rapidly building a large herbarium but its collectors have been working in special areas up to the present. Dr. F. M. Hull, Head of the Department of Biology, University of Mississippi, writes that the Department does not have an herbarium but that

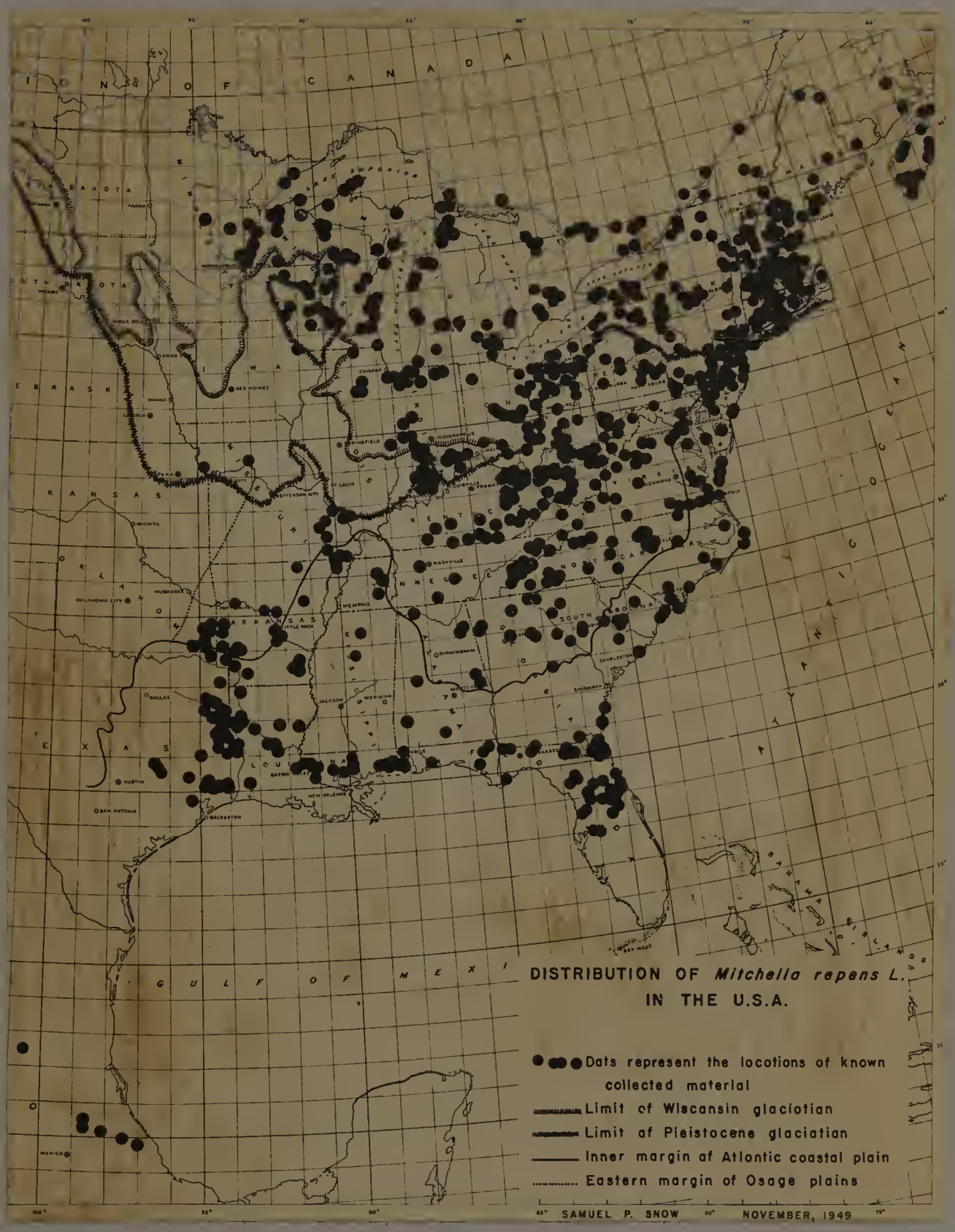
DISTRIBUTION OF *Mitchella repens L.*
IN THE U.S.A.
Dots represent the locations of known collected material
Limit of Wisconsin glaciation
Limit of Pleistocene glaciation
Inner margin of Atlantic coastal plain
Eastern margin of Osage plains
SAMUEL P. SNOW NOVEMBER, 1949
GULF OF MEXICO
CANADA

Figure 5

"...the plant does grow near here." Clemson Agricultural College, South Carolina states "Our file answering letters for the identification of this plant shows that plants of this species have been sent in from the coast, coastal plain, piedmont and mountains."

Apparently in Florida Mitchella is not found south of the 28th parallel, or if it grows there it is not very common. Crevasse only states that "...it is readily obtained in hammocks throughout Central and North Florida...."

The Universities of Indiana, Louisiana, Minnesota and Virginia and Pennsylvania State College have small representative state collections of the partridgeberry in their herbaria but have not felt the need of covering their respective states systematically to determine the plant's exact distribution. The same holds true for the Universities which have much larger state collections of this plant - Duke, Illinois, Michigan, North Carolina, Ohio State and Tennessee.

Dr. F. H. Steinmetz of the University of Maine states that Mitchella is found in all counties of the State. "This plant grows widely distributed in

undisturbed woods but is also found in pastured woodlots."

Of Michigan, Dr. F. C. Gates of Kansas State College writes that "In Emmet and Cheboygan, also Mackinac, Luce, Charlevoix, etc. counties, Mitchella repens is common in Maple-Beech woods - flowers in July, fruits in August, grows in shade only."

The University of Missouri has only a very small number of specimens of partridgeberry in its herbarium. Dr. J. M. Greenman, Curator of the Herbarium at the Missouri Botanical Garden, says that this herbarium has upwards of 200 specimens. Having only a limited amount of time at their disposal the staff only made a list of the specimens obtained from the southern states and sent it to the writer.

Concerning the western boundary of the natural range of the partridgeberry, the author could find no reported collections in the States of North and South Dakota, Nebraska and Kansas. Between the herbaria of the University and Oklahoma A. & M. College there are only seven specimens of the plant collected within a limited range in the southeastern corner of the State. Having observed the conditions

in the southeastern corner of Kansas in traveling across the state many times, the writer believes that the plant probably grows there also.

The Department of Botany of Iowa State College has only one herbarium specimen of Mitchella found in Iowa, this being from Luxemburg, Dubuque County. No other herbarium was found to list collections of this plant from Iowa but the author feels that the state range could be increased with field study.

Regarding the possibilities of the plant being found in South Dakota, I. Verdirin of the University there writes that

> No collections of this genus are in our herbarium, neither does the "Flora of South Dakota" by William H. Over, Curator of our Museum, list this genus. Rydberg does not include South Dakota in the range of this plant, but since it grows in Minnesota it is possible that we have it in the State but that it hasn't yet been reported.

Writing of Texas distribution, Dr. H. B. Parks, Curator of the Museum, Agricultural and Mechanical College of Texas, states

> ...Mitchella repens...is found in every piece of damp or shady woods from the Gulf Coast north to Red River and as far east as San Antonio. It is not found, however, in any location where the altitude is more than 600 feet.
>
> ...One may look for the flowers in April

and May and the fruits turn red in September and are still found in abundance as late as December. In some few places the vines are so thick that it is impossible to see the soil through the mass of leaves. However, in most places a single plant stretches out in such a way that it looks like the spokes of a wheel, some of the branches being from eighteen inches to two feet in length. This vine is somewhat persistent, as I have found it growing in fields that have been in cultivation for a good many years, where it persists around stumps and rocks. The berries seem to be the food of a few birds and I have seen fox squirrels eating them. I have never seen anyone attempt to transplant or to grow this species, although it is my belief that it would be very easy to get a ground cover of this vine as Mitchella and Dichondra are found growing together and their root systems are just about of the same general nature.

From Canada no reply to inquiries was received from the Universities of New Brunswick and Ottowa. The distribution map for the Provinces of Quebec and New Brunswick is quite blank, therefore. It may be possible, however, that neither university has herbarium specimens of Mitchella repens.

Acadia and Dalhousie Universities supplied most of the information for Nova Scotia. Besides this data Roland states that the partridgeberry is

> ...Common throughout; shady and mossy woods, moist banks, and hummocky pastures; characteristic of deciduous climax forest in northern Cape Breton; uncommon and local on turf-covered dunes on Sable Is. It is

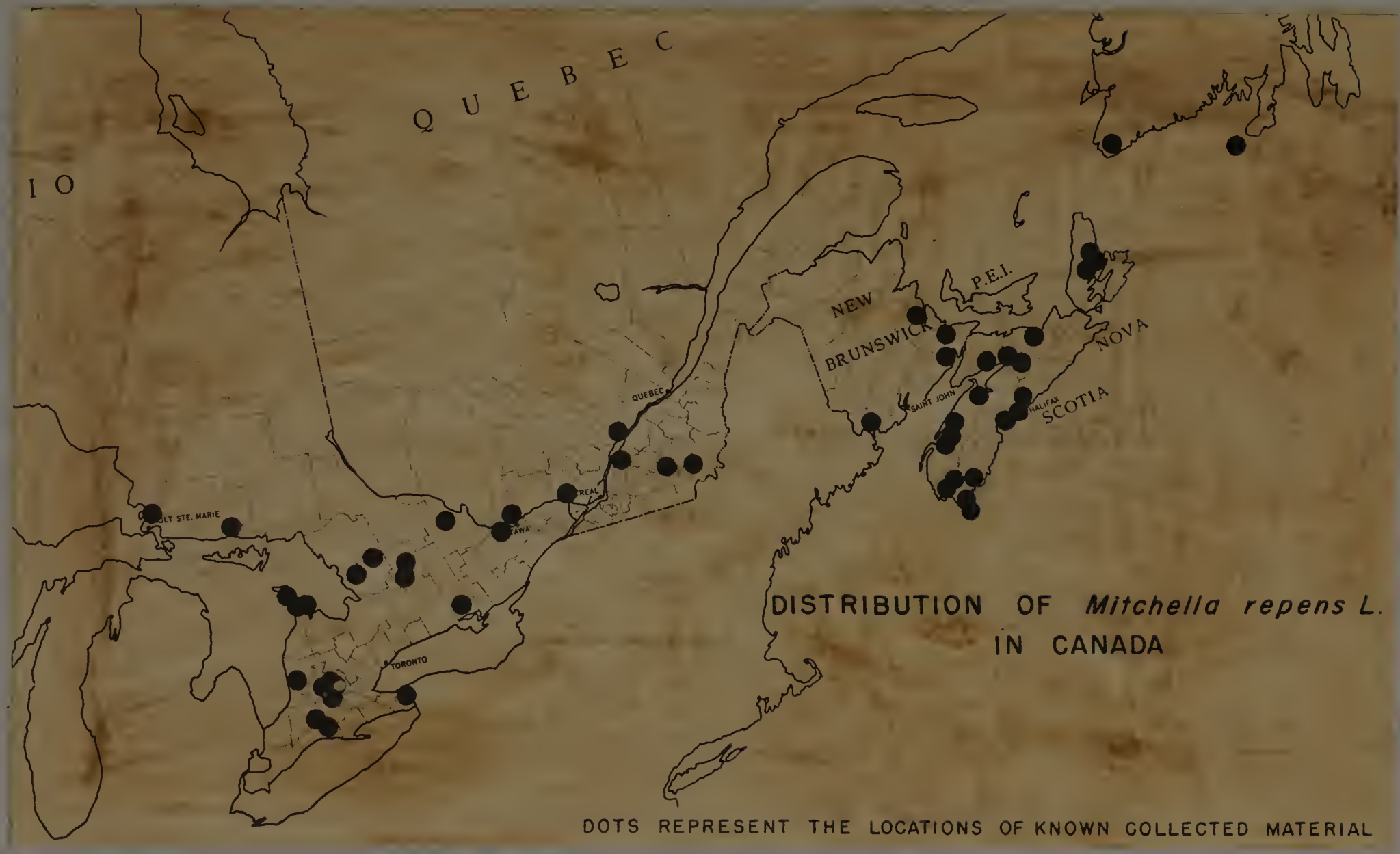
QUEBEC
NEW BRUNSWICK
P.E.I.
NOVA SCOTIA
QUEBEC
SAINT JOHN
HALIFAX
SAULT STE. MARIE
TORONTO
DISTRIBUTION OF *Mitchella repens L.* IN CANADA
DOTS REPRESENT THE LOCATIONS OF KNOWN COLLECTED MATERIAL

Figure 6

> mostly found in moist places where it does not have to meet competition of more vigorous herbs or grasses....(28)

The stations in Quebec and Ontario do not extend beyond the 47th parallel. It is not known at this time whether this is the northern limit of the partridgeberry in this region or whether the upper portions of the provinces have not been explored for the plant.

Seeking some possible stations in Manitoba the author received the following reply from Prof. Lowe of the University of Manitoba's Department of Botany:

> I regret to inform you that the Herbarium here has not a specimen of Mitchella repens. I have made inquiries in the Provincial Museum and among private collectors and find the same result. There is no record of the plant ever being found in the Province of Manitoba. It might occur in the south-east corner near the international border in an area which has not yet been surveyed.

Considerable interest was aroused in noting a specimen of partridgeberry from Sequim, Washington on deposit in the herbarium of the University of Nebraska. Correspondence was immediately entered into with Dr. Pool, Professor of Botany at the University of Nebraska, asking him to check the specimen for if no error in the correctness of the

record appeared, it would be a phenomenal record indeed. The specimen turned out to be an excellent one, covering nearly the whole herbarium sheet, and was in flower at the date of its collection in June, 1916.

In corresponding further with Dr. J. W. Thompson of the University of Washington he had this to say about the specimen and collector.

> ...I happen to know Mr. ____ personally and know a great deal about his method of collecting...If I were in your place, I would forget the whole record of it having been collected at Sequim, Washington. The possibility is this: that he collected it from some person's wild flower garden. Quite a number of people have it growing in their gardens for sentimental reasons, having been acquainted with the plant in the east. It persists here for a few years but eventually dies out. I know that he had the habit of doing that very thing, collecting an eastern plant in cultivation and not giving the word "introduced" on his label.

Turning now to the plants associated with the partridgeberry in its natural habitat, the following observations were made on the Tuxbury lot:

From a location along the stream-side to others progressively farther away from moisture, the stations of partridgeberry were situated under various degrees of hemlock shade. At Station 1 the hemlock

shade was so dense that nothing but Indian pipes and an occasional partridgeberry grew; at Station 10 the hemlocks were sparesely intermingled in a canopy of yellow birch, red maple, red oak, large-toothed poplar, and ash. A large assortment of shrubs and herbs formed the understory and the carpet for the woods floor. Stations 11 through 13 were entirely absent of hemlock, being composed of open areas of hay-scented and interrupted ferns or low bush blueberries and a variety of mixed herbs - Canada mayflower, pokeberry, wintergreen, etc. The black, gray and white birches, red oak, white pine, and an occasional chestnut dominated the upper story.

On the following pages will be found Table 7 giving a partial list of the plant material found on the Tuxbury lot. While not complete the table lists the principal plants associated with the species of this study.

As will be noted on Table 5, soil samples taken from the stations on the Tuxbury lot had a pH range from 4.1 to 5.5 indicating that the partridgeberry thrives on mini-acid to slightly acid soil conditions. Under such conditions, however, the harmful effects of soil acidity must be constantly guarded

TABLE 7

Plant material growing with Mitchella repens on Tuxbury lot

Trees

Acer rubrum L.	Red Maple
Acer saccharum Marsh.	Sugar Maple
Betula lenta L.	Sweet Birch
Betula lutea Michx.	Yellow Birch
Betula papyrifera Marsh.	Paper Birch
Betula populifolia Ait.	Gray Birch
Castanea dentata Borkh.	American Chestnut
Fraxinus americana L.	White Ash
Pinus strobus L.	Eastern White Pine
Prunus serotina Ehrh.	Black Cherry
Quercus alba L.	White Oak
Quercus rubra L.	Red Oak
Tsuga canadensis Carr.	Canada Hemlock

Shrubs

Amelanchier canadensis Med.	Shad. Serviceberry
Cornus alternifolia L.	Pagoda Dogwood
Hamamelis virginiana L.	Common Witchhazel
Kalmia latifolia L.	Mountainlaurel K.
Viburnum acerifolium L.	Mapleleaf Viburnum
Viburnum alnifolium Marsh.	Hobblebush Viburnum
Vitis labrusca L.	Fox Grape

Herbs

Anemone quinquifolia L.	Amer. Wood Anemone
Anemonella thalictroides Spach.	Anemonella
Aquilegia canadensis L.	American Columbine
Arisaema triphyllum Schott.	Indian Jackinthe-pulpit
Chimaphila maculata Pursh.	Striped Pipsissewa
Chimaphila umbellata Nutt.	Common Pipsissewa
Cornus canadensis L.	Bunchberry Dogwood
Cypripedium acaule Ait.	Pink Ladyslipper
Gaultheria procumbens L.	Checkerberry Wintergreen

TABLE 7 - Continued

Herbs

Lysimachia quadrifolia L.....Fourleaf Loosestrife
Maianthemum canadense Desf.....Canada Beadruby
Medeola virginiana L.....Cucumberroot Medeola
Polygonatum biflorum Ell.....Small Solomonseal
Prunella vulgaris L.....Common Selfheal
Pyrola americana Sweet.....American Pyrola
Pyrola elliptica Nutt.....Waxflower Pyrola
Smilacina racemosa Desf.....Feather Solomonplume
Solidago ssp.....Goldenrod
Trillium erectum L.....Purple Trillium

Ferns and Lycopods

Dicksonia punctilobula Gray.....Hayscentedfern
Aspidium thelypteris Sw.....Marshfern
Lycopodium complanatum flabelliforme Fernald
Groundcedar
Lycopodium obscurum dendroideum D. C. Eaton
Groundpine
Osmunda cinnamomea L.....Cinnamonfern
Osmunda claytoniana L.....Interrupted-fern
Polystichum acrostichoides Schott
Christmasfern

against in growing the partridgeberry for ornamental purposes. With the exception of the soil used for the growth of the August batch of rooted cuttings all soils used for this purpose had a much higher pH value. A further development of this matter is discussed later in this thesis.

The organic matter and water holding capacity of the soil samples were high. The percentage of

each sample was determined twice using the methods taught in the freshman agronomy classes at the University of Massachusetts and described by Isgur (13). At one time it was thought that the data regarding the rooting, growing and base materials were lost. Mr. Giddens of the University of Georgia checked these samples again for organic matter, using a different method than that used by the author. The results obtained by the author by estimation by burning were almost four times greater than those determined by Mr. Giddens by the Modified Walkley and Black Method.[1] Using the exact average ratio between the two results the percentage of organic matter by this latter method was estimated for the Tuxbury lot samples.

Although a great deal of care was taken in determining the mechanical analyses of the samples it is thought that results may not be too accurate.

---

[1]Mr. Giddens gives two references for this method: Walkley, Allan, and Black, I. Armstrong. "An Examination of the Degtjareff Method for Determining Soil Organic Matter, and a Proposed Modification of the Chromic Acid Titration Method," Soil Science. 37: 29-38 (January, 1934).

Walkley, Allan. "A Critical Examination of a Rapid Method for Determining Organic Carbon in Soils." Soil Science. 63: 251-264 (1947).

The samples were really too high in organic matter to be determined with a great degree of accuracy by the Bouyoucos hydrometer method. The writer believes that the percentage of sand should be fairly accurate but the organic matter seemed to act as silt.

Later in the thesis the significance of the chemical analyses of the samples - as determined by the extension agronomist of the University of Massachusetts - is discussed with the matter of soil acidity.

Mention was made previously of the very small amount of 1943 seed found on the Tuxbury lot and sown in the greenhouse. In late February, 1945 one seed germinated, seven months after the date of sowing. This seed was the only one found in one berry. After germinating it was grown to a plant in the pot in which it was sown. No other seed germinated.

The 300 berries of the 1944 seed gathered from the lot were found to weigh 28.44 grams - approximately one ounce. From the berries 1192 seeds were obtained, an average of four seeds per berry. When air dried the seeds weighed 3.71 grams. This weight

would make 33,800 seeds per ounce a good estimate.

Of the seeds tested in the Massachusetts Agricultural Experiment Station laboratory only 6 per cent of the first group treated germinated. The following remarks, however, were stated in the report: "We regret that we were unable to give a germination for low temperature. The results we find may mean nothing in regards to true viability of this seed."

No germination took place in the five lots of seed given various degrees of artificial stratification and treatment in the French Hall refrigerator and greenhouses.

Turning to the various aspects of the vegetative propagation of the partridgeberry, it will be recalled that two groups of cuttings were taken on July 8. The first group, when rooted, was placed directly outdoors in a coldframe; the second was potted and placed on the greenhouse bench. From the results of the former trial experiment found on Table 8 it is apparent that this method of handling cuttings is an economical one. The method not only saves the additional handling of the plant material but also saves valuable bench space and costs of

growing plants on in the greenhouse during the winter months. Apparently there is not enough difference between the hardiness of various treatment combinations to warrant drawing any conclusions as to the relative values of the rooting media and kind of root-inducing treatments used. Beyond the fact that there is a high percentage of survival in all cases, the experiment was not of long enough duration to arrive at any conclusions.

It will be noted that some of these cuttings were set out as late as October 30 and suprisingly established themselves at this late date. It is thought by the author that if plants had been set out at a later date that this method would not be an economical one. There probably would never have been such a large percentage of survival even in an uncovered coldframe into which a light natural covering of leaves was allowed to blow.

While 25 cuttings of each treatment combination were placed in the rooting media, it will be seen that in no case were the same number of rooted cuttings set outdoors. A few cuttings rotted but a greater number disappeared from the propagation bench. (It is assumed that some of them made

TABLE 8

Rooted cuttings survival of Mitchella repens during winter of 1944-5

Cuttings set out		Rooting medium	Treatment	Percentage of survival
Date	Number			
10-17-44	19	sand	24 hr. H_2O	100
10-17-44	20	sa-p	24 hr. H_2O	100
10-24-44	14	sa-lm	24 hr. H_2O	100
10-24-44	17	sand	24 hr. H_2O	100
10-25-44	14	sa-p	24 hr. H_2O	86
10-26-44	17	sand	None	88
10-26-44	15	sa-lm	None	100
10-26-44	12	sa-p	None	100
10-27-44	11	sand	Hor. #1	100
10-27-44	14	sa-lm	Hor. #1	100
10-30-44	15	sa-p	Hor. #1	93
10-30-44	9	sand	Hor. #2	89
10-30-44	11	sa-lm	Hor. #2	91
10-30-44	13	sa-p	Hor. #2	100
10-30-44	17	sand	Hor. #3	94
10-30-44	12	sa-lm	Hor. #3	92
10-30-44	14	sa-p	Hor. #3	100

Legend:

sa - Sand
lm - Leafmold
p - Sphagnum peat

attractive boutonnieres.) A number of cuttings had green fruit on them when placed in the bench. Some of these ripened into bright red berries during the rooting period. There appeared to be no difference in the length of the rooting period between those

cuttings bearing fruit and those not.

The record of the rooting of the second group of cuttings taken on July 8 and similar batches taken later is shown on Tables 9 through 16 on the following pages. The first three-week period was chosen as the first one to measure the percentage of rooting of all cuttings. A few rooted in a comparatively short period but the majority were not what were considered to be strong, commercially salable, rooted cuttings until the end of three weeks.

From these tables can be seen many variations in the results obtained. Certain important facts can be stated, however. It will be noted that the months of June through September appear to be the best for taking cuttings from the standpoint of the largest percentage rooting in three weeks. The batch of cuttings taken October 31 took five weeks and the December 17 cuttings four weeks to reach a percentage of rooting comparable to the cuttings taken at more favorable times. The plant's period of lowest activity probably begins to take place at the end of October. However, the low percentage of rooting of cuttings taken during April and,

TABLE 9

Percentage of cuttings rooted of Mitchella repens, taken July 8, 1944

Treatment:	None	Hor. #1	Hor. #2	Hor. #3	H_2O
			Sand medium		
3 weeks	76	76	76	90	8
4 weeks	96	88	76	90	32
6 weeks	100	88	76	94	56
			Sand-leafmold medium		
3 weeks	76	56	84	76	16
4 weeks	96	80	88	88	100
6 weeks	100	100	88	96	100
			Sand-sphagnum peat medium		
3 weeks	76	76	92	76	44
4 weeks	80	84	92	96	88
6 weeks	84	100	92	100	96
10 weeks	84	100	92	100	100

Note: In these tables (9 through 16) it should be noted that the figures represent the total accumulated percentage of rooted cuttings through the period recorded. An absence of any period (such as 5 weeks) indicates that no additional rooting took place during that time. Rooting after a ten-week period had elapsed was not recorded. The same holds true for the number of cuttings rotted.

particularly, May has not been explained. On warm spring days during these months steam may have been turned off and on periodically in the greenhouses even though an effort was made to keep bottom heat

TABLE 10

Percentage of cuttings rooted of *Mitchella repens*, taken August 9, 1944

Treatment:	None	Hor. #1	Hor. #2	Hor. #3	H_2O
			Sand medium		
3 weeks	80	88	96	100	88
4 weeks	96	92	96	100	88
5 weeks	96	92	96	100	96
			Sand-leafmold medium		
3 weeks	48	68	92	88	60
4 weeks	60	84	96	88	64
5 weeks	100	96	100	100	88
7 weeks	100	100	100	100	92
			Sand-sphagnum peat medium		
3 weeks	76	100	96	96	92
4 weeks	84	100	96	96	92
5 weeks	96	100	96	96	92
7 weeks	100	100	100	96	100

in the propagation house by frequent trips to check on conditions there. Even if there were intermittent bottom heat, however, it is not thought that this could account for such a large difference in the percentage of rooting.

As to the comparison of results between the rooting media used, there appeared to be very little difference between the merits of sand and a mixture

TABLE 11

Percentage of cuttings rooted of Mitchella repens taken September 10, 1944

Treatment:	None	Hor. #1	Hor. #2	Hor. #3	H_2O
		Sand medium			
3 weeks	88	88	96	88	60
4 weeks	92	96	96	92	72
5 weeks	100	96	96	92	72
		Sand-leafmold medium			
3 weeks	68	72	76	88	32
4 weeks	88	92	100	96	44
		Sand-sphagnum peat medium			
3 weeks	88	84	92	84	68
5 weeks	88	92	100	84	76
10 weeks	88	100	100	84	80

of sand and sphagnum peat. Cuttings rooted in sand seemed to have a slightly higher percentage of rooting with perhaps a few more cuttings rotting in the other medium. This might be partly the result of softer cuttings, however, and was not considered significant.

The percentage of rooting of cuttings in the sand-leafmold medium appeared to be somewhat less than that in the other media. The leafmold silted between the particles of sand, shutting off air and

PLATE 12

Percentage of cuttings rooted of Mitchella repens taken October 31, 1944

Treatment:	None	Hor. #1	Hor. #2	Hor. #3	H_2O
		Sand medium			
4 weeks	12	24	64	72	16
5 weeks	76	84	96	96	80
6 weeks	100	100	100	100	100
		Sand-leafmold medium			
4 weeks	0	0	48	52	0
5 weeks	40	48	80	84	28
6 weeks	76	84	96	96	60
		Sand-sphagnum peat medium			
4 weeks	16	12	32	80	28
5 weeks	56	76	76	92	64
6 weeks	72	96	88	96	80
10 weeks	76	100	96	96	100

making it difficult to keep from puddling the medium when watering. There seemed to be more rotting of cuttings in this material. Besides this the author felt that the medium was too muddy for easy handling.

It should be noted also that the 24-hour water treatment generally retarded the speed with which the partridgeberry cuttings rooted. For this reason it appears that the plant does not lend itself readily to treatments in which cuttings are soaked in

PLATE 13

Percentage of cuttings rooted of Mitchella repens taken December 17, 1944

Treatment:	None	Hor. #1	Hor. #2	Hor. #3	H_2O
		Sand medium			
4 weeks	92	96	0	92	80
5 weeks	100	100	100	100	100
		Sand-leafmold medium			
4 weeks	72	76	92	88	92
5 weeks	88	100	100	100	100
8 weeks	100	100	100	100	100
		Sand-sphagnum peat medium			
4 weeks	72	84	80	76	80
5 weeks	100	96	92	100	92
8 weeks	100	100	92	100	96

liquid root-inducing solutions. Even when there appear to be certain exceptions to this general situation there is not a sufficient increase in the percentage of rooting to justify the additional time and trouble consumed in using this method.

An examination of the data indicates that the rooting of cuttings was very definitely stimulated when treated with indolebutyric acid during the period from October through May. From June through September, however, when the plant seemed to root

TABLE 14

Percentage of cuttings rooted of Mitchella repens taken April 8, 1945

Treatment:	None	Hor. #1	Hor. #2	Hor. #3	H_2O
		Sand medium			
3 weeks	12	64	44	44	32
4 weeks	60	88	92	80	72
5 weeks	96	100	92	92	92
6 weeks	100	100	92	96	92
9 weeks	100	100	92	96	96
		Sand-leafmold medium			
3 weeks	8	20	32	24	4
4 weeks	36	32	52	68	16
5 weeks	56	64	88	88	64
6 weeks	60	72	96	88	64
7 weeks	72	72	96	88	64
9 weeks	72	76	96	88	68
10 weeks	80	76	96	88	68
		Sand-sphagnum peat medium			
3 weeks	24	36	36	52	44
4 weeks	48	60	80	88	44
5 weeks	64	76	100	96	84
6 weeks	96	92	100	96	96
7 weeks	96	96	100	96	100
8 weeks	100	96	100	96	100

easily without treatment, the use of these different strengths did not increase the percentage of rooting sufficiently to justify the use of the material. This seemed to hold true of cuttings in all three media. In the sand, though, it was noted that the

TABLE 15

Percentage of cuttings rooted of Mitchella repens taken May 24, 1945

Treatment:	None	Hor. #1	Hor. #2	Hor. #3	H_2O
		Sand medium			
3 weeks	12	16	24	24	12
4 weeks	80	76	80	96	80
5 weeks	92	96	92	100	92
		Sand-leafmold medium			
3 weeks	8	8	8	0	4
4 weeks	24	28	16	40	12
5 weeks	36	36	24	48	20
7 weeks	44	48	44	56	32
8 weeks	48	48	48	56	32
10 weeks	64	60	60	56	44
		Sand-sphagnum peat medium			
3 weeks	20	4	8	4	8
4 weeks	80	52	56	56	44
5 weeks	92	76	84	88	80
6 weeks	96	92	100	96	96
7 weeks	96	100	100	100	96

use of Hormodin No. 3 increased the percentage of rooting somewhat. In the sand-leafmold medium there was so much variation between the results of the treatment combinations within a batch and between the batches themselves that no conclusions could be drawn from them.

In the first group of cuttings taken in July a

TABLE 16

Percentage of cuttings rooted of Mitchella repens taken June 11, 1945

Treatment:	None	Hor. #1	Hor. #2	Hor. #3	H_2O
		Sand medium			
3 weeks	84	80	80	96	52
4 weeks	96	92	96	100	52
5 weeks	100	96	96	100	64
6 weeks	100	96	96	100	80
		Sand-leafmold medium			
3 weeks	40	32	68	64	36
4 weeks	72	68	72	72	52
5 weeks	72	96	88	76	64
6 weeks	92	96	88	88	72
		Sand-sphagnum peat medium			
3 weeks	88	60	76	80	80
4 weeks	96	84	84	92	84
5 weeks	96	96	92	92	88
6 weeks	96	100	96	96	88

considerable difference was noted in the number and quality of roots of various partridgeberry cuttings. This difference was observed not only in comparing groups of cuttings having different treatments but in individual cuttings which were treated similarly. Two groups of cuttings were photographed to study these conditions further and to compare summer and spring results.

Fig. 7. 3-week old cuttings of Mitchella repens taken August 9, 1944, no treatment, rooted in sand.

Fig. 8. 3-week old cuttings of Mitchella repens taken August 9, 1944, treated with Hormodin No. 1, rooted in sand.

As can be readily seen from these photographs, there is a great difference in what is meant by the word rooted. One cutting may have one or two strong roots and in the same time another cutting may have a dozen. In either case, however, one does not root more rapidly than the other. It may be that one cutting had more vigor than another or the possibility that one received more indolebutyric acid than the other. On the other hand this would not account for the heavily rooted cuttings to be found in non-treated groups, such as in Figure 7, for example. The writer found no explanation for this variation.

In examining photographs of the cuttings rooted in sand in August, 1944 it will be noted that there is a progressively small increase in the number of roots on the cuttings from the non-treated group through those treated with Hormodin No. 1, Hormodin No. 2 and Hormodin No. 3, in that order. Those cuttings which were soaked in water for 24 hours seemed to have rooted almost as well as the non-treated group except that as noted before only about half as many rooted.

The same tendency seems to hold true in the groups of cuttings rooted in the medium of leafmold

Fig. 9. 3-week old cuttings of Mitchella repens taken August 9, 1944, treated with Hormodin No. 2, rooted in sand.

Fig. 10. 3-week old cuttings of Mitchella repens taken August 9, 1944, treated with Hormodin No. 3, rooted in sand.

and sand. There is very little difference, if any, however, in the groups treated with Hormodin No. 2 and Hormodin No. 3.

Fig. 11. 3-week old cuttings of Mitchella repens taken August 9, 1944, soaked in water 24 hours before placed in rooting medium of sand.

In comparing groups similarly treated but rooted in these above-mentioned media, those rooted in sand had a good many more roots than those rooted in a mixture of leafmold and sand. To indicate this difference more clearly it should be noted that those cuttings treated with Hormodin No. 2 and rooted in leafmold and sand only had about an equal number and quality of roots as those of the non-treated cuttings rooted in sand alone. The poor aeration in the former medium probably had a great deal to do with the small number of roots produced.

Turning to the cuttings rooted in

August in sand and sphagnum peat, exactly the same pattern of rooting does not seem to be found as that followed by the cuttings in the two other media. The cuttings rooted the least were those soaked in water 24 hours before being placed in the rooting medium. Those treated with Hormodin No. 1 seemed

Fig. 12. 3-week old cuttings of Mitchella repens taken August 9, 1944, not treated, rooted in leafmold and sand.

Fig. 13. 3-week old cuttings of Mitchella repens taken August 9, 1944, treated with Hormodin No. 1, rooted in leafmold and sand.

to have more roots, those not treated more again, those treated with Hormodin No. 3 still more, and those treated with Hormodin No. 2 the most roots of all. Of the latter group there were only as many cuttings rooted as with those soaked in water 24 hours or treated with Hormodin No. 1. The non-

Fig. 14. 3-week old cuttings of Mitchella repens taken August 9, 1944, treated with Hormodin No. 2, rooted in leafmold and sand.

Fig. 15. 3-week old cuttings of Mitchella repens taken August 9, 1944, treated with Hormodin No. 3, rooted in leafmold and sand.

treated cuttings and those treated with Hormodin No. 3 produced the greatest number of rooted cuttings although there was very little difference in the amount of rooting between these groups.

In general, the cuttings rooted in sand had many more roots and of as good quality as those rooted in the medium of sand and sphagnum peat. This was especially true of the cuttings treated with increasing concentrations of indolebutyric acid in Hormodin.

Fig. 16. 3-week old cuttings of Mitchella repens taken August 9, 1944, soaked in water 24 hours before placed in rooting medium of leafmold and sand.

As noted previously in Table 14 there was a considerable drop in the percentage of rooted cuttings taken April 8, 1945 as compared with cuttings taken in 1944. The photographs beginning on page 75 show even more graphically this data as

Fig. 17. 3-week old cuttings of Mitchella repens taken August 9, 1944, no treatment, rooted in sphagnum peat and sand.

Fig. 18. 3-week old cuttings of Mitchella repens taken August 9, 1944, treated with Hormodin No. 1, rooted in sphagnum peat and sand.

Fig. 19. 3-week old cuttings of Mitchella repens taken August 9, 1944, treated with Hormodin No. 2, rooted in sphagnum peat and sand.

Fig. 20. 3-week old cuttings of Mitchella repens taken August 9, 1944, treated with Hormodin No. 3, rooted in sphagnum peat and sand.

well as the poor quality and small quantity of roots on the April cuttings.

Fig. 21. 3-week old cuttings of Mitchella repens taken August 9, 1944, soaked in water 24 hours before placed in rooting medium of sphagnum peat and sand.

Examining the results of the cuttings rooted in sand, it will be noted that each group of cuttings followed the same rooting pattern as those taken in August. The non-treated cuttings rooted the least, with the roots of those treated with Hormodin No. 1, Hormodin No. 2 and Hormodin No. 3 increasing in that order. There was, again, very little difference in the number of roots of the last two mentioned. The same was true with the non-treated cuttings and those soaked in water 24 hours except that there was a much smaller number of the cuttings rooted in the latter group.

Fig. 22. 3-week old cuttings of Mitchella repens taken April 8, 1945, not treated, rooted in sand.

Fig. 23. 3-week old cuttings of Mitchella repens taken April 8, 1945, treated with Hormodin No. 1, rooted in sand.

Fig. 24. 3-week old cuttings of Mitchella repens taken April 8, 1945, treated with Hormodin No. 2, rooted in sand.

Fig. 25. 3-week old cuttings of Mitchella repens taken April 8, 1945, treated with Hormodin No. 3, rooted in sand.

One of the effects of treatments on rooting is demonstrated probably more dramatically on the April cuttings rooted in leafmold and sand than on any other batch of cuttings. While the sturdiness of the roots is consistent throughout the whole of this batch, the number of cuttings rooted increased steadily in this order of treatment: soaked in water 24 hours, not treated, dipped in Hormodin No. 1, Hormodin No. 2 and Hormodin No. 3. The number of roots in each group increased in this order also although the difference between each step was very little.

Fig. 26. 3-week old cuttings of Mitchella repens taken April 8, 1945, soaked in water 24 hours before placed in rooting medium of sand.

In the August cuttings rooted in sphagnum peat and sand there appeared a variation in the usual pattern of rooting of treated cuttings. While there

was some variation in the April batch also, this deviation did not appear in cuttings which followed the general sequence of the smallest number of roots on non-treated cuttings to the largest number on those treated with Hormodin No. 1, Hormodin No. 2 and Hormodin No. 3, in that order. The group of

Fig. 27. 3-week old cuttings of Mitchella repens taken April 8, 1945, not treated, rooted in leafmold and sand.

Fig. 28. 3-week old cuttings of Mitchella repens taken April 8, 1945, treated with Hormodin No. 1, rooted in leafmold and sand.

cuttings soaked in water for 24 hours had a larger number of cuttings rooted than the other groups other than those treated with Hormodin No. 3. The roots on the water-soaked group had about the same quality as those treated with Hormodin No. 1.

In comparing the rooting results of the cuttings

Fig. 29. 3-week old cuttings of Mitchella repens taken April 8, 1945, treated with Hormodin No. 2, rooted in leafmold and sand.

Fig. 30. 3-week old cuttings of Mitchella repens taken April 8, 1945, treated with Hormodin No. 3, rooted in leafmold and sand.

taken on April 8, 1945 we can first eliminate those rooted in leafmold and sand. As was the case in the batch taken in August, the results were generally too poor to study further in comparison with those secured from cuttings rooted in sand or sphagnum peat and sand. Of the last two groups non-treated

Fig. 31. 3-week old cuttings of Mitchella repens taken April 8, 1945, soaked in water 24 hours before placed in rooting medium, leafmold and sand.

Fig. 32. 3-week old cuttings of Mitchella repens taken April 8, 1945, not treated, rooted in sphagnum peat and sand.

cuttings and those dipped in Hormodin No. 1 and 2 produced more rooted cuttings in sand than in sphagnum peat and sand. On the other hand those treated with Hormodin No. 3 or soaked in water yielded more rooted cuttings in sphagnum peat and sand than in sand alone.

Fig. 33. 3-week old cuttings of Mitchella repens taken April 8, 1945, treated with Hormodin No. 1, rooted in sphagnum peat and sand.

Fig. 34. 3-week old cuttings of Mitchella repens taken April 8, 1945, treated with Hormodin No. 2, rooted in sphagnum peat and sand.

Fig. 35. 3-week old cuttings of Mitchella repens taken April 8, 1945, treated with Hormodin No. 3, rooted in sphagnum peat and sand.

Fig. 36. 3-week old cuttings of Mitchella repens taken April 8, 1945, soaked in water 24 hours before placed in rooting medium, sphagnum peat and sand.

One of the most interesting portions of this experiment was the noting of the subsequent growth of the partridgeberry plants after rooting. There was a noticeable difference in stem growth between some batches of cuttings growing on the greenhouse bench. It was not until the plants were actually measured and the data tabulated, however, that the phenomenal amount of growth of one batch of cuttings was noted. The results of this portion of the experiment are presented twice on the following pages: once in table form to show the exact figures obtained, and again by means of graphs to help in the comparison of treatment combinations.

It can be readily seen that the subsequent growth of the cuttings rooted in December was almost always twice that of cuttings taken in October and as much as seven times greater than a number of other batches. Because the interval between batches was not constant, or frequent enough in some cases, it is not known whether the December 18 date is really the peak as far as this subsequent growth is concerned. The exploratory experiment gives an indication, however, of when the partridgeberry plant should be propagated by cuttings to obtain the

TABLE 17

Nine months' average growth of partridgeberry plants, cuttings taken July 8, 1944

Rooting medium	Cutting treatment	Increased length (cm.)
sa	None	7.11
lm-sa	None	8.81
sp-sa	None	18.49
sa	24-hr. H_2O	1.62
lm-sa	24-hr. H_2O	24.03
sp-sa	24-hr. H_2O	12.60
sa	Hor. #1	25.66
lm-sa	Hor. #1	13.85
sp-sa	Hor. #1	49.27
sa	Hor. #2	15.42
lm-sa	Hor. #2	40.72
sp-sa	Hor. #2	17.01
sa	Hor. #3	39.38
lm-sa	Hor. #3	22.02
sp-sa	Hor. #3	32.07

Note: The following symbols are used in Tables 17 through 24:

sa - sand
lm - leafmold
sp - sphagnum peat
Hor. - Hormodin
24-hr. H_2O - soaked in water 24 hours

greatest amount of after-growth. The reason for this particular time being the most opportune one is not understood by the writer. Possibly a combination of factors may be involved. Several of the more important of these are discussed below.

Some differences between treatments or batches

TABLE 18

Nine months' average growth of partridgeberry plants, cuttings taken August 9, 1944

Rooting medium	Cutting treatment	Increased length (cm.)
sa	None	26.54
lm-sa	None	46.76
sp-sa	None	26.93
sa	24-hr. H_2O	33.93
lm-sa	24-hr. H_2O	42.65
sp-sa	24-hr. H_2O	33.49
sa	Hor. #1	41.94
lm-sa	Hor. #1	43.20
sp-sa	Hor. #1	25.66
sa	Hor. #2	41.62
lm-sa	Hor. #2	37.72
sp-sa	Hor. #2	49.50
sa	Hor. #3	44.61
lm-sa	Hor. #3	66.37
sp-sa	Hor. #3	31.66

may have arisen from the long stems or runners rooting in several other pots which were packed so closely together. A constant watch was kept to prevent this from occuring. Even so occasionally roots had to be broken away from pots in which they had taken root. The location of some pots on the bench also was probably more favorable for growth than others but this will be discussed later in more detail.

The soil for growing the rooted cuttings varied in its composition for the July, August and October

TABLE 19

Nine months' average growth of partridgeberry plants, cuttings taken September 10, 1944

Rooting medium	Cutting treatment	Increased length (cm.)
sa	None	42.35
lm-sa	None	22.23
sp-sa	None	33.29
sa	24-hr. H_2O	35.56
lm-sa	24-hr. H_2O	23.62
sp-sa	24-hr. H_2O	47.16
sa	Hor. #1	20.33
lm-sa	Hor. #1	28.42
sp-sa	Hor. #1	20.18
sa	Hor. #2	33.99
lm-sa	Hor. #2	28.82
sp-sa	Hor. #2	40.63
sa	Hor. #3	31.22
lm-sa	Hor. #3	56.93
sp-sa	Hor. #3	46.16

batches of cuttings. The results obtained from the after growth were about the same, however. The September, December, April, May and June rooted cuttings were grown on in the same medium so this would not account for the great difference in those results. The only possibility that occurs to the writer in this regard is that a quantity of fertilizer might have been mixed accidentally into the soil mixture. This is not thought to be the case.

It might be thought, also, that photoperiodism may have accounted for some of the unusual length of

TABLE 20

Nine months' average growth of partridgeberry plants, cuttings taken October 31, 1944

Rooting medium	Cutting treatment	Increased length (cm.)
sa	None	88.97
lm-sa	None	93.69
sp-sa	None	92.49
sa	24-hr. H_2O	70.32
lm-sa	24-hr. H_2O	109.41
sp-sa	24-hr. H_2O	84.61
sa	Hor. #1	115.78
lm-sa	Hor. #1	79.08
sp-sa	Hor. #1	83.01
sa	Hor. #2	105.24
lm-sa	Hor. #2	102.51
sp-sa	Hor. #2	114.62
sa	Hor. #3	76.94
lm-sa	Hor. #3	102.89
sp-sa	Hor. #3	97.52

growth of the plants taken December 18, 1944. The increased growth for those plants propagated in October would seem to give some support to this idea for both groups of plants were started during the shorter days of the year. However, the time for the greatest natural growth is during the summer months. In addition it was noted that a few scattered blooms appeared from the middle of October through March. While no accurate recording of blooming dates was kept, it was observed that the abundant flowering took place in early April about three months in

PLATE 21

Nine months' average growth of partridgeberry plants, cuttings taken December 18, 1944

Rooting medium	Cutting treatment	Increased length (cm.)
sa	None	212.82
lm-sa	None	196.74
sp-sa	None	202.37
sa	24-hr. H_2O	221.75
lm-sa	24-hr. H_2O	174.47
sp-sa	24-hr. H_2O	151.57
sa	Hor. #1	202.53
lm-sa	Hor. #1	176.15
sp-sa	Hor. #1	126.99
sa	Hor. #2	201.62
lm-sa	Hor. #2	151.68
sp-sa	Hor. #2	129.43
sa	Hor. #3	170.19
lm-sa	Hor. #3	170.21
sp-sa	Hor. #3	147.85

advance of the normal season.

The author believes that with the exploratory work now accomplished it would be well to repeat the experiment with fewer factors involved. A constant time interval between batches of cuttings, reduction in the number of media, treatments and cuttings used, better arrangement of plants on the growing bench - all these methods should enable the experimenter to attribute the unusual amount of subsequent growth of the December group of cuttings to one or several related factors.

TABLE 22

Nine months' average growth of partridgeberry plants, cuttings taken April 8, 1945

Rooting medium	Cutting treatment	Increased length (cm.)
sa	None	54.57
lm-sa	None	31.55
sp-sa	None	44.81
sa	24-hr. H_2O	25.48
lm-sa	24-hr. H_2O	37.50
sp-sa	24-hr. H_2O	45.26
sa	Hor. #1	57.70
lm-sa	Hor. #1	22.87
sp-sa	Hor. #1	49.53
sa	Hor. #2	54.67
lm-sa	Hor. #2	33.49
sp-sa	Hor. #2	54.55
sa	Hor. #3	43.91
lm-sa	Hor. #3	48.93
sp-sa	Hor. #3	41.91

As was mentioned previously the location of potted plants on the growing bench was unsatisfactory. The plants closest to the edge dried out more often than those in the center. Some on the end of the bench were more subject to drafts than others. A greenhouse plan and experimental design would have avoided these and other difficulties and equalized the results of the investigation.

The following suggestions are offered to show how this experiment may be repeated at a later date. If for a certain date, for instance, 3 rooting media

TABLE 23

Nine months' average growth of partridgeberry plants, cuttings taken May 25, 1945

Rooting medium	Cutting treatment	Increased length (cm.)
sa	None	11.46
lm-sa	None	27.03
sp-sa	None	21.06
sa	24-hr. H O	20.09
lm-sa	24-hr. H O	10.19
sp-sa	24-hr. H O	24.65
sa	Hor. #1	28.21
lm-sa	Hor. #1	11.25
sp-sa	Hor. #1	27.89
sa	Hor. #2	40.92
lm-sa	Hor. #2	27.45
sp-sa	Hor. #2	41.22
sa	Hor. #3	40.01
lm-sa	Hor. #3	12.71
sp-sa	Hor. #3	24.24

and 5 treatments are to be used, there would be 15 treatment combinations. By using 3 replications there would be 15 treatment combinations which should be randomized in 3 blocks. The blocks should be spaced equidistant from each other and the potted plants themselves equally spaced from each other in each block.

The chlorotic condition which developed in the plants propagated on August 9, 1944 can be readily seen in Figure 40. In an effort to determine the nutrient deficiency causing this condition the

TABLE 24

Nine months' average growth of partridgeberry plants, cuttings taken June 11, 1945

Rooting medium	Cutting treatment	Increased length (cm.)
sa	None	24.49
lm-sa	None	31.47
sp-sa	None	29.06
sa	24-hr. H_2O	15.95
lm-sa	24-hr. H_2O	14.51
sp-sa	24-hr. H_2O	16.50
sa	Hor. #1	21.45
lm-sa	Hor. #1	21.72
sp-sa	Hor. #1	20.29
sa	Hor. #2	34.92
lm-sa	Hor. #2	18.58
sp-sa	Hor. #2	28.61
sa	Hor. #3	21.85
lm-sa	Hor. #3	16.78
sp-sa	Hor. #3	18.10

plants were treated as described on page 36. In addition three potted plants showing the worst condition in each group were photographed to show the conditions before and after treatments. (See Figures 41 through 46.)

The average stem length of the group treated with Knop's solution increased 215.3% in two months compared with an increase of 182.5% for the same period for the group treated with calcium nitrate. The group treated with potassium chloride only averaged 24.3% in increased length.

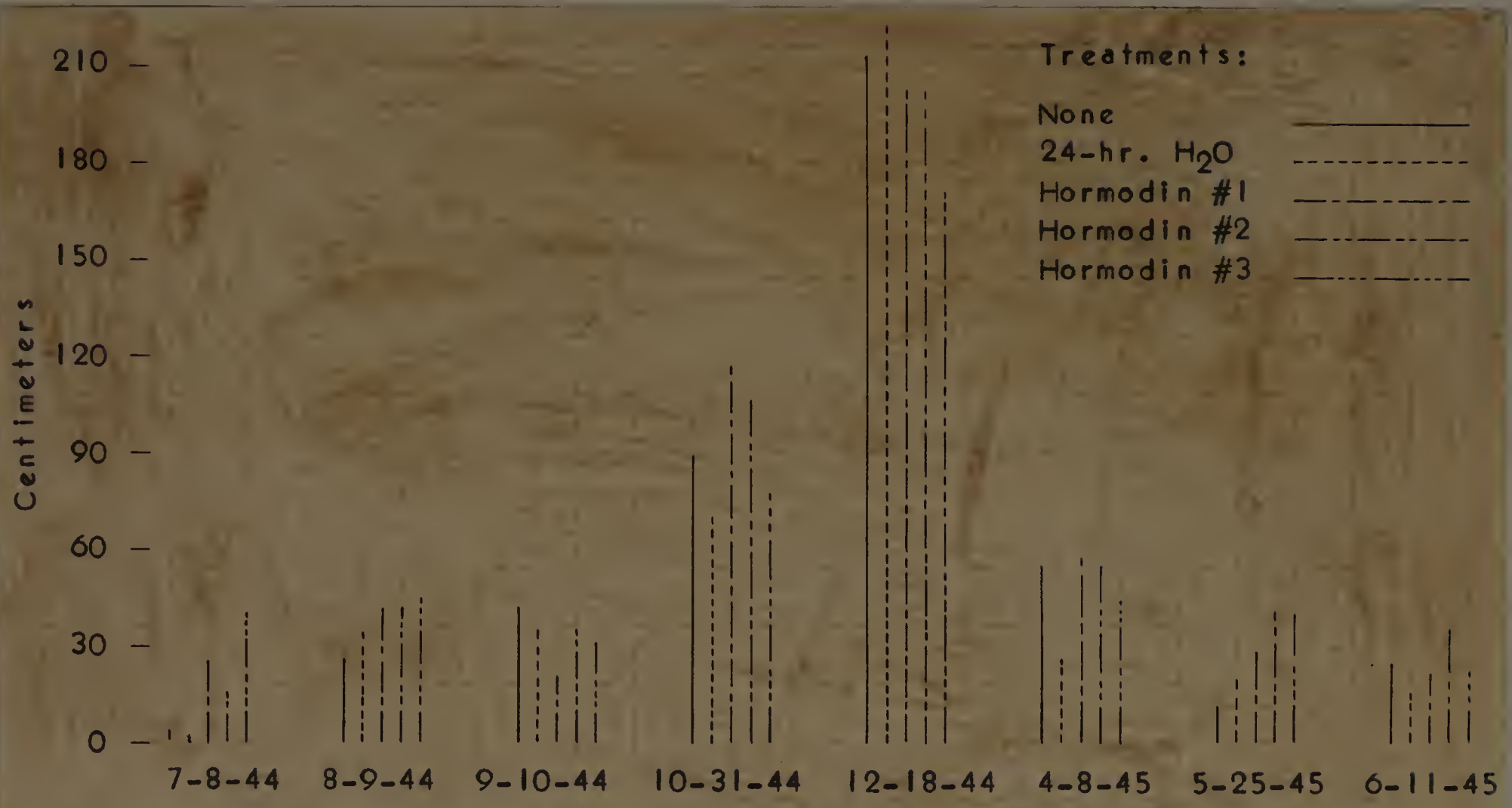

Fig. 37. Nine months' average growth of Mitchella repens plants, cuttings taken on dates indicated, rooted in sand.

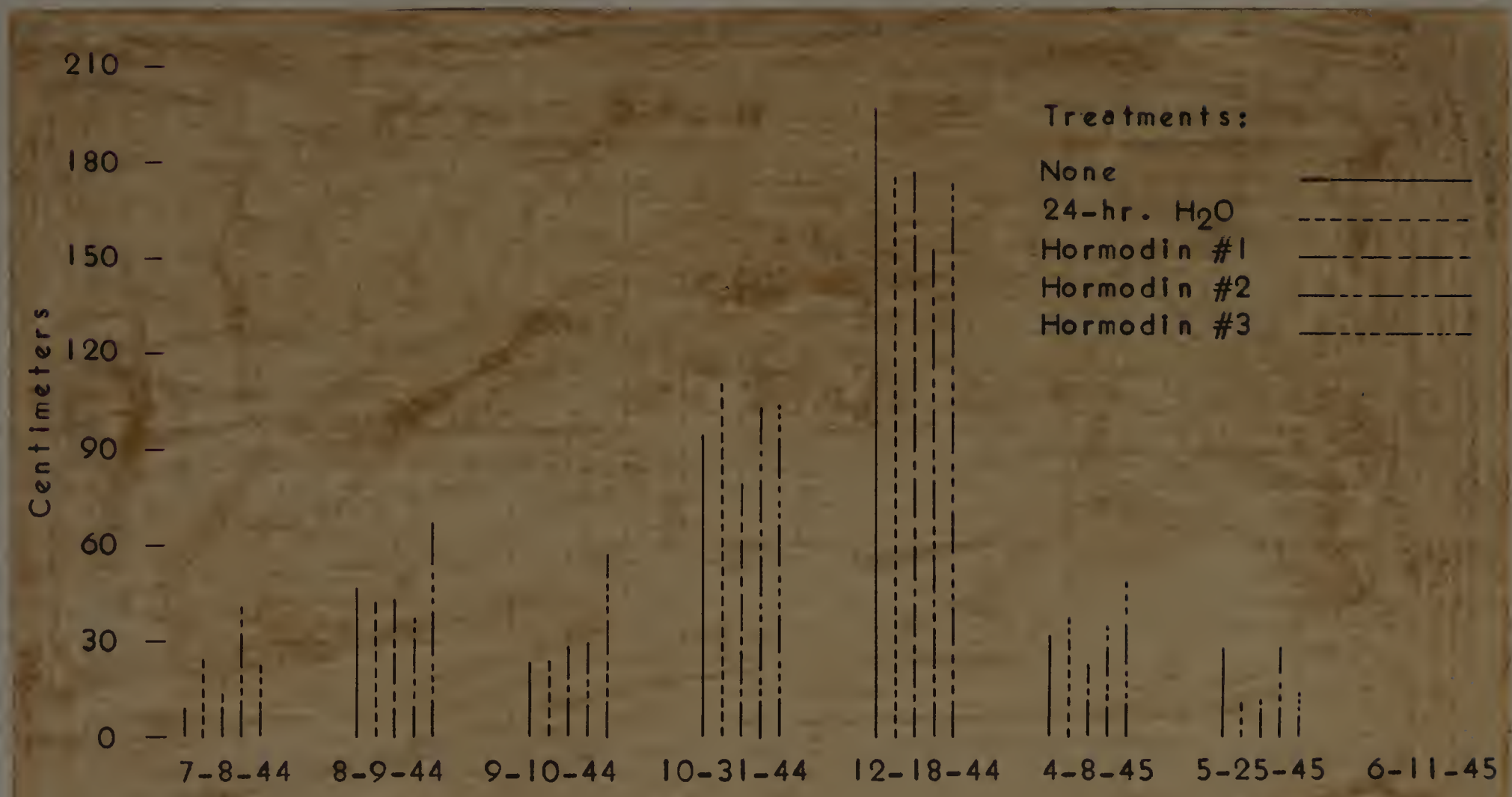

Fig. 38. Nine months' average growth of Mitchella repens plants, cuttings taken on dates indicated, rooted in leafmold and sand.

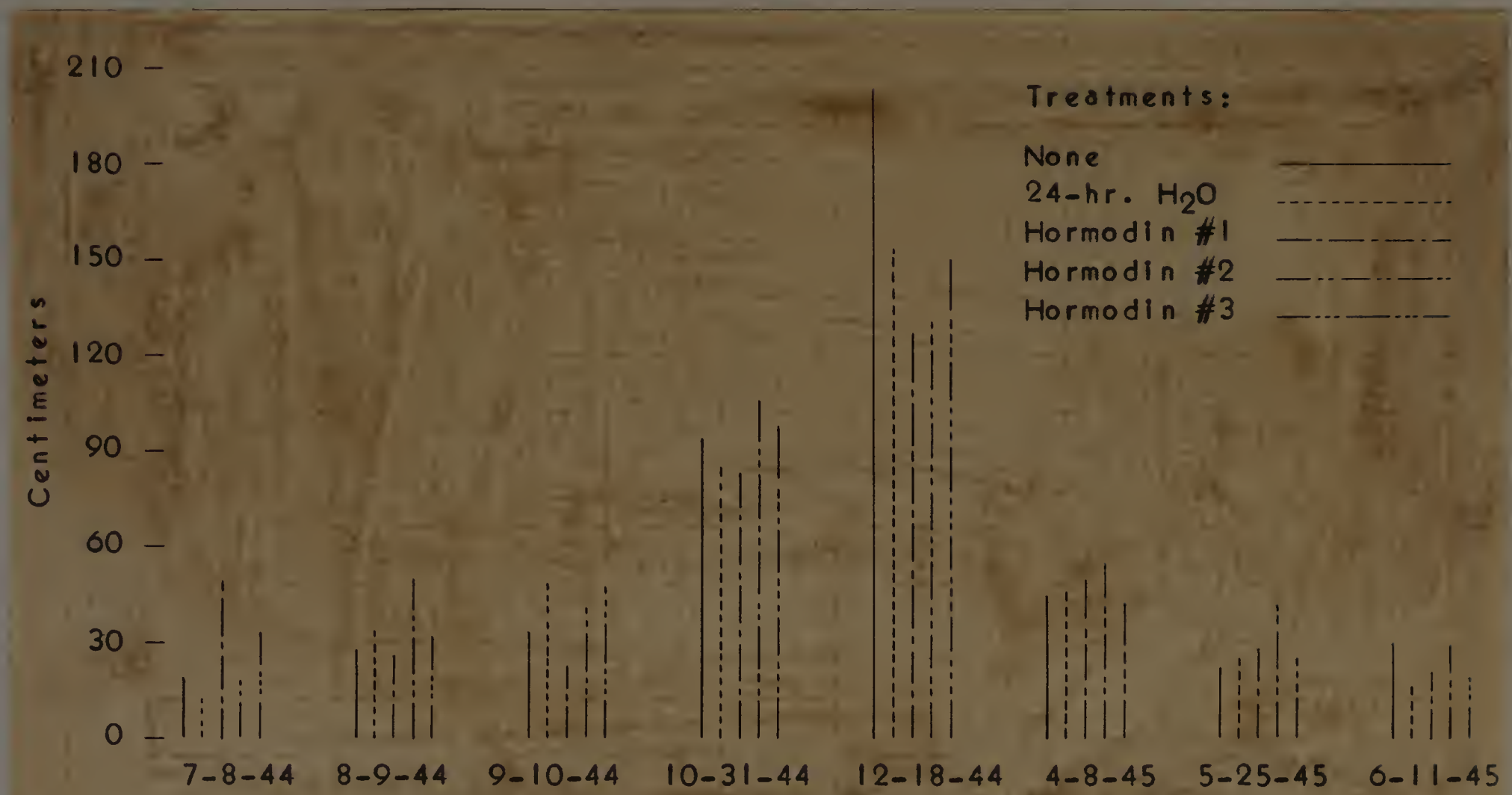

Fig. 39. Nine months' average growth of Mitchella repens plants, cuttings taken on dates indicated, rooted in sphagnum peat and sand.

The Kodachrome prints do not show the detailed conditions as well as the original transparencies. Even so, some idea can be obtained from the prints. All the plants in Figure 41 show an advanced chlorotic condition. Not only are the veins of the leaves yellow but the area between the veins is

Fig. 40. Three age groups of partridgeberry plants. Note chlorotic condition of middle lot. Photograph taken April 2, 1945.

yellow also. This condition is general on the whole plant but somewhat localized on the older, lower leaves. After Knop's solution was applied in small quantities daily for a month these conditions began to clear. The top plant showed only a trace of chlorosis, the middle plant a low amount, and the

Fig. 41, Chlorotic plants of Mitchella repens before treatment with Knop's solution. Photograph taken June 13, 1945. Compare with Figure 42.

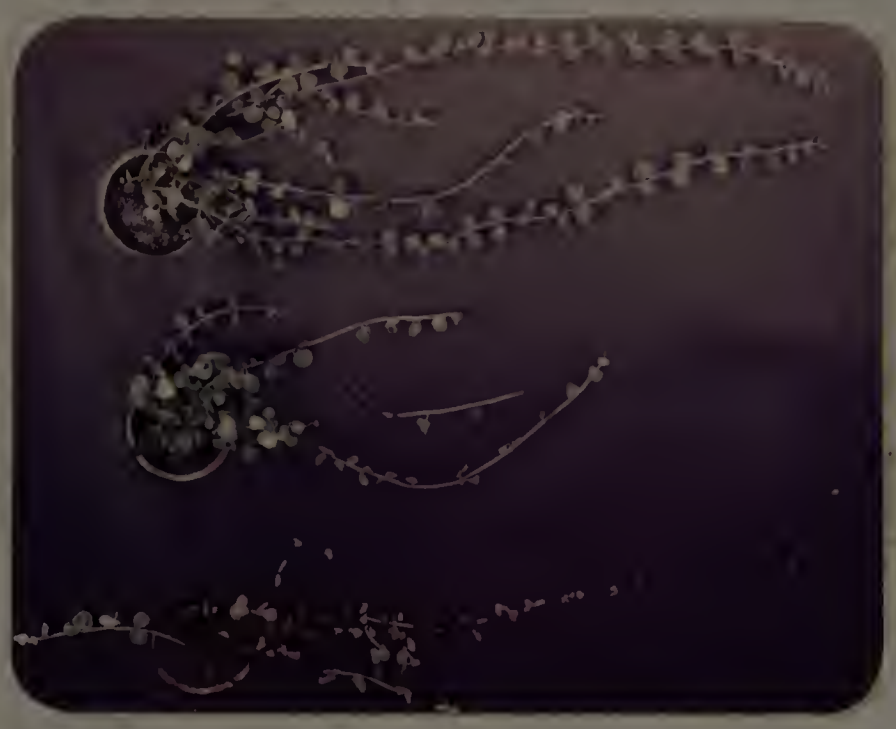

Fig. 42. Chlorotic plants of Mitchella repens after one month's treatment with Knop's solution. Photograph taken September 3, 1945.

Fig. 43. Chlorotic plants of Mitchella repens before treatment with calcium nitrate. Photograph taken June 13, 1945. Compare with Figure 44.

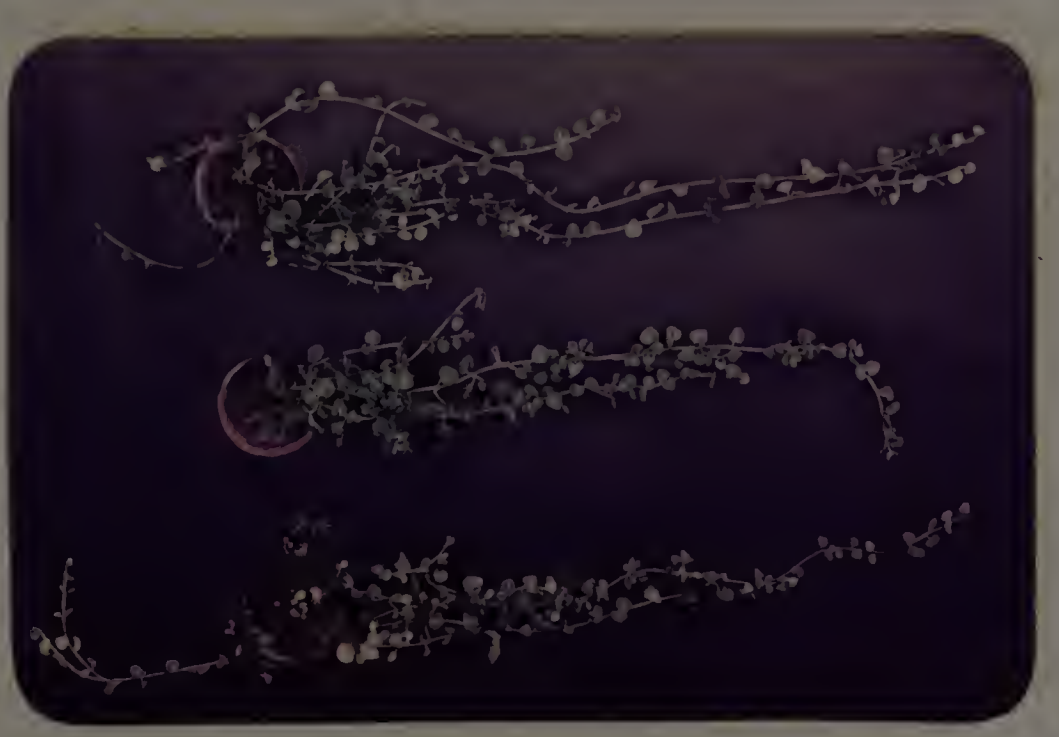

Fig. 44. Chlorotic plants of Mitchella repens after one month's treatment with calcium nitrate. Photograph taken September 3, 1945.

Fig. 45. Chlorotic plants of Mitchella repens before treatment with potassium chloride. Photograph taken June 13, 1945. Compare with Figure 46.

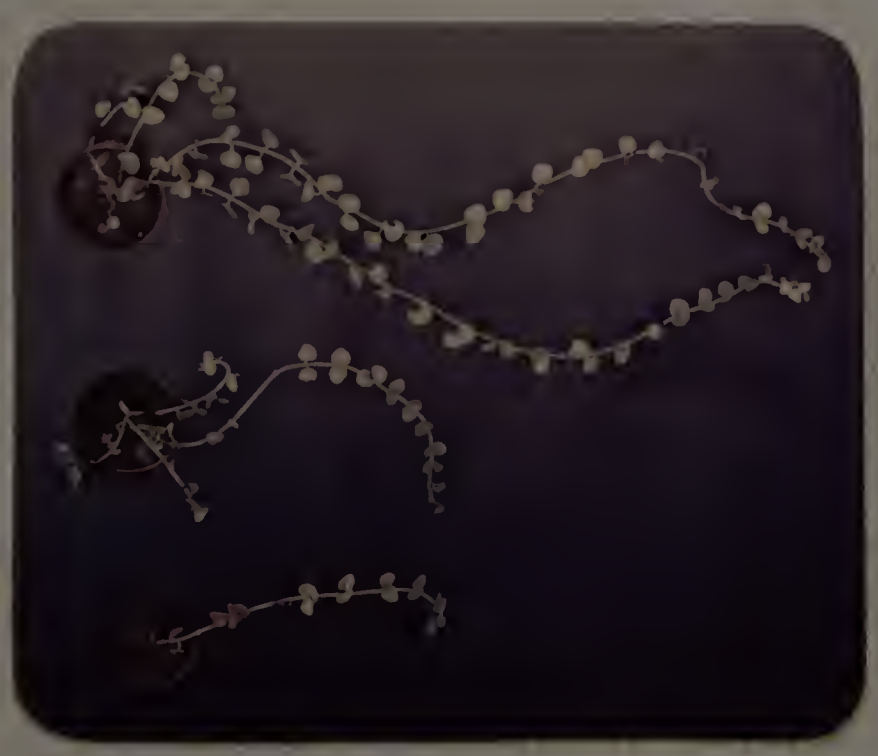

Fig. 46. Chlorotic plants of Mitchella repens after one month's treatment with potassium chloride. Photograph taken September 3, 1945.

lower none at all after three months. Figure 42 shows the improved situation fairly well, the bottom plant in the photograph revealing a casualty. Not only did a main stem become broken but the plant was allowed to dry out somewhat. With the concentration of nutrients the plant was badly burned.

In Figure 43 the two top plants show a medium chlorotic condition, the veins being yellow only. The lower plant is in an advanced condition of chlorosis. Treatment with calcium nitrate left no chlorotic condition in the upper two plants in Figure 44 with only a trace of chlorosis evident still in the lower plant. The upper plant was burned somewhat with the heavy dosage of nutrient.

About one fourth of the plants receiving potassium chloride treatment advanced in their chlorotic condition. Figures 45 and 46 do not show any plants where this development took place. All plants in these photographs had a medium chlorotic condition before and after treatment.

From the foregoing it can be seen that calcium nitrate cleared up the chlorotic condition by itself while potassium chloride did not. It appears, therefore, that a deficiency of nitrogen caused the

chlorotic condition which developed in the plants taken in August. This would appear very likely considering that these plants grew in a medium of which only one third was composted soil, the other two-thirds being made up of equal parts of sand and sphagnum peat.

III. SUMMARY AND CONCLUSIONS

The distribution of Mitchella repens extends approximately from the southern tip of Newfoundland eastward to north central Minnesota and southward to the Gulf of Mexico from 97° west longitude to the Atlantic Ocean with the exception of the southern half of Florida. The partridgeberry has also been collected in the east central sections of Mexico and Guatemala.

The partridgeberry is found growing in a variety of plant associations: on rocky ground in partial shade among the shrub masses on open hillsides; in open pine and oak woods at the bases of these trees; in open glades under the ferns and tall grasses among scattered groups of paper, black and yellow birches; and in the old woods where the beeches, maples and hemlocks are found growing together in varying proportions.

The partridgeberry makes its most favorable growth where soil is comparatively damp, slightly acid, relatively high in water holding capacity and organic matter and has a mechanical analysis of from 40 to 60 per cent sand.

There are approximately 33,800 partridgeberry seeds per ounce.

Propagation by seedage is not economically feasible for average commercial production because partridgeberry seed must have a six-month after-ripening period at controlled temperatures.

The most practical means of propagation of Mitchella repens for home use or limited commercial production is by division or layering of plants.

For the nurseryman the most practical method of propagating the partridgeberry appears to be that of treating stem cuttings with Hormodin No. 2, rooting in sand in summer and placing directly into coldframes. The largest percentage of rooting of partridgeberry cuttings within the first three weeks took place during the summer months.

Of the cuttings rooted in leafmold and sand, those treated with Hormodin generally showed a larger percentage of rooting in the first three weeks than those not treated. The difference in percentage of rooting between treated and untreated cuttings was not as great, generally, during the same period in sphagnum peat and sand or in the sand alone.

In general, no difference in percentage of rooting was noted in comparing no treatment and Hormodin No. 1 treatment combinations. There was an appreciable difference between these combinations and those involving Hormodin No. 2 and 3. However, with Hormodin No. 2 treatment combinations showing a slightly higher percentage of rooting than Hormodin No. 3.

On the whole, cuttings rooted in sand alone showed a slightly higher percentage of rooting during the first three weeks than in sphagnum peat and sand. In comparison the percentage of cuttings rooted in leafmold and sand during the same period was a poor third.

There was a considerable variation in the number and quality of roots of cuttings receiving the same treatment.

In noting the subsequent growth of partridge-berry plants, there was no general difference found in those plants originating from untreated cuttings and those dipped in Hormodin. All cuttings taken in December, however, produced almost twice as much stem growth as those taken in October and as much as seven times that of cuttings taken at other times

of the year.

To obtain the maximum amount of subsequent stem growth, Mitchella repens should be rooted in December and grown on in the greenhouse until climatic conditions permit shifting to outdoor culture.

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APPENDIX

List of Herbaria Contributing Data
to the Distribution Map of Mitchella repens L.

Canada

Manitoba
University of, Winnipeg
Prof. Charles W. Lowe
Nova Scotia
Acadia University, Wolfville
Dalhousie University, Halifax
S. M. Mason, Curator
Ontario
University of Toronto, Toronto
James H. Soper, Curator
Quebec
McGill University, Montreal
Nicholas Polunin, Visiting Professor

United States

Alabama
Alabama Polytechnic Institute, Auburn
Dr. James L. Seal
Arkansas
Arkansas College, Batesville
Dr. W. H. Pride; No data available
University of, Fayetteville
Dr. D. M. Moore
Connecticut
Connecticut College, New London
University of, Storrs
Dr. G. S. Torrey
Delaware
University of, Newark
Florida
University of, Gainsville
Dr. Lillian E. Arnold
Georgia
University of, Athens
Dr. Wilbur H. Duncan
Illinois
Chicago Natural History Museum, Chicago
John R. Millar, Deputy Director

List of Herbaria Contributing Data - continued

Illinois
University of, Urbana
Dr. G. N. Jones
Indiana
Butler University, Indianapolis
Indiana University, Bloomington
Purdue University, La Fayette
Dr. A. T. Girard
Iowa
Iowa State College, Ames
Dr. Ada Hayden
Kansas
Kansas State College, Manhattan
Dr. F. C. Gates
Kentucky
University of, Lexington
Dr. F. T. McFarland
Louisiana
Louisiana State University, Baton Rouge
Tulane University, New Orleans
Dr. William T. Penfound
Maine
University of, Orono
Dr. F. H. Steinmetz
Maryland
University of, College Park
Dr. Russell G. Brown
Massachusetts
Harvard University, Gray Herbarium, Cambridge
Dr. Bernice G. Schubert
University of, Amherst
Dr. Ray E. Torrey
Michigan
University of, Ann Arbor
Dr. E. B. Mains
Minnesota
University of, Minneapolis
Mississippi
University of, Oxford
Dr. F. M. Hull; No data available
Missouri
Missouri Botanical Garden, St. Louis
Dr. J. M. Greenman, Curator

List of Herbaria Contributing Data - continued.

Missouri
University of, Columbia
Dr. Robert B. Livingston
Nebraska
University of, Lincoln
Dr. Raymond J. Pool
New Hampshire
University of, Durham
Dr. A. R. Hodgon
New Jersey
Rutgers University, New Brunswick
Dr. Murrey F. Buell
New York
Brooklyn Botanic Garden, Brooklyn
William Durkin, Curatorial Assistant
Cornell University, Ithaca
Dr. Robert T. Clausen
New York Botanical Garden, Bronx
North Carolina
Duke University, Durham
North Carolina State College, Raleigh
Dr. William B. Fox
University of, Chapel Hill
North Dakota
North Dakota Agricultural College, Fargo
University of, Grand Forks
Ohio
Ohio State University, Columbus
Dr. Clyde H. Jones
Oklahoma
Oklahoma A. & M. College, Stillwater
Dr. Robert Stratton, Curator
University of, Norman
Dr. George J. Goodman
Pennsylvania
Pennsylvania State College, State College
Dr. J. P. Kelly
Rhode Island
Rhode Island State College, Kingston
Dr. V. I. Cheadle
South Carolina
Clemson Agricultural College, Clemson
University of, Columbia

List of Herbaria Contributing Data - continued.

South Dakota
- South Dakota State College, Brookings
- University of, Vermillion

Tennessee
- University of, Knoxville
  - Dr. A. J. Sharp

Texas
- A. & M. College of, College Station
  - Dr. H. B. Parks, Curator
- Southern Methodist University, Dallas
- University of, Austin

Virginia
- University of, Charlottsville
  - Dr. Edwin M. Betts
- Virginia Polytechnic Institute, Blacksburg
  - Dr. A. B. Massey

Washington
- University of, Seattle
  - Dr. J. W. Thompson, Assistant Curator

West Virginia
- Marshall College, Huntington
  - Dr. E. L. Plymale
- West Virginia University, Morgantown
  - Dr. E. L. Core

Wisconsin
- University of, Madison
  - Dr. N. C. Fassett

List of Herbaria from which No Data was Received
(but from which information was requested)

Canada

New Brunswick
University of, Fredericton
Ontario
University of Ottowa, Ottowa

United States

Massachusetts
Arnold Arboretum, Jamaica Plain
Mississippi
Mississippi State College, State College
Pennsylvania
Academy of Natural Sciences, Philadelphia
University of, Philadelphia
Vermont
University of, Burlington

Approved:

Lyle L. Blundell

Lyle L. Blundell

William L. Doran

William L. Doran

Clark L. Thayer.

Clark L. Thayer, Chairman

May 16, 1950.

Date