NUTRITION OF
BEGONIA SEMPERFLORENS

Thesis for the Degree of M. S.
MICHIGAN STATE COLLEGE
Elmer John Fuhr
1947

THESIS

This is to certify that the

thesis entitled

NUTRITION OF BEGONIA SEMPERFLORENS
The growth and appearance of Begonia semperflorens in three growing media as affected by various levels of nitrogen, phosphorus, and potassium with controlled pH.

presented by

Elmer John Fuhr

has been accepted towards fulfillment of the requirements for

M.S. degree in Horticulture

Roy E. Marshall
Major professor

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NUTRITION OF BEGONIA SEMPERFLORENS

The growth and appearance of Begonia Semperflorens in three growing media as affected by various levels of nitrogen, phosphorus and potassium with controlled pH

by

Elmer John Fuhr

A THESIS

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THESIS

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INTRODUCTION

There is need of information regarding the nutrient requirements of specific flowering plants. The purpose of this study was to determine the most desirable growing media and nutrient levels for Begonia semperflorens.

The importance of growing high-grade plants is far greater today than it was a generation or two ago. It is more difficult to market plants of average quality today because of the competition offered by specialists in each crop who have the best seed.

The writer attempts to illustrate the necessity for the proper growing medium, the proper fertility levels, and a uniform pH if quality greenhouse plants are to be obtained.

Although vermiculite may be used as a rooting medium and peat may be used for mulching, and also to supply organic matter for greenhouse soils, it is interesting to know how each of these growing media will produce a crop when used alone rather than in combination as a complete greenhouse compost soil. Soil obtained from the Horticulture Department orchard which was poor in both nutrients and organic matter was also used alone as a growing medium along with vermiculite and peat, because it represents a typical source of soil that many greenhouse operators select for their greenhouse crops.

It is also important to maintain a pH of about 6.5 and a proper fertility level for most greenhouse crops.

The technique of the problem was to adjust the proper

nutrient levels and pH by periodic checking and corrections of nutrients and pH level by the addition or leaching out of materials from the different media until the desired optimums were reached.

Proper pH levels are also very important if maximum yields and highest quality of begonias are desired. When the crop is grown under improper pH, the nutrients are not as readily available to the plants, and inferior crops may result.

An interpretation of the data collected should serve as a basis for the evaluation and modification, if necessary, of the cultural methods of the begonia by growers of such crops under glass.

REVIEW OF LITERATURE

Begonias are the subject of a large literature and most of this is in a form of well-organized information for the grower. Commercial Floriculture, by Fritz Bahr (1) is one of the good commercial books providing information on Begonia culture. Commercial Flower Forcing, by Laurie and Kiplinger (4) contains both fundamental and advanced information on the culture of the Begonia in addition to the latest information on the appearance of various nutrient defficiencies of the Begonia plant. Chapter 8, Diagnosing Greenhouse Ills, includes some information on the nutrient deficiency symptoms of the Begonia.

For more technical information on the culture of the Begonia semperflorens in relation to Baule units required for maximum crop yields according to the universal yield curve[1], the A B C of Agrobiology by Willcox (12) is one of the most satisfactory sources of information.

Complete information on Begonia varieties and taxonomy is available in the Cyclopedia of Horticulture by Bailey. In addition to the botanical information and general cultural references mentioned, the writer has used special technical bulletins very advantageously in assisting with the routine of this problem. Spurway's Special Bulletin 306 on Soil Reaction (pH) Preferences of Plants (8) was very helpful in determining the optimum pH range for the Begonia plants used in this problem, and his Technical Bulletin 132, A Practical System of Chemical Soil

1. The Universal Growth Curve is found under Methods page.

Diagnosis was a valuable guide.

Spurway's Special Bulletin 325 (10) showed how soil testing in this problem could be used as a guide for soil fertility control in greenhouses. Rates of application and general properties of the materials used to treat soils are assembled in the above-mentioned reference.

Peat has been used as a growing medium for many floricultural crops grown in the field but little information is available regarding its use for pot-plant culture. Wildon (13) defines peat in terms that can be easily understood by florists who grow these greenhouse pot-plant crops. In another article, he (14) expresses the value of peat as a soil builder and the importance of peat, because of its extremely beneficial absorbing qualities. He further states that this absorbing power of peat is of much value in sandy, gravelly and other loose or well-drained soils and in preventing losses of nitrates, potash and other easily soluble plant foods.

Vermiculite, a cultural medium, is in the experimental stage of usage and most of the work that has been done has been in relation to rooting crops rather than growing a crop to maturity in the greenhouse in pots. O'Rourke (7) worked with cuttings grown in various grades of vermiculite at Michigan State College, and C. A. May (8) worked with the cuttings of Weigela floribunda and Ligustrum ovalifolium as well as Chrysanthemum morifolium cuttings, but the work was done in a basement darkroom under continuous illumination from a 100-wat mazda lamp and automatic bottom heat provided by a lead-sheathed soil-heating cable controlled by a thermostat,using coarse grade vermiculite.

Milton (6) calls vermiculite the "Garden Stepchild" in his bulletin, and Terra-lite is termed "Plant Aid" and is recommended as a growing medium for rooting cuttings, plant propagation, seed germination, mulch, to lighten heavy soil, and for storing bulbs.

California Stucco Products (11) defines vermiculite as a mineral mica, roasted at over 2,000°F. until it has "popped" like corn. This extreme heat destroys every vestige of life. Thus Mica-Gro is completely freed of all diseases, fungi, bacteria, and insects. At the same time, the extreme temperature changes the physical structure of the mica ore, causing each particle to become a tiny sponge, capable of absorbing many times its weight in water. In the maze of interstices formed, so much air is also trapped that it is difficult to drown or smother roots growing in vermiculite. This property also makes possible the absorption of chemical fertilizers to a greater degree even than by humus. Moisture and air, the two vital requirements to growth, may thus be supplied by Mica-Gro Vermiculite in generous measure..

Success in seed starting with Mica-Gro Vermiculite, in rooting cuttings, in conditioning soil, mulching, storing tubers and bulbs, is being reported by many of America's foremost horticulturists and greenhouse men.

Hunt Company (3) of Chicago has analyzed two samples of vermiculite for the Universal Zonolite Insulating Company of Detroit and the results of their findings of the "Raw Ore" and "Exfoliated" samples are shown in Table No. 1 .

Chadwick (2) grew softwood and deciduous cuttings with silica and vermiculite under three different watering systems and heat.

METHODS OF RESEARCH

I. Media used.

A chemical analysis showed the vermiculite to contain:

Nitrates	0 ppm.
Phosphorus	0 ppm.
Potash	10 ppm.

Further information of complete chemical analysis of both the raw ore and the exfoliated material will be found in Table 1.

The soil came from the Horticulture Department orchard which was in sod and partially shaded during the growing season. It was classified as a heavy phase Hillsdale fine sandy loam. A chemical soil analysis showed it to contain:

Nitrates	7 ppm.
Phosphorus	0 ppm.
Potash	7 ppm.

The peat, classified as Rifle peat, came from a farm in the Lansing area and had been stored for some time in a pile unprotected from the weather. A chemical soil analysis showed it to contain:

Nitrates	7 ppm.
Phosphorus	2 ppm.
Potash	10 ppm.

The above media were adjusted to a uniform pH and maintained at different nutrient levels for the culture of *Begonia semperflorens*.

TABLE No. 1

Analyses of "Vermiculite"

Percentage in duplicate samples

	"Raw Ore"	"Exfoliated"
Moisture (loss at 105°C)	2.90	1.25
Silica (SiO_2)	39.30	39.00
Iron oxide (Fe_2O_3)	10.96	11.04
Aluminum oxide (Al_2O_3)	13.54	14.16
Titanium dioxide (TiO_2)	1.30	1.40
Calcium oxide (CaO)	1.04	1.08
Magnesium oxide (MgO)	19.80	21.90
Sodium and potassium oxides (Na_2O-K_2O)	4.80	4.88
Chlorine (Cl)	Trace	Trace
Sulfur trioxide (SO_3)	0.02	0.02
Loss on ignition (other than moisture)	5.93	4.85

II. Nutrient levels used.

Preparing a properly balanced chart was no easy task since an equivalent ratio of fertilizer elements had to be altered in proper sequence.

It was decided that three levels, low, medium, and high, should be established for nitrogen and potash and that phosphorus should be maintained and a high level throughout the experiments except for the check plants.

To simplify the work, numbers 1, 2, and 3 have been used to indicate low, medium, and high nutrient levels, respectively.

Table 2 presents the possible combinations of low, medium, and high nutrient levels of nitrogen and potash; it was decided to maintain a high level of phosphorus in the growing media for all plants.

TABLE No. 2

Possible combinations of low (1), medium (2), and high (3) concentrations of nitrogen and potash and high phosphorus.

1 - 3 - 1	2 - 3 - 1	3 - 3 - 1
1 - 3 - 2	2 - 3 - 2	3 - 3 - 2
1 - 3 - 3	2 - 3 - 3	3 - 3 - 3

III. Potting and identification of plants.

The Begonia plants were taken from three-inch pots that contained greenhouse pot-plant soil of high organic content. The plants were uniform and in a healthy condition before they were transferred to the growing media of vermiculite, soil, and peat. The soil was completely washed off the roots of the begonia plants before they were transferred to the new medium and then watered sufficiently to continue normal growth. A few days after the plants had oriented themselves to their new environment, the first fertilizer application was made.[1]

Each pot was marked twice, first with a six-inch wooden pot label with the proper nutrient level identification marked ont it, and, second, black numbers of the proper nutrient levels were marked on the pot for identification if the wooden label were lost.

The proper nutrient level identification numbers were taken from Table No. 2, and each group of numbers was labeled alike on each of the three pots of each series, as 1 - 3 - 1, for group and series No. 1, of plants growing in vermiculite, soil and peat.

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1. See page 11.

IV. Fertilizing and leaching the crop.

The following fertilization procedures for the growing media, vermiculite, soil, and peat, respectively, were followed:

For low nutrient levels, the various media were used without addition of nutrients.

1 teaspoonful, or 8 grams, of ammonium nitrate or of potassium sulphate was used in two gallons of water to represent the medium nutrient levels.

2 teaspoonfuls, or 16 grams, of ammonium nitrate or potassium sulphate were used in two gallons of water to represent the high nutrient levels.

drops of phosphoric acid was used in two gallons of water for heavy phosphorus applications for all media.

The above treatments were only tentative and it was planned to leach or apply additional fertilizers after the plants became oriented to the media. As soil tests indicated the need, additional fertilizers were applied until the satisfactory nutrient levels were reached.

Check plants

Check plants were used to compare with the different fertilized plants. Two different types of check plants were used: (1) those grown unfertilized in each of the selected media, and (2) those grown in a fertile composted soil of manure and sod.

V. Soil testing.

After the first fertilizer application, chemical analyses were made of the media and showed the following: The nitrogen, phosphorus and potash had increased in parts per million over the original analysis before the fertilizer had been applied, but still not enough for optimum plant growth. The hydrogen-ion concentrations were still below or above 6.5.

In addition to another application of nitrogen, phosphorus and potash, an acid such as orthophosphoric acid should be applied to the vermiculite to change the H-ion concentration to that denoted by a pH of 6.5. Positive ions such as calcium hydroxide should also be added to the peat to change the H-ion concentration to that denoted by a pH of 6.5. It is noteworthy that, even though the vermiculite was treated with orthophosphoric acid, it altered the H-ion concentration of vermiculite from 8.0 to 7.5. These data served as an approximation of how much to apply to run tests on growing media in flower pots without plants growing in them.

On the following page is shown the different amounts of each chemical to use as trial applications for the pH requirements for *Begonia semperflorens.*

Reference: Figures 1, 2, and 3.
Tables 3, 4, and 5 - Series 1, 2, and 3.

VI. Control of hydrogen-ion concentration.

In order to determine the proper amounts of material to apply to a four-inch pot of growing media to alter the hydrogen-ion concentration value, some trials were made with unplanted pots of media containing different concentrations of plant nutrients.

The writer used 15 pots, or 5 pots for each media, at different concentrations to determine the quantity of lime or acid to apply to the planted pots in the experiment.

In the case of the vermiculite, the hydrogen-ion concentration was that denoted by a pH reading of 7.5, though 6.5 was desired. Accordingly, 1, 2, 3, 4, and 5 drops of orthophosphoric acid were added to pots 1, 2, 3, 4, and 5, respectively.

In the case of the soil where the pH was 5.5 and had to be raised to 6.5, quantities of 5, 10, 15, 25, and 75 ml. of calcium hydroxide solution were used on the five trial pots of media.

In the case of the peat where the pH was 4.0 and the desired level was 6.5, quantities of 50, 100, 150, 200, and 250 ml. of calcium hydroxide solution were used.

After two or three days, the trial pots were tested to determine the hydrogen-ion concentration. It was found that the following amounts of solution were sufficient to change the media reaction to the proper level:

Vermiculite: 6 drops of orthophosphoric acid per pot.
Soil: 15 ml. of calcium-saturated hydroxide solution per pot.
Peat: 75 ml. of calcium saturated hydroxide solution per pot.

VII. Nutrient Control.

Below are nutrient and pH control recommendations for the second fertilizer application in an attempt to bring the nutrients up to the proper levels. For low nutrient levels the various media were used without addition of nutrients.

1 teaspoonful of ammonium sulphate to two gallons of water, or 8 grams for the plants requiring medium nitrogen, and potassium treatments.

2 teaspoonsful of ammonium sulphate to two gallons of water, or 16 grams for the plants requiring heavy nitrogen, and potassium treatments.

10 drops of orthophosphoric acid to all media for medium phosphorus treatments.

20 drops of orthophosphoric acid to all media for heavy phosphorus treatments.

In addition to fertilizer treatments, the following materials were added for pH control:

6 drops of orthophosphoric acid per pot for vermiculite.

15 ml. of calcium-saturated hydroxide solution per pot of soil.

75 ml. of calcium-saturated hydroxide solution per pot of peat.

Reference: Figures 1, 2, and 3.
Tables 3, 4, and 5 - Series 1, 2, and 3

Below are nutrient and pH control recommendations for the third fertilizer application in a final attempt to bring the nutrients up to the proper levels. For low nutrient levels the various media were used without the addition of nutrients except in very low nutrient cases where plants were approaching death.

2 teaspoonfuls of ammonium sulphate in two gallons of water, or 16 grams, for the vermiculite plants requiring medium nitrogen treatments.

4 teaspoonfuls of ammonium sulphate in two gallons of water, or 32 grams, for the vermiculite plants requiring heavy nitrogen treatments.

1 teaspoonful of ammonium sulphate in two gallons of water, or 8 grams, for the soil plants requiring medium nitrogen treatments.

2 teaspoonfuls of ammonium sulphate in two gallons of water, or 16 grams, for the soil plants requiring heavy nitrogen treatments.

The same nitrogen recommendations were used for the peat as for the soil, and in some cases no nitrogen was needed.

1 teaspoonful of potassium sulphate treatments to two gallons of water, or 8 grams, for medium potassium treatments for all media.

2 teaspoonfuls of potassium sulphate to two gallons of water, or 16 grams, for heavy potassium sulphate treatments.

10 drops of orthophosphoric acid to two gallons of water, for medium phosphorus treatments.

20 drops of orthophosphoric acid to two gallons of water, for heavy phorphorus treatments.

In addition to the orthophosphoric acid used to bring up the level of phosphorus in ppm units, an addition of superphosphate was added at the rate of 1 gram per pot to the pots of vermiculite and soil that showed low nutrient levels.

For the pH controls the following system was used:

3 drops of orthophosphoric acid per pot for vermiculite.

5 ml. of calcium-saturated hydroxide solution per pot of soil.

25 ml. of calcium-saturated hydroxide solution per pot of peat.

Reference: Figures 4, 5, and 6.
Tables 6, 7, and 8 - Series 4, 5, and 6.

Table No. 3
CHART OF NUTRIENT LEVELS
Series No. 1

	Nitrogen	Phosphorus	Potassium	pH
1 - 3 - 1 Group				
Vermiculite	5	2	5	8.0
Soil	5	2	5	5.5
Peat	10	2	10	4.0
1 - 3 - 2 Group				
Vermiculite	2	2	5	7.5
Soil	5	1	10	5.5
Peat	10	2	15	4.0
1 - 3 - 3 Group				
Vermiculite	1	2	5	7.5
Soil	7	1	15	5.5
Peat	10	2	20	4.0

(Parts per million)

FIGURE NO. 1

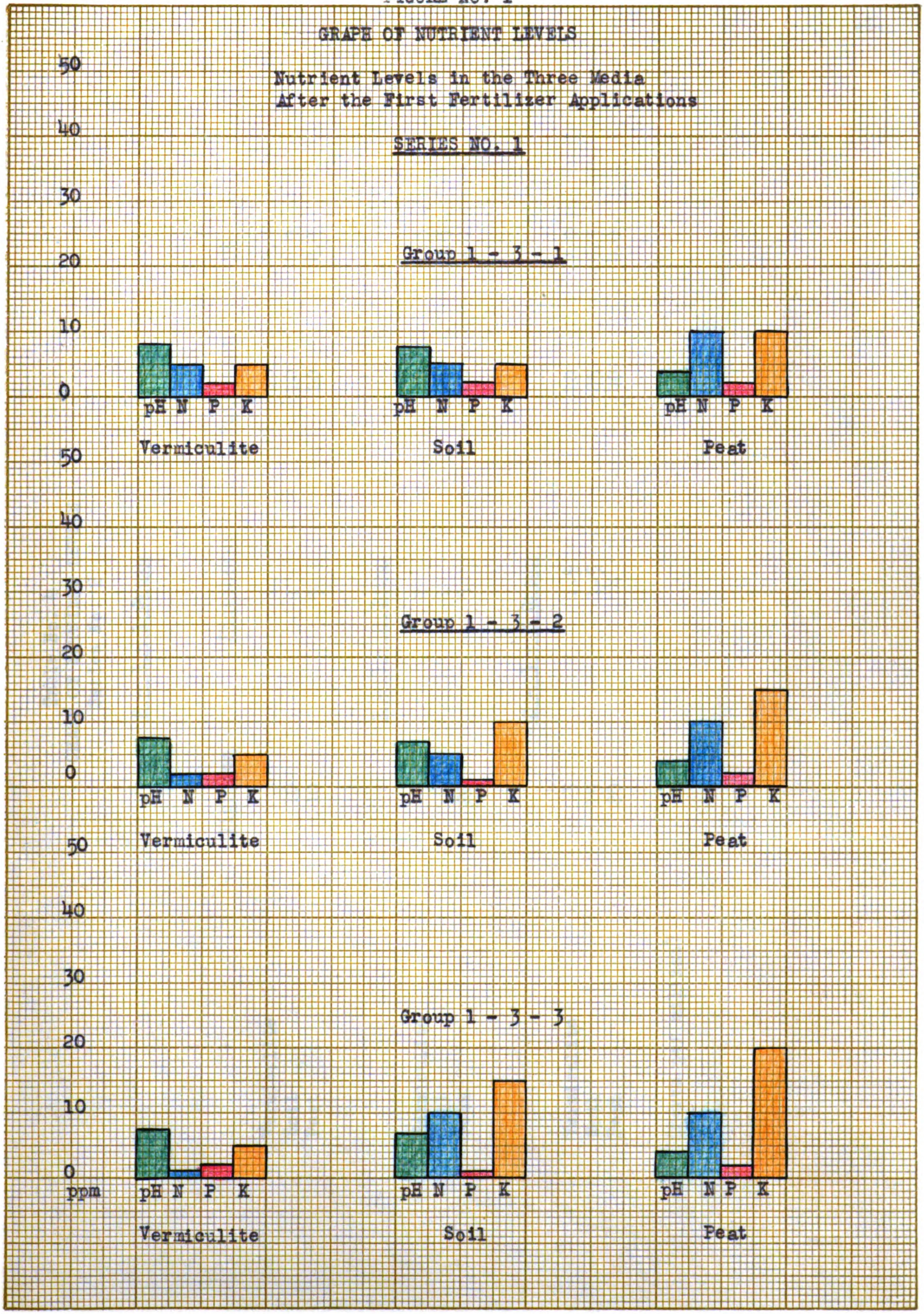
GRAPH OF NUTRIENT LEVELS
Nutrient Levels in the Three Media
After the First Fertilizer Applications
SERIES NO. 1
Group 1 - 3 - 1
50
40
30
20
10
0
pH N P K
Vermiculite
pH N P K
Soil
pH N P K
Peat
Group 1 - 3 - 2
50
40
30
20
10
0
pH N P K
Vermiculite
pH N P K
Soil
pH N P K
Peat
Group 1 - 3 - 3
50
40
30
20
10
0
ppm
pH N P K
Vermiculite
pH N P K
Soil
pH N P K
Peat

Table No. 4
CHART OF NUTRIENT LEVELS
Series No. 2

	Nitrogen	Phosphorus	Potassium	pH
2 - 3 - 1 Group				
Vermiculite	3	1	10	7.5
Soil	10	1	10	6.0
Peat	10	5	10	4.5
2 - 3 - 2 Group				
Vermiculite	5	2	10	7.5
Soil	7	1	15	5.5
Peat	20	5	20	4.0
2 - 3 - 3 Group				
Vermiculite	3	1.5	10	7.0
Soil	15	1.5	25	5.5
Peat	20	4	40	4.0

(Parts per million)

FIGURE No. 2

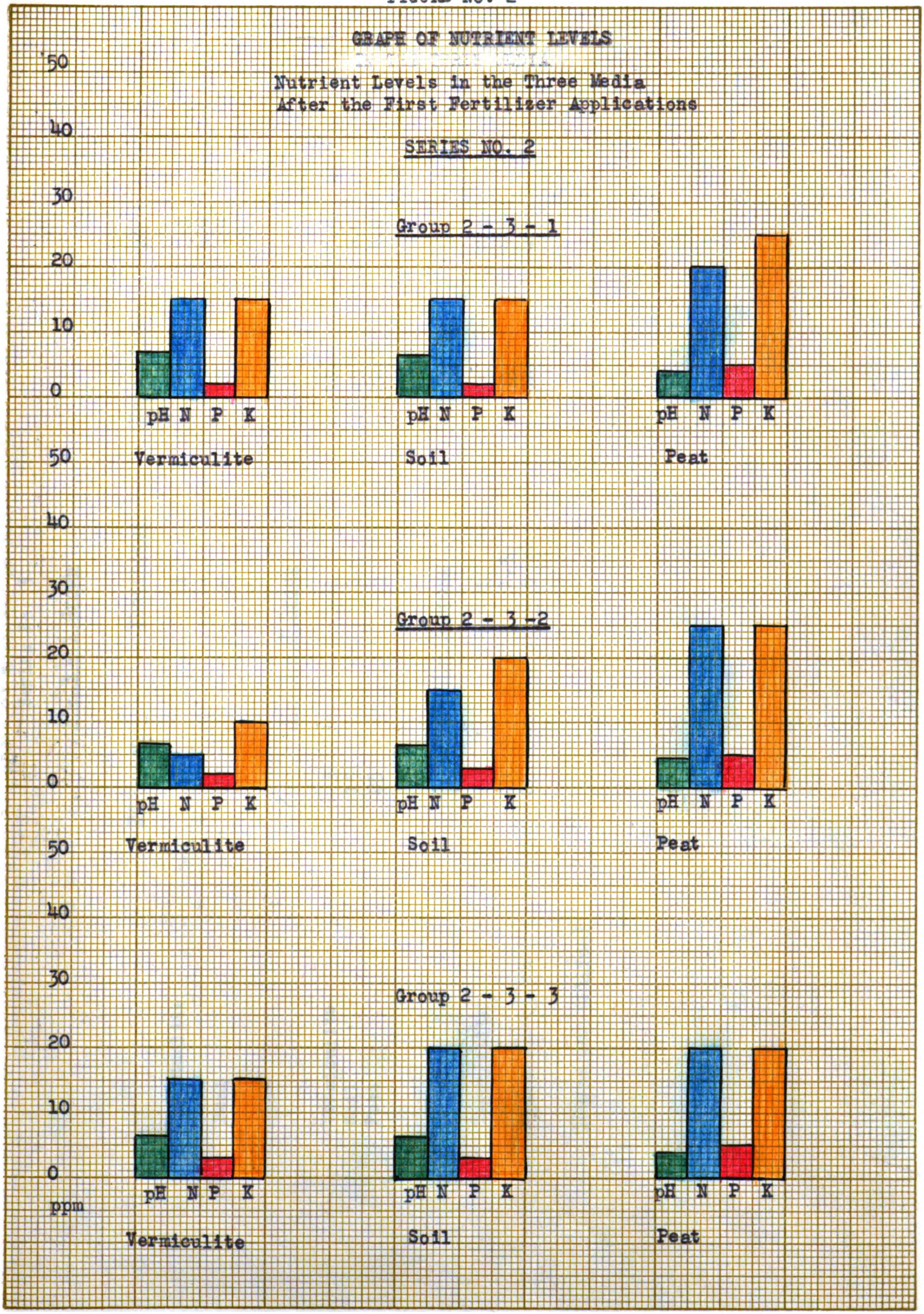
GRAPH OF NUTRIENT LEVELS
Nutrient Levels in the Three Media
After the First Fertilizer Applications
SERIES NO. 2
Group 2 - 3 - 1
50
40
30
20
10
0
pH N P K
Vermiculite
Soil
Peat
Group 2 - 3 -2
Vermiculite
Soil
Peat
Group 2 - 3 - 3
ppm
Vermiculite
Soil
Peat

Table No. 5
CHART OF NUTRIENT LEVELS
Series No. 3

3 - 3 - 1 Group

	Nitrogen	Phosphorus	Potassium	pH
Vermiculite	3	1	10	7.5
Soil	10	1	10	6.0
Peat	10	5	10	4.5

3 - 3 - 2 Group

	Nitrogen	Phosphorus	Potassium	pH
Vermiculite	3	1	10	7.5
Soil	15	1	15	6.0
Peat	25	5	20	4.0

3 - 3 - 3 Group

	Nitrogen	Phosphorus	Potassium	pH
Vermiculite	2	1	15	7.0
Soil	25	1.5	30	5.5
Peat	25	5	30	4.5

)Parts per million)

FIGURE NO. 3

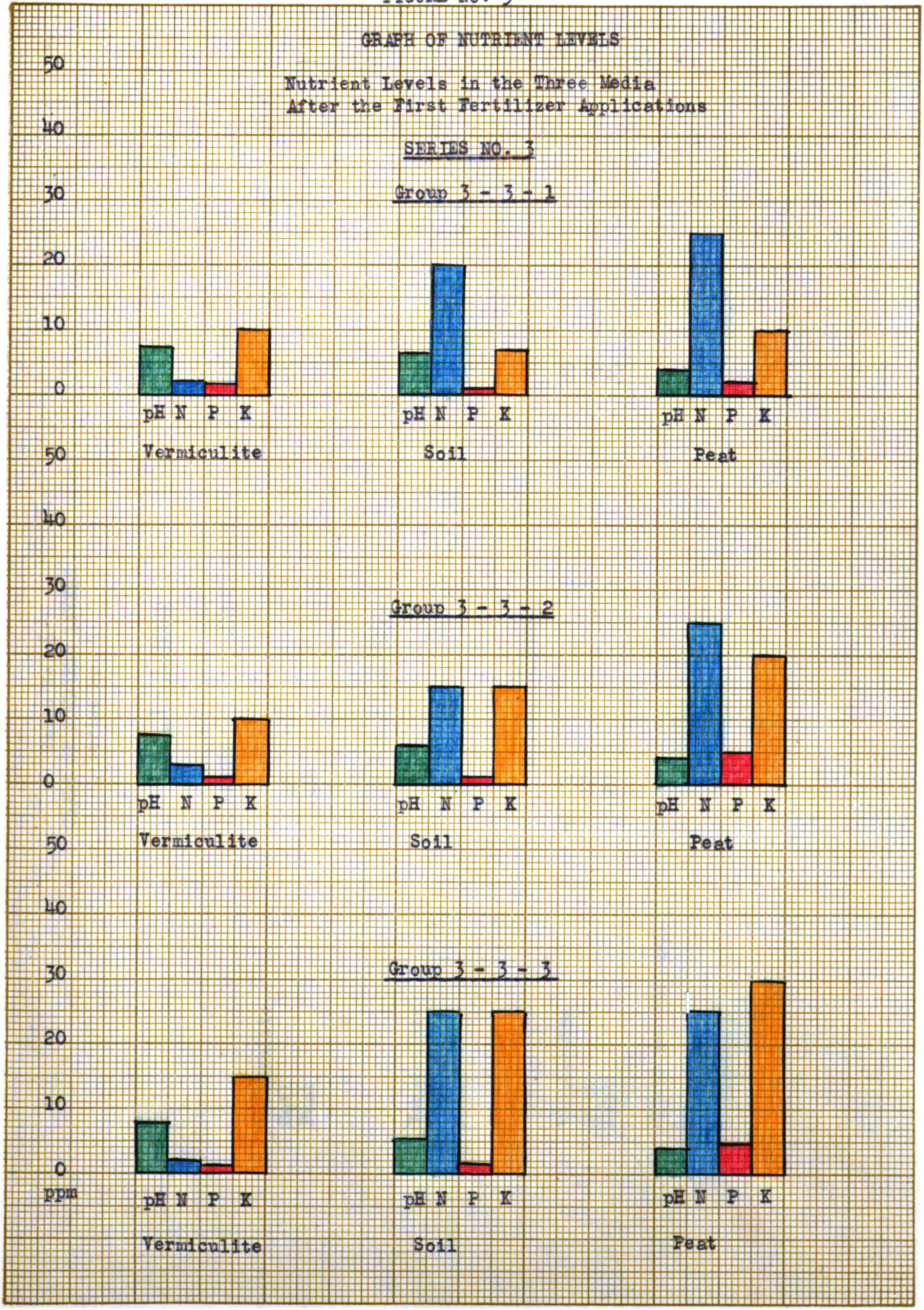
GRAPH OF NUTRIENT LEVELS
Nutrient Levels in the Three Media
After the First Fertilizer Applications
SERIES NO. 3
Group 3 - 3 - 1
Group 3 - 3 - 2
Group 3 - 3 - 3
50
40
30
20
10
0
ppm
pH N P K
Vermiculite
Soil
Peat

Table No. 6
CHART OF NUTRIENT LEVELS
Series No. 4

	Nitrogen	Phosphorus	Potassium	pH
1 - 3 - 1 Group				
Vermiculite	5	2	15	6.8
Soil	15	3	15	6.5
Peat	20	5	25	4.5
1 - 3 - 2 Group				
Vermiculite	2	2	15	6.5
Soil	15	3	20	6.5
Peat	25	5	25	4.5
1 - 3 - 3 Group				
Vermiculite	1	3	20	6.8
Soil	20	3	25	6.5
Peat	20	3	35	4.5

(Parts per million)

FIGURE 4

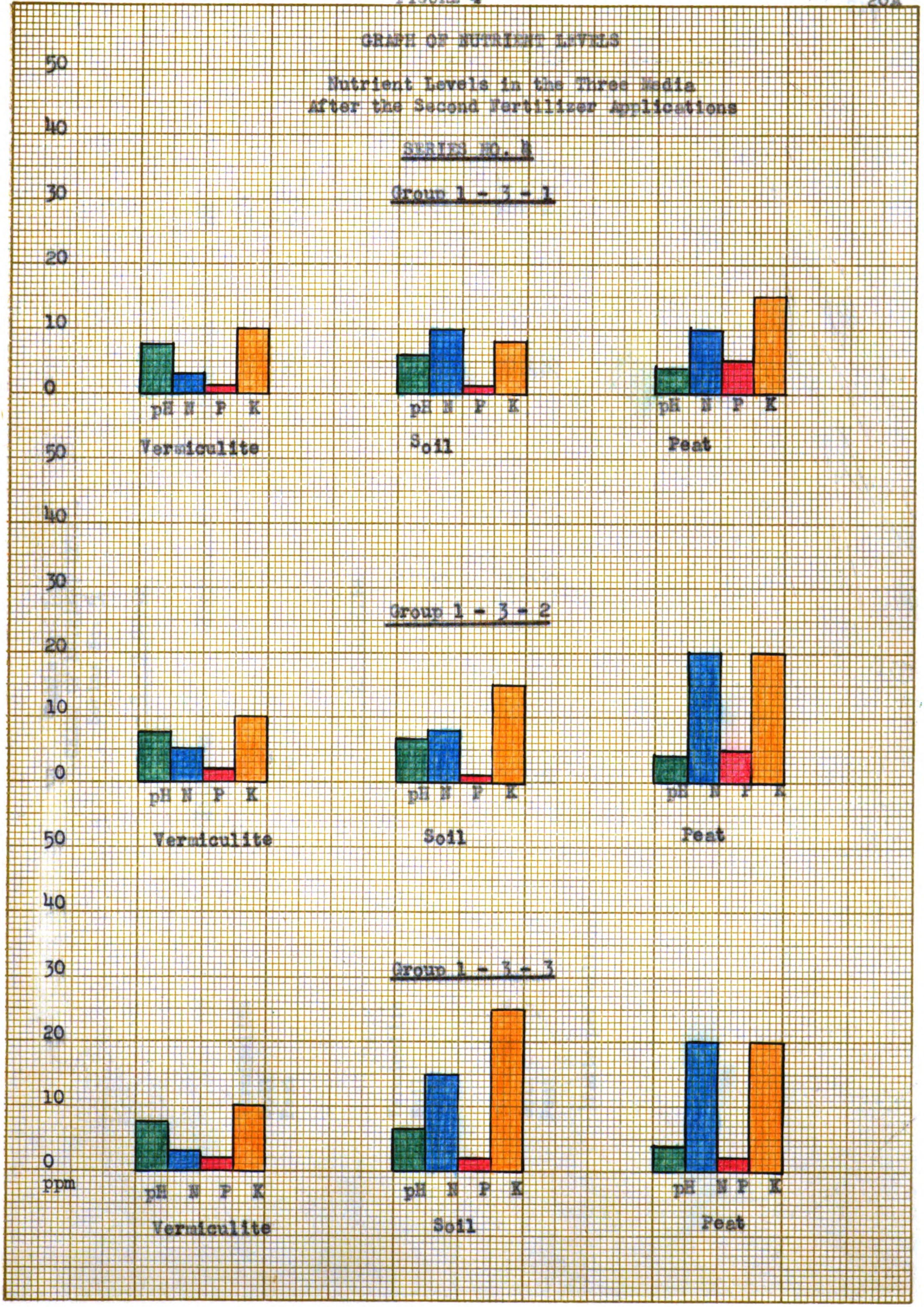
GRAPH OF NUTRIENT LEVELS
Nutrient Levels in the Three Media
After the Second Fertilizer Applications
SERIES NO. 1
Group 1 - 3 - 1
50
40
30
20
10
0
pH N P K
Vermiculite
Soil
Peat
Group 1 - 3 - 2
Vermiculite
Soil
Peat
Group 1 - 3 - 3
ppm
Vermiculite
Soil
Peat

Table No. 7
CHART OF NUTRIENT LEVELS
Series No. 5

2 - 3 - 1 Group

	Nitrogen	Phosphorus	Potassium	pH
Vermiculite	10	2	15	6.8
Soil	25	2	15	6.5
Peat	30	5	20	4.5

2 - 3 - 2 Group

	Nitrogen	Phosphorus	Potassium	pH
Vermiculite	2	1	20	6.8
Soil	20	3	25	7.0.
Peat	30	5	20	7.0
Vermiculite	2	2	25	7.0
Soil	25	3	30	7.0
Peat	30	5	35	7.0

)Parts per million)

FIGURE 5

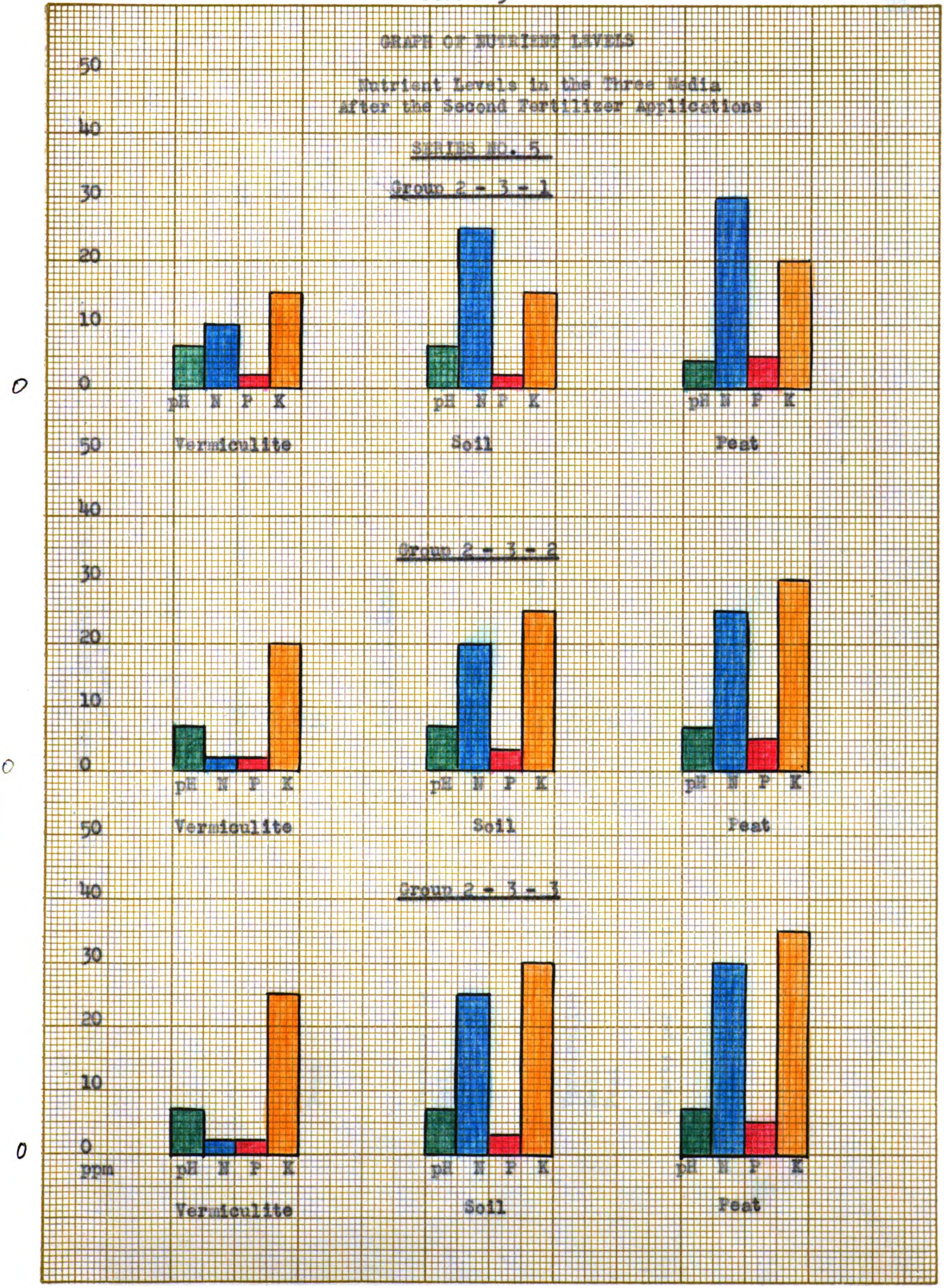
GRAPH OF NUTRIENT LEVELS
Nutrient Levels in the Three Media
After the Second Fertilizer Applications
SERIES NO. 5
Group 2 - 3 - 1
50
40
30
20
10
0
pH N P K
Vermiculite
Soil
Peat
Group 2 - 3 - 2
Group 2 - 3 - 3
ppm

Table No. 8
CHART OF NUTRIENT LEVELS
Series No. 6

<u>3 - 3 - 1 Group</u>

	Nitrogen	Phosphorus	Potassium	pH
Vermiculite	10	2	10	6.5
Soil	25	3	10	6.8
Peat	35	5	25	4.5

<u>3 - 3 - 2 Group</u>

	Nitrogen	Phosphorus	Potassium	pH
Vermiculite	15	3	15	6.8
Soil	25	2	30	7.0
Peat	30	5	40	4.5

<u>3 - 3 - 3 Group</u>

	Nitrogen	Phosphorus	Potassium	pH
Vermiculite	15	2	25	6.8
Soil	25	3	35	6.5
Peat	30	5	45	4.5

(Parts per million)

FIGURE 6

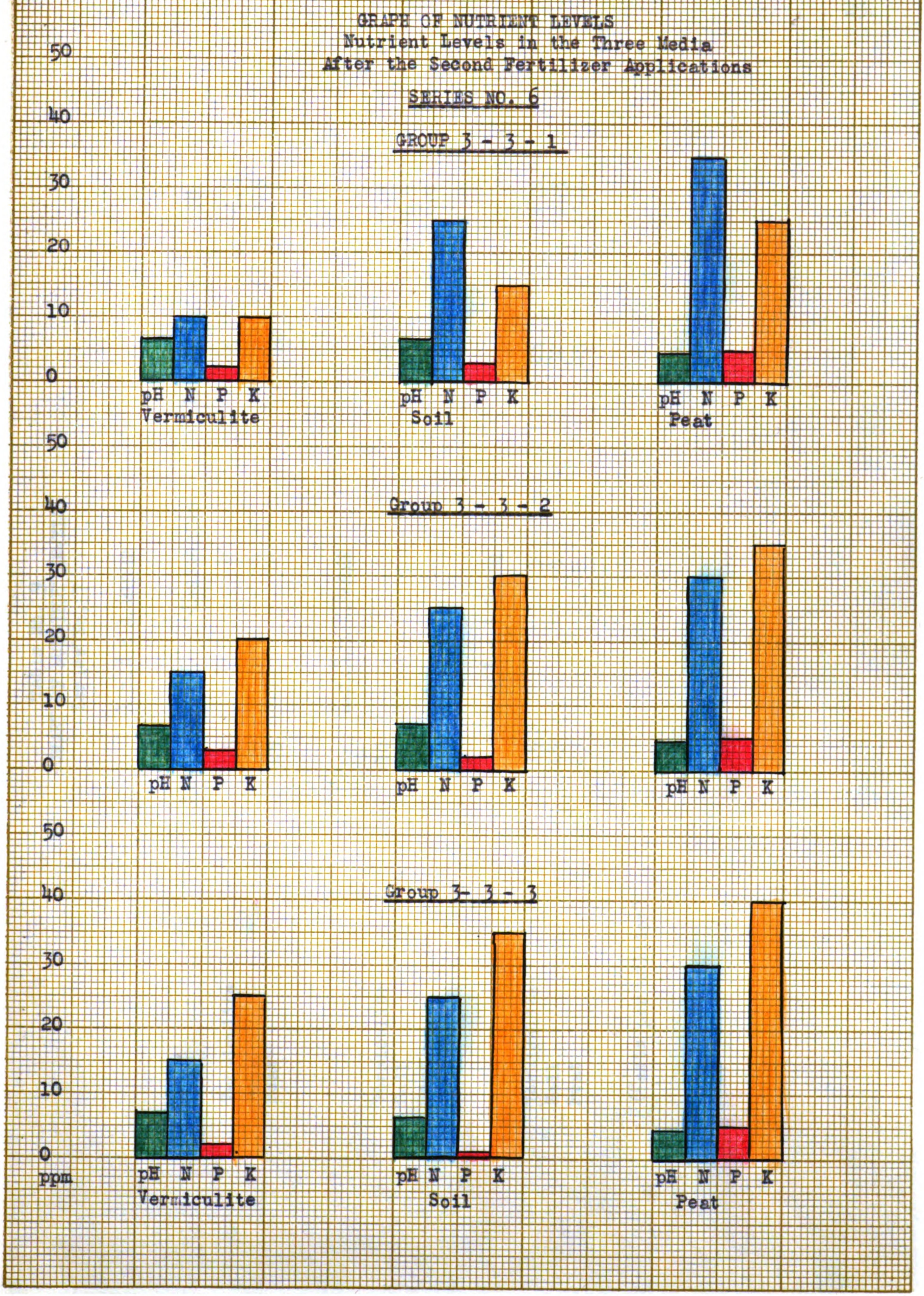
GRAPH OF NUTRIENT LEVELS
Nutrient Levels in the Three Media
After the Second Fertilizer Applications
SERIES NO. 6
GROUP 3 - 3 - 1
Group 3 - 3 - 2
Group 3- 3 - 3
50
40
30
20
10
0
ppm
pH N P K
Vermiculite
Soil
Peat

Table No. 9
CHART OF NUTRIENT LEVELS
Series No. 7

	Nitrogen	Phosphorus	Potassium	pH
1 - 3 - 1 Group				
Vermiculite	15	5	20	6.8
Soil	20	4	20	6.5
Peat	25	4	20	6.0
1 - 3 - 2 Group				
Vermiculite	10	5	15	6.5
Soil	15	5	25	6.5
Peat	20	5	40	6.0
1 - 3 - 3 Group				
Vermiculite	15	5	25	6.8
Soil	15	5	30	6.5
Peat	25	5	45	5.5

(Parts per million)

FIGURE 7.

GRAPH OF NUTRIENT LEVELS
Nutrient Levels in the Three Media
After the Third Fertilizer Applications

SERIES NO. 7

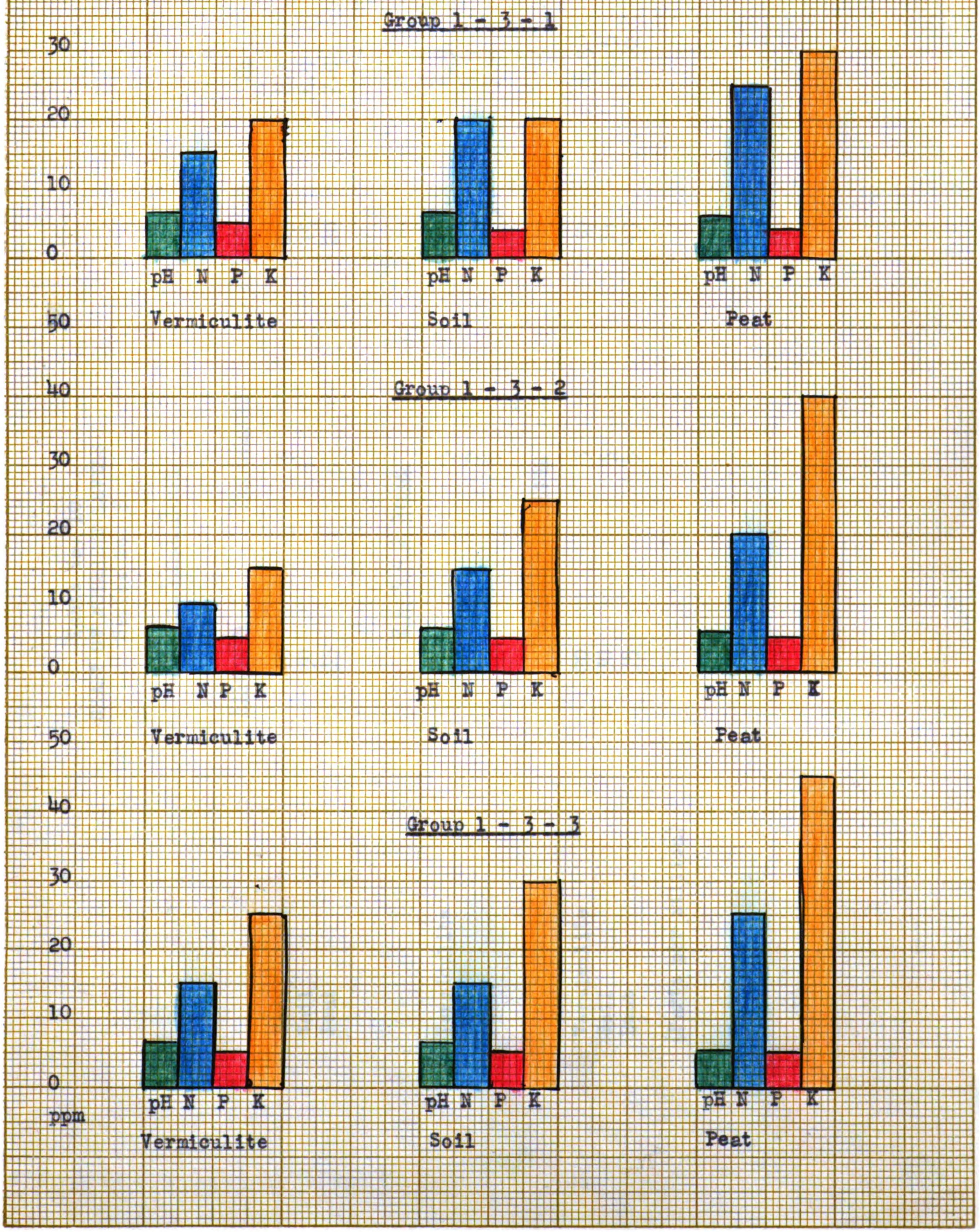

Table No. 10
CHART OF NUTRIENT LEVELS
Series No. 8

	Nitrogen	Phosphorus	Potassium	pH
2 - 3 - 1 Group				
Vermiculite	20	5	15	6.5
Soil	30	5	15	6.0
Peat	35	5	20	7.0
2 - 3 - 2 Group				
Vermiculite	15	3	20	6.5
Soil	30	5	25	6.5
Peat	30	5	35	7.0
2 - 3 - 3 Group				
Vermiculite	20	3	30	6.5
Soil	30	5	35	6.5
Peat	35	5	45	7.0

(Parts per million)

FIGURE 8

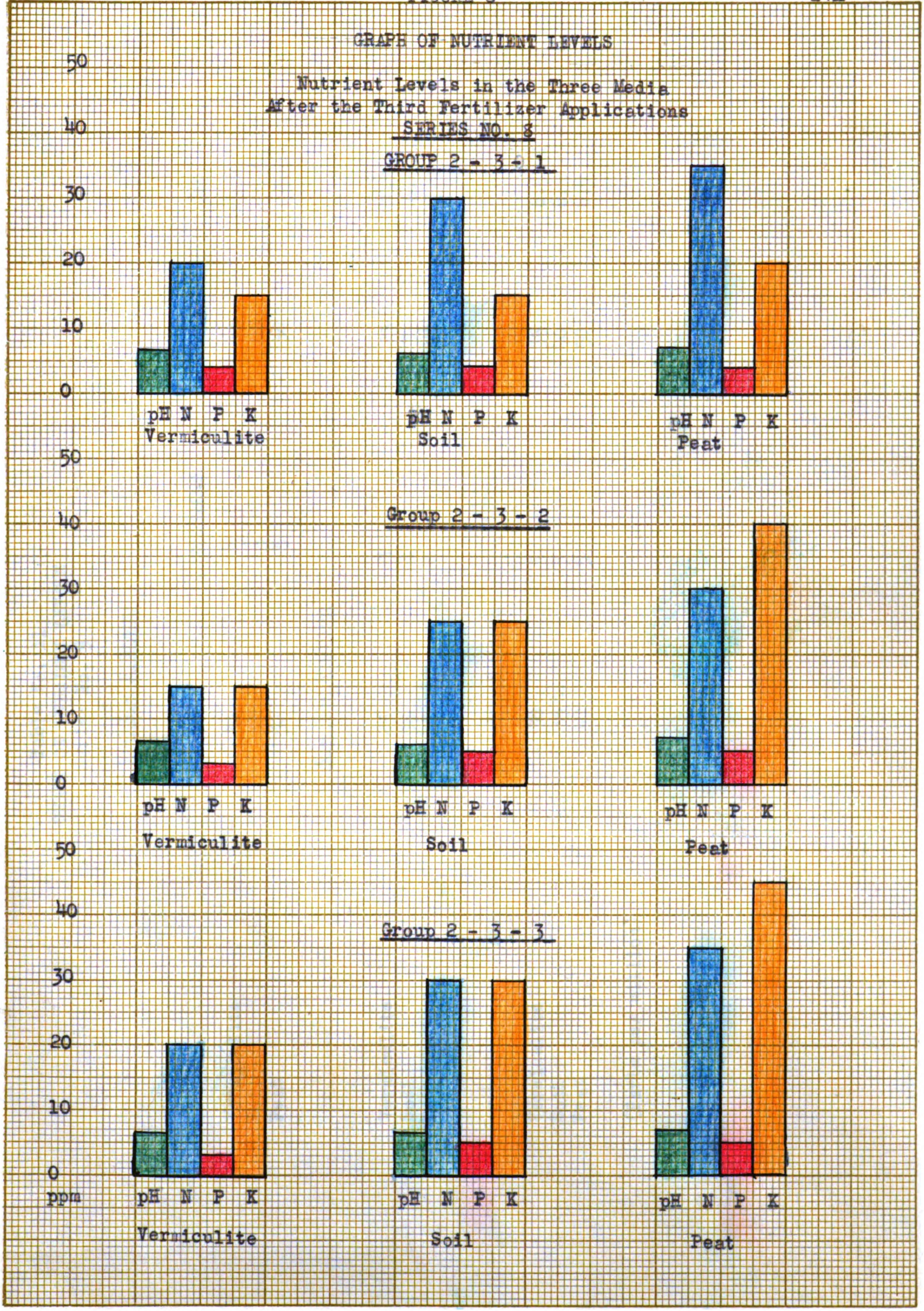
GRAPH OF NUTRIENT LEVELS
Nutrient Levels in the Three Media
After the Third Fertilizer Applications
SERIES NO. 3
GROUP 2 - 3 - 1
50
40
30
20
10
0
pH N P K
Vermiculite
pH N P K
Soil
pH N P K
Peat
Group 2 - 3 - 2
50
40
30
20
10
0
pH N P K
Vermiculite
pH N P K
Soil
pH N P K
Peat
Group 2 - 3 - 3
50
40
30
20
10
0
ppm
pH N P K
Vermiculite
pH N P K
Soil
pH N P K
Peat

Table No. 11
CHART OF NUTRIENT LEVELS
Series No. 9

3 - 3 - 1 Group

	Nitrogen	Phosphorus	Potassium	pH
Vermiculite	30	5	15	6.5
Soil	35	5	20	6.0
Peat	50	5	30	5.5

3 - 3 - 2 Group

	Nitrogen	Phosphorus	Potassium	pH
Vermiculite	25	3	25	7.0
Soil	35	4	35	6.5
Peat	45	4	40	7.0

3 - 3 - 3 Group

	Nitrogen	Phosphorus	Potassium	pH
Vermiculite	30	3	35	6.5
Soil	35	3	40	6.5
Peat	40	5	50	6.0

(Parts per million)

FIGURE No. 9

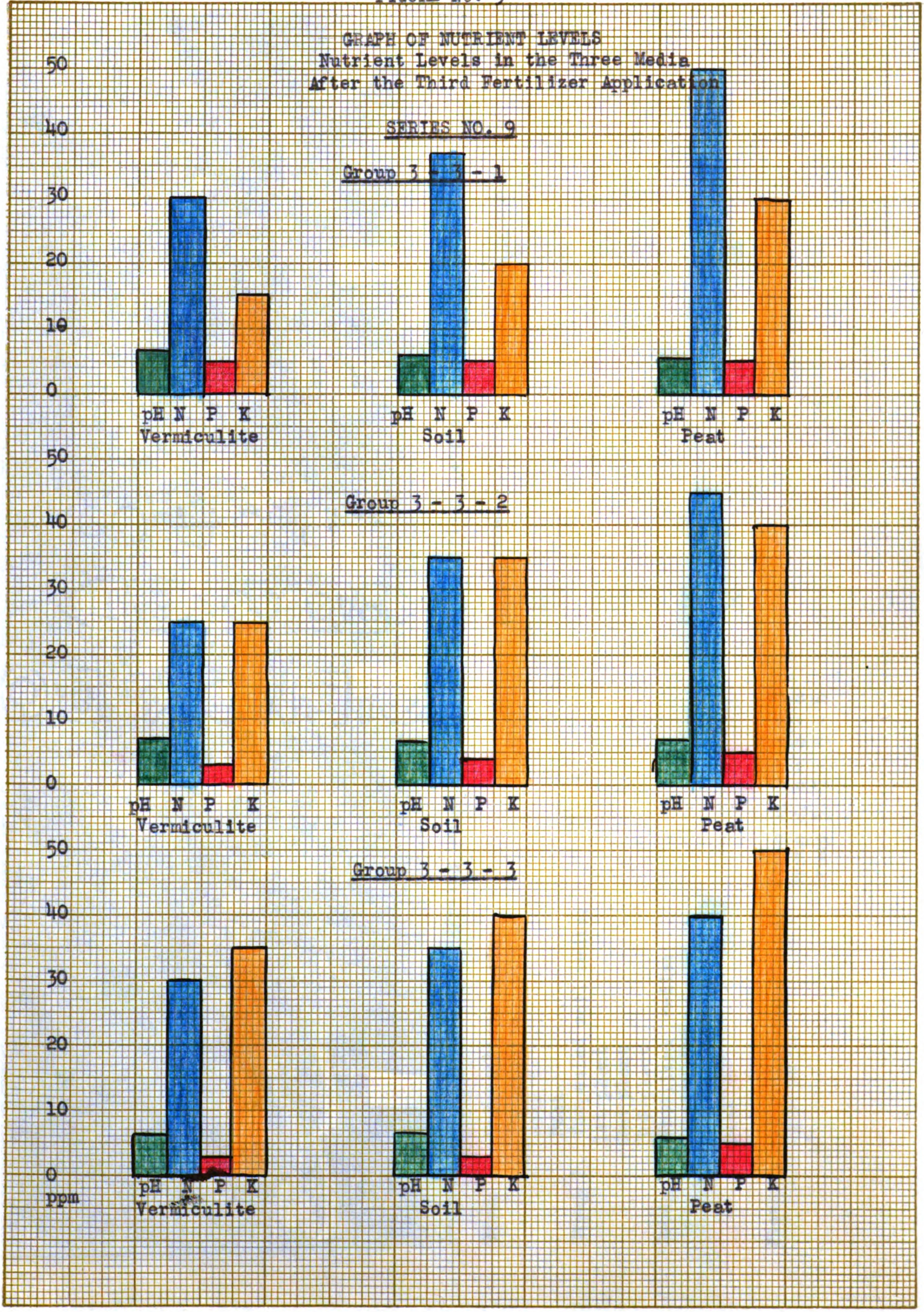
GRAPH OF NUTRIENT LEVELS
Nutrient Levels in the Three Media
After the Third Fertilizer Application
SERIES NO. 9
Group 3 - 3 - 1
Group 3 - 3 - 2
Group 3 - 3 - 3
50
40
30
20
10
0
ppm
pH N P K
Vermiculite
Soil
Peat

Plate No. 1

Begonia plants in different growing media and with different nutrient levels.

	Height (cms.)	Width (cms.)
Group 1. Unfertilized media:		
Vermiculite	6	14
Soil	12	16
Peat	18	18
Group 2. Composted soil media:		
1st plant	35	32
2nd plant	34	30
3rd plant	35	34
Group 3. Fertilized media:		
Vermiculite	18	15
Soil	24	19
Peat	30	28

Flower yield ratio comparisons: Group 1, 0 - 1 - 3
Group 2, 6 - 6 - 6
Group 3, 3 - 5 - 6

Plate No. 2

Begonia plants grown at different nutrient levels in three media.

	Height (cms.)	Width (cms.)
Group 1. Low nitrogen, low phosphorus, low potash:		
Vermiculite	6	14
Soil	12	16
Peat	18	28
Group 2. Medium nitrogen, low phosphorus, low potash:		
Vermiculite	12	11
Soil	15	16
Peat	17	18
Group 3. High nitrogen, low phosphorus, low potash:		
Vermiculite	11	16
Soil	16	20
Peat	20	23

Flower yield ratio comparisons: Group 1, 0 - 1 - 3
Group 2, 1 - 1 - 3
Group 3, 1 - 2 - 3

Plate No. 5

Begonia plants grown at different nutrient levels in three media.

	Height (cms.)	Width (cms.)
Group 1. Low nitrogen, high phosphorus, low potash:		
Vermiculite	17	16
Soil	19	21
Peat	21	17
Group 2. Medium nitrogen, high phosphorus, low potash:		
Vermiculite	12	16
Soil	16	14
Peat	20	16
Group 2. High nitrogen, high phosphorus, low potash:		
Vermiculite	12	10
Soil	20	16
Peat	33	28

Flower yield ratio comparisons: Group 1, 1 - 2 - 3
Group 2, 1 - 3 - 4
Group 3, 2 - 3 - 5

Plate No. 4

Begonia plants grown at different nutrient levels in three media:

	Height (cms.)	Width (cms.)
Group 1. Low nitrogen, high phosphorus, medium potash:		
Vermiculite	14	15
Soil	18	15
Peat	23	25
Group 2. Medium nitrogen, high phosphorus, medium potash:		
Vermiculite	13	11
Soil	17	16
Peat	23	19
Group 2. High nitrogen, high phosphorus, medium potash:		
Vermiculite	20	17
Soil	26	22
Peat	22	20

Flower yield ratio comparisons: Group 1, 2 - 2 - 4
Group 2, 2 - 3 - 5
Group 3, 3 - 6 - 6

Begonia plants grown at different nutrient levels in three media:

	Height (cms.)	Width (cms.)
Group 1. Low nitrogen, high phosphorus, high potash:		
Vermiculite	12	13
Soil	18	15
Peat	25	30
Group 2. Medium nitrogen, high phosphorus, high potash:		
Vermiculite	15	10
Soil	12	13
Peat	18	15
Group 3. High nitrogen, high phosphorus, high potash:		
Vermiculite	18	15
Soil	24	19
Peat	30	28

Flower yield ratio comparisons: Group 1, 1 - 3 - 4
Group 2, 2 - 2 - 4
Group 3, 3 - 5 - 6

Plate No. 6

Begonia plants grown on different media at different nutrient levels:

Left to right: Row 1, greenhouse compost, nutrient levels high.
Rows 2, 3, and 4, vermiculite, soil, and peat, respectively, nutrient levels low.
Rows 5, 6, and 7, vermiculite, soil, and peat, respectively, medium nitrogen, low phosphorus, low potash.

PRESENTATION OF RESULTS

First Chemical Analysis of Growing Media.

From the information obtained from the first soil test and compared with the required recommendations of nutrient levels for *Begonia semperflorens*, it was found that the nutrients were increased somewhat for nitrates and potassium, but the phosphorus was still too low for optimum requirements. Either the orthophosphoric acid is not the proper form of phosphorus as compared with superphosphate or the applications were not heavy enough.

The second application of fertilizers was made in the attempt to bring the nutrient requirements up to the proper levels.[1, 2]

Second Chemical Analysis of Growing Media.

After a week to ten days, another series of soil tests was made and the results are as follows:

The available phosphorus had increased and the potash was nearly at the desired level, but the nitrogen test of the vermiculite series showed only two to three ppm. instead of 30 to 50 ppm., as indicated by the tests made on the peat pots that are at the optimum levels. The soil pots, on the other hand, showed a test for 10 to 25 ppm. of nitrogen, which is about one-half of the optimum for the nitrogen requirements.

For further reference of the above fertilizer treatment and results refer to footnotes 3 and 4.

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1. For second fertilizer applications see page 11.
2. For results of second fertilizer applications see Figures 1, 2, and 3, Tables 3, 4, and 5, in Series 1, 2, and 3.
3. Refer to Figures 4, 5, and 6.
4. Refer to pages 10, 11, 13.

Third Chemical Analysis of Growing Media

After ten or twelve days the last series of soil tests was made, allowing enough time for the fertilizers to react on the crop, and the following results were evident:

The ppm. requirements for the Begonia semperflorens were not only evident from the soil test figures, but also the evidence could be seen in the foliage color change from a brick-red in the low nutrient vermiculite plants to a dark green color again.

In addition to the foliage color change back to normal, there was a very noticeable increase in growth throughout the entire group of plants as well as rapid advancement in flower formation and development. Pictures were taken of this experiment shortly after the soil analyses were made and the normality of the plant color was restored.

The ppm. requirements for nitrates, phosphates, and potassium were 30 to 50, 5, and 30 to 50, respectively. Although a few of the plants were a little over or under the requirements, they did not show much difference in actual plant comparisons.

In reference to the pH requirements for this crop, a pH of 6.5 was recommended. Most of the plants in the experiment had reached that goal by the close pH control methods.

For further reference to the last fertilizer treatment and chemical analyses see footnotes 1 and 2.

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1. Refer to figures 7, 8, and 9.
2. Refer to Tables 9, 10, and 11, Series 7, 8, and 9.

DISCUSSION AND CONCLUSIONS

From the data assembled and analyzed in this study, the following significant inferences may be drawn:

1. That there is a need for information regarding the nutrient requirements of specific flowering plants.

2. That there is a necessity for showing growing medium, proper fertility levels, and a uniform pH if quality greenhouse plants are to be obtained.

3. That there is a need for data regarding crop yields under glass when grown on these different growing media.

4. Vermiculite may be used for a rooting medium and peat may be used for mulching and also as an organic mixture for greenhouse soils; yet when one is used alone the results are quite different from a mixture of these materials.

5. Proper pH values are also very important if maximum yields and highest quality of begonias are desired. When the crop is grown under improper pH, the nutrients are not as readily available to the plants.

6. An interpretation of the data collected should serve as a basis for the evaluation and modification, if necessary, of the cultural methods of the begonia by growers of such crops under glass.

7. The writer provided some experimental evidence concerning the selection of proper growing media at the most desirable nutrient levels and the optimum hydrogen-ion concentration of the growing medium required for best growth of *Begonia semperflorens*.

8. It can be concluded that the plants grown in the peat have given the best results, not only for size of plants, but for greener foliage and a greater production of flowers, due to the ability of the peat to hold the nutrients and a better base exchange.

9. The vermiculite showed the least production of foliage, and quality of color as well as less flower production, because of the length of time required for the vermiculite to build up a nutrient supply to become available to the crop as compared with soil or peat. If the vermiculite is given a long enough time to allow the nutrients to become available, then the results would be somewhat similar to plants grown in peat. Vermiculite can be used as a rooting medium satisfactorily, but when used for maturing a crop it takes a longer time for the crop to become established and requires a lot more nutrients to mature the crop as compared with the soil and peat grown plants.

10. The soil-grown plants made an intermediate growth and yielded an intermediate supply of flowers and the foliage was not as green in appearance as the plants grown in the peat. The soil would have produced a growth similar to that produced on the peat if peat and sand had been added, which is evident in the check plants where such a mixture was made. Because of the poor physical condition of the soil used in the experiment, in which case no peat or other organic matter was added to increase the porosity of the soil, the result was an intermediate growth and this is where most of the growers who grow crops under glass, especially potted plants, should be careful in proper soil mixture, nutrient supply, and maintenance of proper pH levels for each specific crop.

SUMMARY

1. The experiment was set up to determine the nutrient levels of nitrogen, phosphorus, and potassium for *Begonia semperflorens*.

2. The different media used for growing the Begonia plants were vermiculite, soil, and peat.

3. A hydrogen-ion concentration of 6.5 seems to be desirable for optimum growth and development of *Begonia semperflorens*.

4. It was found that the parts per million requirement for best growth and development for *Begonia semperflorens* was 30 to 40 of nitrogen, 5 of phosphorus, and 30 to 40 of potassium.

5. Improper nutrient levels and hydrogen-ion concentrations will result in inferior crops of stunted growth and discolored foliage, which was evident at the beginning of the experiment when the nutrients and hydrogen-ion concentrations had to be adjusted.

6. Proper nutrient levels and hydrogen-ion concentrations, as well as proper growing media, result in the most desirable crop,

7. The plants grown in peat gave the best results, due to the ability of the peat to hold the nutrients and provide a better base exchange.

8. The vermiculite showed the least production because of the length of time required to build up a nutrient supply to become available to the crop, as compared with soil or peat.

9. The plants grown in soil made an intermediate growth because of the poor physical condition of the soil, which was due to the lack of organic matter such as peat or manure, as well as sand, to aid in the porosity of the soil and nutrient holding capacity.

10. It was observed that, as this crop was finally brought to proper nutrient levels and hidrogen-ion concentrations, the brick-red color and blemishes cleared up and the entire crop, except for one or two plants growing in the vermiculite and soil, was again brought back to a healthy green color.

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