Effect of Five Antibiotics in Varying Concentrations on Growth of Young Corn Plants

William E. Harris

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Butler University
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(1929-1964)

Edited by

J. E. Potzger
The *Butler University Botanical Studies* journal was published by the Botany Department of Butler University, Indianapolis, Indiana, from 1929 to 1964. The scientific journal featured original papers primarily on plant ecology, taxonomy, and microbiology. The papers contain valuable historical studies, especially floristic surveys that document Indiana’s vegetation in past decades. Authors were Butler faculty, current and former master’s degree students and undergraduates, and other Indiana botanists. The journal was started by Stanley Cain, noted conservation biologist, and edited through most of its years of production by Ray C. Friesner, Butler’s first botanist and founder of the department in 1919. The journal was distributed to learned societies and libraries through exchange.

During the years of the journal’s publication, the Butler University Botany Department had an active program of research and student training. 201 bachelor’s degrees and 75 master’s degrees in Botany were conferred during this period. Thirty-five of these graduates went on to earn doctorates at other institutions.

The Botany Department attracted many notable faculty members and students. Distinguished faculty, in addition to Cain and Friesner, included John E. Potzger, a forest ecologist and palynologist, Willard Nelson Clute, co-founder of the American Fern Society, Marion T. Hall, former director of the Morton Arboretum, C. Mervin Palmer, Rex Webster, and John Pelton. Some of the former undergraduate and master’s students who made active contributions to the fields of botany and ecology include Dwight. W. Billings, Fay Kenoyer Daily, William A. Daily, Rexford Daudenmire, Francis Hueber, Frank McCormick, Scott McCoy, Robert Petty, Potzger, Helene Starcs, and Theodore Sperry. Cain, Daubenmire, Potzger, and Billings served as Presidents of the Ecological Society of America.

Requests for use of materials, especially figures and tables for use in ecology text books, from the *Butler University Botanical Studies* continue to be granted. For more information, visit www.butler.edu/herbarium.
EFFECT OF FIVE ANTIBIOTICS IN VARYING CONCENTRATIONS ON GROWTH OF YOUNG CORN PLANTS*

By William E. Harris

The products of microorganisms collectively known as antibiotics, have been investigated extensively as aids to medical sciences, but they have not been thoroughly studied for possible other uses. Several papers have appeared in recent years concerning work done on antibiotic stimulation of growth in such domestic animals as young pigs (1) and chicks (2), the addition of certain antibiotics, notably penicillin and streptomycin, to commercial feeds becoming somewhat general. It is also well known that certain antibiotics in very low concentration may stimulate growth of some bacteria (3). Most work involving higher plants dealt with antibiotic effects on germination of seeds, and growth characteristics were not noted.

For normal growth, many higher plants require a symbiotic relationship with some bacteria and/or a mycorrhizal relationship with some fungi (4), and since most antibiotic substances come from soil microorganisms it seemed likely that antibiotics in low concentration might affect plant growth. It was for this reason that the present study of effects of five antibiotics on growth of young corn plants was undertaken. This study is exploratory, intended to cover a wide range of antibiotics in varying concentrations to discover any possible growth stimulation or inhibition.

METHODS

In this study certain experiments were designated "pilot experiments," and others "confirmatory experiments." Pilot experiments were those in which several concentrations of antibiotics were tested on fewer plants so that there would be a better chance of discovering an antibiotic concentration capable of producing growth effects on the plants. Confirmatory experiments were those using one concentration of an antibiotic which appeared to affect the growth of test

* A thesis submitted in partial fulfillment of the requirements for the Bachelor of Science degree, Magna Cum Laude, in Butler University.
plants in a pilot experiment on a larger number of test and control plants.

Test plants for all pilot experiments (Ex. I, II, IV-VI) were equally spaced in six rows of twelve plants each, with about three inches between each row. Each plant in five of these rows was treated with 25 ml of five selected antibiotic concentrations four times a week, one concentration per row. The sixth row as a control was watered only with tap water. Plants were grown for five weeks, but treated only the last four weeks, making a total of 16 antibiotic applications. After 16 applications, each plant had been treated with the following quantities of antibiotic:

<table>
<thead>
<tr>
<th>Concentration</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Group</td>
<td>0.0 Mg.</td>
</tr>
<tr>
<td>.5 PPM</td>
<td>.2 Mg.</td>
</tr>
<tr>
<td>1 PPM</td>
<td>.4 Mg.</td>
</tr>
<tr>
<td>3 PPM</td>
<td>1.2 Mg.</td>
</tr>
<tr>
<td>5 PPM</td>
<td>2.0 Mg.</td>
</tr>
<tr>
<td>10 PPM</td>
<td>4.0 Mg.</td>
</tr>
<tr>
<td>20 PPM</td>
<td>8.0 Mg.</td>
</tr>
</tbody>
</table>

Test plants of confirmatory experiments (Ex. III, VII) were placed in two groups and given equal light exposure. These plants were watered and treated four times a week in the same manner as were the plants in pilot experiments.

After five weeks it was found that the plants were root-bound in the pots and it was deemed advisable to halt tests at that point.

Seven experiments utilizing five antibiotics were accomplished:

Experiment I was a pilot experiment testing five concentrations of potassium penicillin (.5, 1, 3, 5, and 10 PPM or Mg/ml.) on growth of corn plants. Twelve corn plants were treated with each concentration of antibiotic and twelve plants were left untreated for control.

Experiment II was a pilot experiment testing five concentrations (.5, 1, 3, 5, and 10 PPM or Mg/ml.) of procaine penicillin on young corn. Again twelve plants were treated with each concentration and twelve untreated plants were used as control.

Experiment III was a confirmatory experiment testing the reliability of one concentration (5 PPM) from experiment I.
treated plants were used, and 36 plants were left untreated for controls.

Experiment IV was a pilot experiment testing five concentrations (.5, 1, 3, 5, and 10 PPM or Mcg/ml.) of the antibiotic bacitracin, utilizing twelve untreated plants for each concentration and twelve untreated plants for control.

Experiment V was a pilot experiment testing five concentrations (1, 3, 5, 10, and 20 PPM or Mcg/ml.) of the antibiotic erythromycin. Twelve corn plants were used for each concentration and twelve untreated plants were for control.

Experiment VI was a pilot experiment testing five concentrations (1, 3, 5, 10, and 20 PPM or Mcg/ml.) of the antibiotic streptomycin sulfate. Once more twelve plants were treated with each concentration and twelve plants were left untreated for control.

Experiment VII was a confirmatory experiment testing further one concentration of experiment V (5 PPM). 36 plants were treated, and 36 were left untreated as controls. The 36 control plants were dried and weighed in three groups of 12 plants each.

Plants were measured for height in Cm. approximately one week after planting (just before first treatment) and weekly thereafter. The height of the plants was measured when turgid as the tallest plant part from soil level, either leaf tip or leaf midsection. After four weeks of treatment the corn plants were cut off at ground level and all plants from a single concentration were placed in a previously weighed 800 ml beaker. The beaker and its contents were weighed immediately for wet weight, then placed in an oven at 105°C for 48-72 hours. The beaker and contents were then weighed again to obtain dry weight.

Funk’s G-99 hybrid corn seed was used for all tests. The seed was planted two seeds per four inch flower pot: then upon germination where two seeds grew and germinated in the same pot, one was removed. Thus when antibiotic treatment was begun, one corn plant was growing in each plot. Temperatures were regulated as accurately as possible near 80°F. The plants were watered as needed, except that anytime test plants were treated with antibiotic solution, a volume of water equal to the volume of antibiotic solution was ap-
plied to the control plants. An attempt to keep humidity normal was made by placing pans of water under benches in each greenhouse compartment. All plants from a single experiment were always grown in the same compartment, and where tests on two antibiotics were run simultaneously, a different greenhouse compartment was used. The glass was removed from a partition between two compartments for better air circulation and to equalize temperature and humidity conditions between compartments. No auxiliary lighting was used, since the corn did grow satisfactorily in the winter sun, and any deficiency in growth of test plants due to less sunlight than is available during the normal growing season of corn would be cancelled by a like deficiency in growth of the control plants. Fertile loam soil known to be in good condition was used in all experiments.

The antibiotics were kept in a dry state at 20°C. Stock solutions of .2 g./liter concentration were made fresh weekly with distilled water. Prior to each treatment of corn plants, the stock solution was diluted with tap water to the desired concentration. The solutions were prepared on Mondays and last used on Fridays; thus no solution was over five days old when used. The antibiotic solutions used in the present study are known to be stable for this length of time when kept at 20°C. (5).

All antibiotics were of high purity, and had the following potencies (5):

- Potassium penicillin G .......... 1585 Units/Mg.
- Procaine penicillin G .......... 983 Units/Mg.
- Bacitracin ........................ 528 Units/Mg.
- Streptomycin sulfate .......... 740 Mcg./Mg.
- Erythromycin ........................ 965 Mcg./Mg.

A procedure to determine whether erythromycin was absorbed by the corn plants was carried out. Four plants which had been given five ml. of the .2g/ml. stock solution 24 hours preceding the extraction were extracted in the following manner:

The leaves of the four plants were cut into small pieces with scissors and then extracted with twenty ml. of water in a Waring blender. Five control plants were treated in a like manner. This was essentially the method of Hayes (6) for extraction of antibiotic substances from higher plants, except that in this study scissors were
used for the initial maceration rather than a food grinder. The ex-
tracts from both treated and control plants were analyzed by a test
for erythromycin sensitive to 4 Mcg./ml.

RESULTS

Results of the study are perhaps best understood if Tables I to
VIII are studied. However, some results and observations which
could not conveniently be incorporated in the tables or which are
especially noteworthy are presented here.

Results of Experiment I utilizing potassium penicillin are shown
in Table I. It is to be noted that although overall weight was less for
treated than for control plants, dry weights for all treated (except .5
PPM) were greater than for control plants (Table I). The greatest
increase in dry weight and wet weight over control occurred in the
5 PPM treated group. For the group in general it can be said that
treated plants had higher dry and wet weight than controls.

Results of Experiment II using procaine penicillin are shown in
Table II. The greatest dry weight occurred in the 3 PPM group
which, although having final average height lower than control,
weighed 10% more dry. Note that all other dry weights were less
than or the same as the control, the .5 PPM group having only
80% dry weight of the controls. Height trends of Experiment II groups
corresponded more nearly to dry weight trends of this group than
it did in Experiment I.

The control plants of Experiments I and II were planted at the
same time and grown under identical conditions. However, final
measurements are somewhat different. Note that average height
after 16 treatments was 25.3 Cm. for Ex. I control plants (Table I)
and 23.4 Cm. for Ex. II control plants (Table II). Dry weight also
varied, it being 4.3 g. for Ex. I control plants, and 4.9 g. for Ex. II
control plants (Tables I and II).

Results of Experiment III, a more accurate reliability test on
part of Experiment I (36 pots treated with 5 PPM potassium peni-
cillin and 36 control plants), are shown in Table IV. Some signifi-
cant points found in Table IV are, average height after 16 treatments
for treated plants was 20.0 Cm. and for the controls average height
was 22.5 Cm. The dry weight of treated plants was 6.7 g. however,
while that for controls was 6.1 g. As in the pilot experiment, the average height was less for treated but the dry weight was 10% more than control dry weight. While this experiment was being performed, the temperature of the greenhouse in which the plants were growing was allowed to become quite low several times. During this period also, many dark days occurred. This is evidenced by the low average weights and heights for this experiment in comparison with dry weights and heights of groups from other experiments.

Results of Experiment IV testing effects of bacitracin are shown in Table III. On a dry weight basis, control was higher than any treated group except the 5 PPM (Table III). Both final height and dry weight were more in the 5 PPM treated group than in control. The results of this experiment are somewhat questionable because the same weather and temperatures were encountered as in Ex. III since both were performed at the same time.

Results of Experiment V testing erythromycin are shown in Table V. In this experiment the greatest final average height was in the 10 PPM treated. Before treatment was begun, both the 20 PPM and control group had a higher average height than did the 10 PPM group, (control—5.8 Cm., 20 PPM—6.3 Cm., 10 PPM—5.0 Cm.). Dry weight shows the 5 PPM treated plants to weigh more dry than any other group. (Table V) The 10 PPM group, which it will be remembered were tallest, weighed less dry than controls and all treated excepting the 1 PPM group. (Table V)

Results of Experiment VI, testing streptomycin sulfate, are shown in Table VI. All treated groups, except the 20 PPM, had less final height than control. The 20 PPM treated had the greatest height of all treated groups. Dry weights showed control to weigh more than any treated except the 10 PPM group which weighed 1% more than the control group. The 20 PPM treated group, which had the greatest height, weighed the least dry of all groups. In general, treated plants weighed less dry than controls.

Results of Experiment VII are shown in Table VII. These results are practically duplicates of those observed in Experiment V (Table V). In Experiment V, the dry weight increase was 10% over control dry weight. In Experiment VII, the dry weight increase
over controls was 8%. The control plants when dried in three separate groups, of 12 plants showed the following weights per group:

- Group I: 4.5 g.
- Group II: 4.4 g.
- Group III: 4.1 g.

Tests sensitive to 4 Mcg/ml for erythromycin presence in water extracts of control and plants treated with erythromycin 24 hours previously were both negative.

**DISCUSSION**

Growth is defined, perhaps somewhat imperfectly, as being increase in size, or increase in height and weight (7). In the present study, growth of corn plants was determined by three criteria:

1. Increase in length (height) of stem.
2. Increase in dry weight.
3. Increase in fresh (wet) weight.

These indices of growth are from six named by Meyer and Anderson (7).

In a study of this type, the problem of significance of results arises, i.e. is the phenomenon under consideration an artifact, or is it a result of the treatment administered by the investigator. It can be seen from the results that by consideration of the indices of growth mentioned above, in certain cases antibiotic treated corn plants grew larger than control plants, and in certain other cases control plants grew larger than treated plants. One can infer from these results that where a growth increase occurred, that concentration of antibiotic stimulated growth in respect to a wet and dry weight increase and/or a height increase. However results are such that one can infer that each antibiotic also inhibited growth at some concentration other than the concentration which supposedly stimulated growth. (Tables I-VIII). The question to be answered is, were these growth increases and decreases due to antibiotic treatment or to other factors which were beyond experimental control. Tables I-VIII show considerable inconsistence between dry weights and height measurements; that is, some groups weighing more than others had less average height. Due to their morphology, corn plants are
somewhat difficult to measure for height. In some cases, a plant which had the uppermost leaves vertical would be measured as taller than a more mature and often larger plant on which the uppermost leaves had bent downward. Therefore, not too much significance is attached to results dealing with height of the plants, and the remainder of this discussion will be concerned more with interpretations of dry weight increases and decreases.

It is well known that each living organism is an entity with its own physiological weaknesses and strong points. Although in these experiments only genetically pure seed was used, there could not help but be differences in growth capabilities of each seed; some plants should, under the same conditions, be able to grow larger in a given length of time than others because of this. It is thought that root and light competition did not enter in since the plants were grown in individual flower pots, and at the spacing they were given, serious overlapping of leaves did not occur. On the other hand, it is likely that in a study of this type, some plants might have available a slightly larger amount of water, and be exposed to a little more sunlight than others, thus in a few cases adding to the advantages of some plants over others.

It is admitted, therefore, that even in groups of 12 test and 12 control plants, some variations in height and weight may have been, and in a majority of cases probably were caused by factors other than antibiotic treatments. The growth effects of two groups of treated plants do appear to have been caused by antibiotic treatment. These are the 5 PPM group of Ex. I (potassium penicillin) and the .5 PPM group of Ex. II (procaine penicillin).

The results of the 5 PPM treated group in Ex. I are obviously most spectacular for growth increase. Here, where dry weight of the treated plants averaged 40% more than control, a growth stimulation of some sort cannot be denied. Since height of treated plants remained about equal to controls, it would mean that the treated plants weighed more per unit height than did the controls. In Experiment III the results were not so spectacular, the dry weight increase of treated plants being only 10% (Table IV). Since 36 plants in each group were measured and weighed in Ex. III it should have been more reliable, however, the facts that during the course of this experiment the plants were periodically subjected to some rather low
temperatures and there was much dark weather may have tempered the results, and perhaps if conditions had been more ideal, results more nearly approaching those of Experiment I would have occurred.

It has been shown that penicillin is taken up by higher plants (Lepidium), although the antibiotic is decomposed considerably in soil (8). Wright has shown that growing on agar on pH of 6.0, the root growth of wheat, white mustard and red clover seedlings is enhanced by penicillin at a 5 PPM concentration. The form, i.e. potassium penicillin, etc., was not named (9). These results tend to substantiate the indication that at a concentration of 5 PPM potassium penicillin stimulated growth of young corn plants in this study.

From Table II, it can be seen that growth of the .5 PPM procaine penicillin treated group was 20% less than that of the control group on a dry weight basis. Wet weight and height measurements are also somewhat lower indicating that at this concentration procaine penicillin seemingly inhibits growth. Reported cases where penicillin in such low concentration inhibits growth are lacking, and again the question of whether an actual inhibition due to penicillin action took place, or whether other factors are responsible for this inhibition arises. That the antibiotic treatment and other factors both are involved in this inhibition of growth is entirely possible. Since all treated groups of Ex. II have lower average height, lower wet weight, and all but the 3 PPM treated group have lower dry weight than controls it appears as if a general inhibition of growth for plants treated with various small amounts of procaine penicillin has taken place.

Since the antibiotic portion of the compound was the same in the potassium and procaine forms, one would think that results of Ex. I and Ex. II would be similar if not identical. However, the results of the treated groups in Ex. II are exactly opposite to the results in Ex. I. Remember that in Ex. II most treated groups weighed less dry than the controls, but in Ex. I, nearly all groups which were treated weighed more dry than did the controls. (Tables I, II, VIII.) After noting that corn treated with potassium penicillin generally grew larger than controls, while those treated with procaine penicillin generally grew less than controls, one recognizes the possibility of the growth stimulating and inhibiting causes resting with the cations potassium and procaine respectively rather than with the antibiotic anion penicillin. It is well known (7) that potassium is an essential
element for plant growth, and the small amounts of potassium added with the antibiotic could have had a stimulating effect especially if the soil should have been slightly deficient in potassium to begin with. Procaine on the other hand is well known as a narcotic. The presence of this compound in soils might very well cause a growth inhibition if absorbed since some narcotics in low concentration do cause a slowdown of photosynthesis and respiration (7).

Further evidence that the dry weight increase for the 5 PPM potassium penicillin treated group and the dry weight decrease for the .5 PPM procaine penicillin treated group due to factors other than inherited physiological differences is offered through a comparison of control plant data for both the potassium and procaine groups. The difference in dry weight for control plants of Ex. I and Ex. II is only 14%. It is to be remembered that these plants were planted at the same time and grown under identical light and moisture, and temperature conditions.

Attention is also called to the results observed when the control plants from Experiment VII were divided into three groups of 12 plants each before dry weight was measured. The greatest dry weight difference between these three groups was only 10 per cent. Thus, in two instances where (theoretically) identical dry weights should have been obtained between two and three groups of plants the differences were only 14 per cent and 10 per cent. It is thought after considering the above mentioned comparisons that a weight difference of over 20 per cent is due, partially at least, to either the cations potassium and procaine or to the anion penicillin derived from antibiotic treatment.

The results of Experiments IV, V, and VI show no dry weight increase over 10 per cent for treated over control, nor any dry weight decrease of over 18 per cent. Height differences, too, were slight. However, what is thought to be a significant factor is observed in that all experiments show the same general trend as to dry weight and height. The .5 or 1 PPM groups are generally of lower dry weight and height than are the controls (Tables I, II, III, V, VI). An increase in dry weight then occurs through 3, 5, and 10 PPM groups in many cases, with a leveling off or drop of dry weight and height in the 10 or 20 PPM groups (Tables I, II, III, V, VI). This appears
to the writer to be further indication that the antibiotic treatments did have some effect on the plants.

Results showing less than 20 per cent dry weight increase are thought not to be conclusive evidence for the effect of antibiotics, however, some importance may be attached to the fact that in Experiment VII, using 36 treated and 36 control plants, treated plants showed nearly the same dry weight increase as the corresponding group in Experiment V. The results of Experiment VII further strongly indicate that a concentration of 5 PPM erythromycin may be the cause for an increase in dry weight. However, even using the number of plants as in Experiment VII there still remains the possibility that a dry weight increase of only 8 per cent is likely to be due to factors other than antibiotic treatment.

The most nearly constant dry weight, wet weight and average heights are found in Experiment VI, the streptomycin sulfate treated group. This lack of significant effects on growth by the streptomycin treatments may be due to the fact that streptomycin is adsorbed by soil particles, and is practically inactivated in this manner (10). It was also found that adsorbed streptomycin is difficult to remove by base exchange procedures; ion exchange has been found to be one of the ways in which roots of higher plants absorb materials (7). It should not be inferred from the preceding statement, however, that streptomycin was not absorbed by the roots of the corn plants in Experiment VI, for it has been shown that from an aqueous solution streptomycin is absorbed by soy bean seedlings (11). If there is an effect on growth of corn by these lower concentrations of streptomycin, it would have to be considered a general growth inhibition similar to the effect of the procaine penicillin in Experiment II.

Anderson (11) has found that at concentrations of 50 to 200 units/ml. streptomycin is toxic to tomato and radish seedlings and stunts soy bean seedlings which as seeds had been immersed in a solution containing the antibiotic. The corn plants in Experiment VI were given from 140 to 5920 Mcg. of streptomycin per week, so it may very well be that if any streptomycin was absorbed inhibition of growth occurred.

In a study similar to the one under consideration, Nickell (12) has found that terramycin apparently stimulates growth and increases
germination of corn seed. However, Nickell (12) obtained only 41 per cent germination of antibiotic treated seed and 25 per cent germination of control seed. It seems that seeds which should be expected to give accurate results would have given a much higher percentage of germination in both cases. It has been shown that terramycin is inactivated, it too may be adsorbed by soil particles (13). The growth increase of the treated group over controls in Nickell’s (12) study was 27.5 per cent on a dry weight basis, and 25 per cent on an average height basis. The conditions under which Nickell (12) grew his corn plants (in two greenhouse flats) did not rule out root competition. Thus the significance of results in Nickell’s study is doubtful just as it is in the present study. Of course, it may be argued that in Nickell’s study the control plants being fewer and probably planted farther apart had every advantage to outstrip the treated plants in weight because the controls would have more room for root growth and increased light conditions, (Nickell used 12 control and 20 treated plants). It is suspected that after four weeks of growth twenty corn plants averaging over 17 inches in height would be crowded for space if grown in a standard size greenhouse flat, the dimensions of which are about 18 by 24 inches. It is very possible, therefore, that growing in individual pots corn plants treated with terramycin may show more than 27.5 per cent dry weight increase. Both Nickell’s and the present results should be accepted with reservation until further experiments with terramycin are performed.

SUMMARY

1. This study deals with effects of 5 antibiotics on growth of young corn plants.

2. Indications are that a 5 PPM solution of potassium penicillin increases growth of young corn plants which are watered with 25 ml. of the solution per plant four times a week for a period of four weeks.

3. Indications are that a .5 PPM solution of procaine penicillin inhibits growth of young corn plants when treated with 25 ml. of the antibiotic solution per plant four times a week for four weeks.

4. If the growth increases and decreases were due to potassium and procaine penicillin respectively the possibility exists that these effects may have been due to the potassium and procaine rather than the penicillin.
5. Effects on growth of corn plants of the antibiotics bacitracin, erythromycin and streptomycin are thought to be slight.

6. Tests sensitive to 4 Mcg./ml for presence of erythromycin in water extracts of treated plants and control plants were negative.

ACKNOWLEDGMENTS

Thanks is expressed to the following persons: To the late Dr. Ray C. Friesner for his aid in working out the procedure for the initial supervision of the study; Dr. Rex N. Webster for suggestions and continued supervision of the research; Dr. J. E. Potzger for suggestions and critical reading of the manuscript; Mr. William A. Daily and Dr. James M. McGuire of Eli Lilly and Company for their suggesting the problem; to my fellow student Robert O. Petty for help in measuring the plants.

The antibiotics used in the experimentation were furnished by Eli Lilly and Company. They also provided the facilities for extracting and testing the extracts for presence of erythromycin. It is with gratitude that this support of the investigation is acknowledged.

LITERATURE CITED


### TABLE I

Height and weight of treated and control plants from Experiment I
(Potassium Penicillin)

<table>
<thead>
<tr>
<th>Concentration (PPM)</th>
<th>Height (Cm.)</th>
<th>Weight (Gms.)</th>
<th>% of dry weight of control</th>
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### TABLE II

Height and weight of treated and control plants from Experiment II
(Procaine Penicillin)

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<th>Concentration (PPM)</th>
<th>Height (Cm.)</th>
<th>Weight (Gms.)</th>
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Height and weight of treated and control plants from Experiment IV
(Bacitracin)

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### TABLE IV
Height and weight of treated and control plants from Experiment III
(Potassium Penicillin)

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<thead>
<tr>
<th>Concentration PPM.</th>
<th>Height (Cm.)</th>
<th>Weight (Gms.)</th>
<th>% of dry weight of control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ave.</td>
<td>Median</td>
<td>Mode</td>
</tr>
<tr>
<td>Control</td>
<td>22.5</td>
<td>22</td>
<td>24</td>
</tr>
<tr>
<td>5</td>
<td>20</td>
<td>19</td>
<td>19</td>
</tr>
</tbody>
</table>

### TABLE V
Height and weight of treated and control plants from Experiment V
(Erythromycin)

<table>
<thead>
<tr>
<th>Concentration PPM.</th>
<th>Height (Cm.)</th>
<th>Weight (Gms.)</th>
<th>% of dry weight of control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ave.</td>
<td>Median</td>
<td>Mode</td>
</tr>
<tr>
<td>Control</td>
<td>31.0</td>
<td>31</td>
<td>33</td>
</tr>
<tr>
<td>1</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>3</td>
<td>30.4</td>
<td>30</td>
<td>31</td>
</tr>
<tr>
<td>5</td>
<td>31.4</td>
<td>31</td>
<td>35</td>
</tr>
<tr>
<td>10</td>
<td>32.7</td>
<td>32</td>
<td>35</td>
</tr>
<tr>
<td>20</td>
<td>32.4</td>
<td>32</td>
<td>35</td>
</tr>
</tbody>
</table>
### TABLE VI
Height and weight of treated and control plants from Experiment VI
(Streptomycin)

<table>
<thead>
<tr>
<th>Concentration (PPM)</th>
<th>Height (Cm.)</th>
<th>Weight (Gms.)</th>
<th>% of dry weight</th>
<th>Wet</th>
<th>Dry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>30.3</td>
<td>28</td>
<td>28.5</td>
<td>66.2</td>
<td>7.7</td>
</tr>
<tr>
<td>1</td>
<td>29.7</td>
<td>29</td>
<td>29</td>
<td>57.2</td>
<td>7.1</td>
</tr>
<tr>
<td>3</td>
<td>28.0</td>
<td>28</td>
<td>30</td>
<td>58.7</td>
<td>7.4</td>
</tr>
<tr>
<td>5</td>
<td>28.5</td>
<td>29</td>
<td>30</td>
<td>53.2</td>
<td>7.3</td>
</tr>
<tr>
<td>10</td>
<td>27.8</td>
<td>29</td>
<td>30</td>
<td>63.5</td>
<td>7.8</td>
</tr>
<tr>
<td>20</td>
<td>29.0</td>
<td>29</td>
<td>32</td>
<td>52.4</td>
<td>6.9</td>
</tr>
</tbody>
</table>

### TABLE VII
Height and weight of treated and control plants from Experiment VII
(Erythromycin)

<table>
<thead>
<tr>
<th>Concentration (PPM)</th>
<th>Height (Cm.)</th>
<th>Weight (Gms.)</th>
<th>% of dry weight</th>
<th>Wet</th>
<th>Dry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>27.0</td>
<td>28</td>
<td>29</td>
<td>118.7</td>
<td>13.0</td>
</tr>
<tr>
<td>5 PPM</td>
<td>27.5</td>
<td>28</td>
<td>30</td>
<td>117.1</td>
<td>14.0</td>
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</tbody>
</table>

### TABLE VIII
Showing dry weight % above or below control dry weight for various concentrations—for comparison

<table>
<thead>
<tr>
<th>Antibiotic</th>
<th>.5</th>
<th>1</th>
<th>3</th>
<th>5</th>
<th>10</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>K Penicillin</td>
<td>98%</td>
<td>126%</td>
<td>110%</td>
<td>140%</td>
<td>108%</td>
<td></td>
</tr>
<tr>
<td>Procaine</td>
<td>80</td>
<td>92</td>
<td>110</td>
<td>88</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Bacitracin</td>
<td>84</td>
<td>94</td>
<td>84</td>
<td>110</td>
<td>94</td>
<td></td>
</tr>
<tr>
<td>Erythromycin</td>
<td>82</td>
<td>97</td>
<td>110</td>
<td>90</td>
<td>104%</td>
<td></td>
</tr>
<tr>
<td>Streptomycin</td>
<td>92</td>
<td>95</td>
<td>95</td>
<td>101</td>
<td>90</td>
<td></td>
</tr>
</tbody>
</table>

86