SOME EFFECTS OF VARIOUS ANTIBIOTICS ON THE EARLY GROWTH OF CERTAIN CROP PLANTS

by

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INTRODUCTION

The growth of plants is of fundamental importance to agriculturists and to students in all phases of the plant sciences. Growth commonly implies a permanent increase in the size of the plant or its parts as the result of the incorporation of materials from the environment. Boysen-Jensen (1936) considered plant growth to be the result of the absorption of water, the synthesis of new protoplasm, extension of cellular walls, and increase in weight.

When attempts are made to analyze the different chemical reactions and physical conditions that contribute to plant growth it has been found useful to separate the substances concerned into two classes. The first class includes the inorganic nutrients, the organic foodstuffs, and water. This class has to do mainly with the nutritive aspect of growth. The second class includes the chemical growth regulators. This class is concerned with the chemical regulation and integration of growth. Members of this class act in very low concentrations as compared with those of the first class. In order to give this distinction a concrete basis and thus clearly separate the two classes, Thimann (1952) suggested that the designation "low concentration" be interpreted as concentrations below one thousandth molar (M/1000).

The concept of plant growth being under the control of substances native to the plant and existing therein in low concentrations was first implied late in the nineteenth century. Since then it has received scientific confirmation and has been extended to include many chemical compounds not native to the plant. Many different groups of chemicals of the latter type have been found capable of regulating plant growth and plant physiologists are constantly searching for this quality in other compounds. The present study involves a critical investigation of five members of a group of compounds known collectively as "antibiotics" to determine if they have this quality, particularly in the sense of being able to stimulate the rate and extent of growth in seed plants.

REVIEW OF LITERATURE

Charles Darwin, noted pioneer student of organic evolution, and Julius von Sachs, often considered the father of modern plant physiology, were the first to postulate the existence of chemical substances, native to plants, that regulate and integrate their growth. Darwin (1881) showed that the tip of the stem axis of a grass seedling must be present for phototropism to occur. From this he deduced a vague generalization that the tip is the source of the substances controlling this reaction. Went (Skoog, 1951) stated that Sachs in summarizing his studies extending from 1865 to 1887 developed a more soundly based concept of chemical control.

Went (Skoog, 1951) further stated that Sachs made attempts to extract these "chemical messengers" but that his crude methods prevented success. Other workers of that and following eras did not consider Sachs' hypothesis valid and a series of studies extending well into the present century were designed to discredit it. Thus the controversy regarding chemical control and integration of plant growth continued unabated for many years. Went and Thimann (1937) reported that Paal in 1919 was the first worker to clearly establish that growth in a plant is controlled through the agency of a substance or substances formed continuously in small amounts in the plant, particularly at the stem tip, and capable of diffusing through the plant. They also stated that Paal found that such a substance normally gives rise to symmetrical growth of a plant and that the various tropisms are but distortions of the normal symmetrical pattern of growth. Paal's studies definitely established a basic concept in the field of plant physiology that all growth is regulated and integrated by a diffusible substance or substances produced by the plant itself.

Starling (1906), an animal physiologist, coined the term hormone for chemical substances produced in one part of an animal and transported in small quantities to distant parts where they produced their effects. Curtis and Clark (1950) stated that this term was soon adopted by plant physiologists for the chemical substance or substances that diffuse in minute amounts from the tip of a plant axis and control growth and integration in that axis. Thus, the designation "hormone" is useful and correct for such substances synthesized by the plant itself. Kögl, Erxleben, and Haagen-Smit (1934) and Kögl, Haagen-Smit, and Erxleben (1934) clarified the chemical nature of plant hormones when they isolated three compounds from plant materials, of which one, then designated heteroauxin but now known to be indoleacetic acid, is probably, according to Meyer and Anderson (1952), the principal hormone functioning in higher plants.

In addition to the naturally occurring hormones in plants there are a number of compounds known which, according to Meyer and Anderson (1952), when introduced into the plant in relatively small quantities, induce growth effects, similar to if not identical with those produced by the indoleacetic acid. By an extension of the original concept of the term hormone it is used to include these additional compounds. Mitchell and Marth (1947) clarified the situation by retaining the term "hormone" when the substance is synthesized by the plant and using the term "growth regulator" for substances not native to the plant. In the functional sense the designation "growth regulator" is correctly used for both groups.

The importance of the discovery that the control of growth and integration of plants is not limited to native hormones was the realization that many other chemicals can be used to influence plant growth. Since, as Bonner and Galston (1952) stated, agricultural research is primarily a matter of applying scientific findings to specific problems of crop production, the discovery that many organic compounds not native to plants could influence plant growth and integration brought man a step closer to the goal of scientific agriculture, namely, the control of plant growth and development.

From the time it was learned that organic compounds not synthesized by the plant could influence plant growth, plant physiologists have been constantly seeking additional compounds or groups of compounds which cause this effect. Robbins (1939) stated that Williams had reported as early as 1920 that vitamins exercised a favorable growth effect on higher plants but that the crudeness of his preparation prevented definite confirmation of this fact. Robbins further stated that chemically pure vitamin B_1 became available in 1934. Bonner (1937) found vitamin B_1, or thiamin, necessary for continued growth of excised roots. Later work confirmed this finding. Knowledge that vitamin B_1 is essential for growth of excised roots led to experimentation to determine if it influences growth in intact plants. Bonner and Greene (1938) reported that vitamin B_1 gave rise to increased growth in intact plants. This finding, apparently premised on insufficient data, has not been confirmed. However, Logan (1939) writing in a popular garden magazine presented this unconfirmed report in a sensational manner thus confusing the general public who considered vitamins essential to animals but not to plants. Curtis and Clark (1950) summarized the present concept by stating that all plants require vitamin B_1 but that apparently all higher plants synthesize it in sufficient quantities and that there is no justification for the claim that higher plants are stimulated to increased growth by adding vitamin B_1 to the soil.

Another heterogeneous group of chemicals, the antibiotics, have recently been reported to exercise a stimulatory effect on growth when applied in very low concentrations to the soil in which higher plants are growing. This invokes the question regarding the absorption of antibiotics in the soil by the roots of higher plants and their subsequent translocation within the plant.

Several workers have shown that various antibiotics can be absorbed by the roots of higher plants and translocated through such plants. Anderson and Nienow (1947) found that streptomycin sulfate was absorbed from sand cultures by soybeans. Boyle (1949) reported that penicillin diffused through the tissues of the giant cactus when injected into the plant with a hypodermic needle. Blanchard and Diller (1951) observed that aureomycin was absorbed by the roots of the lima bean and translocated through the plant. Brian, Wright, Stubbs, and May (1951) detected griseofulvin in the guttation droplets of oat seedlings grown in a solution containing the antibiotic. They further observed that this antibiotic was translocated in the tomato as demonstrated by its action as a systemic fungicide when the plants were grown in nutrient solution containing the antibiotic. Gopalkrishnan and Jump (1952) found that tomatoes did not develop fusarium wilt when grown in solutions containing the antibiotic, thiolutin. Streptomycin sulfate and dihydrostreptomycin sulfate were found to be absorbed through the stem and translocated to the primary leaves of beans by Mitchell, Zaumeyer, and Anderson (1952). Winter (1952) found that garden cress absorbed and translocated penicillin and streptomycin from both nutrient solutions and composted soil.

Nickell (1952a) reported that plant growth, at least, in the early stages, was influenced in a stimulatory manner when a very low concentration of an antibiotic was added, the day of planting and each of the three days following, to the soil in which higher plants were growing. He used terramycin at a concentration of 5 ppm. Nickell (1952b) added a liter of the antibiotic solution to each of the experimental flats and a liter of tap water to the control flats each of the four days of the treatment period and gave both groups ordinary greenhouse care thereafter during the 28-day growing period. He used increases in plant height, wet weight, and dry weight of experimental plants over control plants as criteria of growth.

Mitchell (1953) reported that studies patterned after those reported by Nickell (1952a and 1952b) failed to show that terramycin hydrochloride stimulated the early growth of higher plants as the latter had reported. Mitchell used plant height and dry weight increases of treated plants as criteria of growth. He used this antibiotic at concentrations of 1.25, 5.0, and 20 ppm the day of planting. He kept the amount of antibiotic constant during the test period which varied from 2 to 8 days even though weather conditions necessitated a change in the water volume to be added. Hence, these indicated concentrations were specifically adhered to only the first day of the test period. He used U.S. 13 hybrid field corn as the test plant in most of the work but also used the Scarlet Globe variety of radish and the Black Valentine variety of bean in limited studies. Mitchell stated, "..... results of experiments completed so far fail to show that terramycin hydrochloride consistently stimulated the early growth of plants studied."

Nickell (1953) reaffirmed his previous finding that antibiotics have a stimulatory influence on plant growth. He presented data on additional antibiotics, namely, bacitracin, procaine penicillin, diamine penicillin as well as terramycin. Many unduplicated experiments involving small numbers of samples were reported. Two generalizations may be drawn from the findings presented: (a) It is contended that antibiotics at low concentrations stimulate the growth of higher plants, at least, during the first few weeks after germination, and (b) it is conceded that antibiotics may "best show their effects in overcoming adverse conditions."

MATERIALS AND METHODS

Plant Materials

The experimental plants were field corn, wheat, sweet corn, and snap bean. The first two represent agronomic crops and the last two horticultural crops. None of the seed used had been treated with a fungicide.

The field corn was furnished by Dr. Loyd A. Tatum, U.S.D.A. Agronomist, located at Kansas State College. A single cross, K148 x K150, with a germination of 97 percent, and a double cross white corn, CB 8907W, with a germination of 96 percent, were used for the various experiments as indicated. The single cross was selected for its high degree of genetic uniformity and the double cross for its relatively high genetic uniformity and its availability in sufficient quantities. The wheat used was Pusa 52 x Federation C.I. 11764, germination 95 percent, a short season, white seeded, hard spring wheat from India obtained from C. O. Johnston, U.S.D.A. Pathologist, located at Kansas State College. It has been found to grow extremely well in the greenhouse in Kansas during the winter season.

The sweet corn used was a hybrid, Golden Cross Bantam variety, which gave a germination of 93 percent. It was furnished by the Corneli Seed Company of St. Louis, Missouri. A snap bean, designated Tenderlong No. 15, with a germination of 87 percent, provided by the Associated Seed Growers, Inc., Indianapolis, Indiana, was used.

Antibiotics Used

The following five antibiotics were used: aureomycin, bacitracin, penicillin, streptomycin, and terramycin. Chas. Pfizer & Co., Inc., Brooklyn, N. Y., furnished the procaine penicillin, streptomycin sulfate, and terramycin hydrochloride and the Lederle Laboratories Division, American Cyanamid Company, Pearl River, New York, supplied the aureomycin hydrochloride and bacitracin.

All antibiotics used were both readily soluble and stable in aqueous solution. They were kept dry in closed containers in the refrigerator. Solutions were prepared in tap water as needed for each treatment and were used the day they were prepared. The concentration of the solution was based on the activity of the antibiotic. Baron (1950) defined the activity of an antibiotic as a measure of its strength given in micrograms or units per milligram. The activity in units of the antibiotics used was: aureomycin hydrochloride 1008 and 937, bacitracin 50 and 54.5, procaine penicillin 1008 and 1036, streptomycin sulfate 765, and terramycin hydrochloride 890. Thus in these experiments 5, 10, 15, or 20 units of activity in 1000 milliliters of water were considered as 5, 10, 15, or 20 parts per million (ppm) respectively.

Experimental Methods

All experimentation was conducted in the greenhouse. The methods used for plants grown in flats were those of Nickell (1952a), while the general procedures of Mitchell (1953) were used for pot-grown plants. Both flats and pots were filled with a good loam soil to which fertilizer (Vigoro) and a fine sand had been added at the rate of 30 cc of fertilizer and one shovelful of fine sand to five shovelfuls of soil. These were mixed by running through a soil pulverizer. The same soil was used in all experiments. The soil was repulverized and fertilizer added at the same rate between experiments.

Much of the experimentation was done with plants grown in flats measuring 12 x 22 x 3 inches inside. Field and sweet corn were planted 44 kernels per flat, wheat 55 kernels, and beans 28 seeds per flat. The more extensive later experimentation was done with plants grown in 5-inch pots to facilitate statistical treatment. The pot experiments were limited to field corn which was planted four kernels per pot. Planting guides were used in all instances to space the plants uniformly and plantings were made at a depth of a half inch. The number of flats or pots used varied with the experiment.

The plants were harvested four or six weeks after planting by severing at the soil line. While height and wet weight of the aerial portions of the plants were obtained, only the dry weight is reported here.

Killing of the plant tissues was accomplished either by holding in the air stream of a circulating hot air oven at 105° C. or by autoclaving for five minutes at five pounds pressure (Loomis and Shull, 1937). In either case drying was completed in the circulating hot air oven at 105° C. for a three-hour period. After drying, the materials were cooled and the dry weight taken.

Method and Time of Application of Antibiotic Solution

In most experiments the antibiotic solution was sprinkled uniformly over the soil each day for four days, beginning the day of planting. This concluded the period of treatment in these experiments, following which the plants received regular greenhouse care except that special precautions for uniformity in watering were observed.

Experiment 2 had to do with the time of application of the antibiotic. The experimental plants were divided into two groups, one of which received the antibiotic solution each day for the first four days after planting, as in the experiments described above, and the second group received them for four consecutive days beginning one week after planting.

All plantings, treated and untreated, received the same amount of water and were provided with free drainage at all times. Care was exercised to get uniform distribution of antibiotic solutions and/or water over the entire soil surface.

The first experiment was of an exploratory nature. It involved five antibiotics; aureomycin, bacitracin, penicillin, streptomycin, and terramycin, each applied at a concentration of 5 ppm the first four days of the experiment. One liter of solution was added to each flat each day. Six flats each of wheat, snap beans, and a single cross field corn were used of which five were experimental and one a control. The beans and corn were harvested at the end of four weeks and the wheat at six weeks. The experiment extended from mid-November through December 1952.

The second experiment was concerned with time of application of one antibiotic, terramycin. It was applied at concentrations of 5, 10, and 15 ppm using a single cross field corn as the test plant. The amount of test solution used the first week was 800 milliliters but due to cloudy weather only 500 milliliters were used the second week. Two flats were used for each concentration, one treated the first week and the other the second. The plants were harvested four weeks after planting. The experiment extended through the month of December 1952.

The third experiment involved sweet corn as the test plant and terramycin as the antibiotic, both of which were used in the experimentation of Nickell (1952). The sweet corn used had a germination of 93 percent, which was much higher than that used by Nickell. The terramycin was used at 5 and 10 ppm and each treatment was replicated three times. Three untreated flats served as controls. The treatment was started at the time of planting and 500 milliliters of solution applied each day for four days. This experiment extended from mid-December 1952 through mid-January 1953.

Experiment 4 was quite extensive. It involved a comparison of the effect of the various antibiotics with that of the other antibiotics and with the untreated control. Sufficient pot-grown plants of a double cross field corn were used to render statistical treatment valid. The experiment was divided into two parts. Three antibiotics, aureomycin, streptomycin, and terramycin, and a control were included in the first stage which was conducted during the month of April 1953 and a second during May 1953 with the three antibiotics, bacitracin, penicillin, and streptomycin, and a control. The concentrations of antibiotics used were 5 and 20 ppm, except in the first part streptomycin was used at 15 ppm rather than 20 ppm. The volume of antibiotic used was 100 milliliters per pot per day during the treatment period. In this experiment all treatments were made the day of planting and the three following days. One control unit and six treatment units, each unit consisting of four pots, were randomized in each block. The pots containing missing and/or abnormal plants were removed from the experimental blocks and replaced with identically treated pots having four normal plants. Such exchanges were made early in the experiment. The plants were harvested four weeks after planting with seven blocks harvested in the first and nine in the second stage. The entire experiment was protected by a guard row.

EXPERIMENTAL RESULTS

It is difficult to define growth, but one of the more satisfactory definitions from a quantitative standpoint is the increase in dry weight of a plant or plant part (Curtis and Clark, 1950). The criterion of growth used in this study is a comparison of the dry weight of treated and untreated plants.

In Experiment 1 the five antibiotics (aureomycin hydrochloride, bacitracin, procaine penicillin, streptomycin sulfate, and terramycin hydrochloride) at a concentration of 5 ppm were compared with each other and with the control using six flats, one of which served as control, for each of three test crops, namely, wheat, snap beans, and a single cross field corn (K148 x K150). The corn and beans were harvested four weeks and the wheat six weeks after planting. No consistent influence on growth was shown by any of the antibiotics on any of the test crops nor did any of the antibiotics cause consistent growth stimulation over the controls. The average dry weight per plant for each treatment and for the controls is given in Table 1.

One decision reached as a result of the experiment was the choice of field corn of, at least, relatively high genetic stability for all additional experiments to be conducted in this study except the experiment on sweet corn. Such field corn was available and its low plant to plant variability was considered to provide a suitable background for any growth influence antibiotics may have. The unevenness of tillering in the wheat and the tall, spindly growth of the beans under winter conditions in the greenhouse aided in this decision.

Table 1. The average dry weight of plants from each antibiotic treatment and from the control.

	Crop		
	Beans	Corn	Wheat
Treatment		gm	
Aureomycin	0.576	0.566	0.488
Bacitracin	0.714	0.555	0.406
Penicillin	0.663	0.505	0.433
Streptomycin	0.796	0.558	0.519
Terramycin	0.596	0.495	0.491
Control	0.660	0.493	0.426

In Experiment 2 terramycin (terramycin hydrochloride) was applied to half the plantings of a single cross field corn (K148 x K150) at three concentrations, 5, 10, and 15 ppm, at planting time and to the other half a week after planting. Six flats were used in the experiment. One flat at each concentration was treated the day of planting and the treatment repeated each of the three following days while the other flat at each concentration was treated for four consecutive days beginning a week after planting. No controls were used as this experiment was concerned with the influence of relative concentration and time of application of the antibiotic. The plants were harvested four weeks after planting. Analysis of variance showed no differences in growth, based on dry weight, for either differences in concentration or time of application. Table 2 summarizes the average dry weight per plant for the different concentrations used and for the time of application.

Table 2. The average dry weight per plant of field corn (K148 x K150) grown in flats and treated with three concentrations of terramycin which were applied to three flats at planting and to three a week later.

Average dry weight per plant of the two flats at each concentration.

Concentration	Average dry weight
5 ppm	0.429 gm
10 ppm	0.425 gm
15 ppm	0.435 gm

Average dry weight per plant of the three flats treated at each time of application.

Time of application	Average dry weight
Immediately after planting	0.401 gm
One week after planting	0.457 gm

Analysis of variance.

Sources	d.f.	Mean square	F
Between concentrations	2	0.105	--
Between time of application	1	9.1	10
Interaction treatments x time (error)	2	0.92	
Total	5		

No significant difference between concentration or time of application.

In Experiment 3 terramycin (terramycin hydrochlcride) was applied to sweet corn at two concentrations (5 and 10 ppm). Sweet corn was used as the test crop as it was one of the plants used by

Nickell (1952a) when he reported antibiotics (terramycin) had a stimulatory influence on higher plants at least the first few weeks after germination. The sweet corn used had a much higher germination than that used by Nickell, however, as it was considered desirable to work with fresh seed of a genetically uniformly strain of sweet corn. Three flats were treated at each of the two concentrations and three were retained as controls. The plants were harvested four weeks after planting.

Analysis of variance showed that there was no significant difference in growth between plants treated with 10 ppm and the untreated controls. The 5 ppm treatment compared with the untreated control plus the 10 ppm treatment showed a curvilinear inhibition of growth (Table 3). This curvilinearity was significant at the 5 percent level. Table 3 shows the average dry weight per plant of the three flats of each treatment and of the controls.

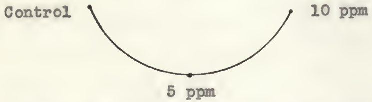
Table 3. The average dry weight per plant of three flats of sweet corn (Golden Cross Bantam) treated with terramycin at 5 and 10 ppm compared with the controls. Also a curve showing curvilinear inhibition of growth at 5 ppm.

Concentration	Average dry weight
Control	0.421 gm
5 ppm	0.384 gm
10 ppm	0.415 gm

Analysis of variance.

Sources	d.f.		Mean square		F	
Between blocks	2		1.78		5.93	
Between treatments	2		1.87		6.23	
Control vs. 10 ppm		1		0.082		0.027
Control plus 10 ppm vs. 5 ppm		1		3.645		12.15*
Interaction blocks x treatments (error)	4		0.30			
Total	8					

* Significant at the 5 percent level.



Curve showing curvilinear inhibition of growth at 5 ppm.

Experiment 4 was an extensive study involving the five antibiotics applied at two concentration levels and providing sufficient control and treatment units that valid statistical analyses could be made. The crop used was a double cross white field corn (CB 5907W). Four kernels were planted to a pot. Sixteen plants in four pots constituted a treatment and/or control unit. Six treatment units and one control unit were randomized in each block (replication) and there were seven blocks in the first half of the experiment and nine in the second half.

The experiment was divided into two parts because of the greenhouse space available. Part 1 was conducted during April 1952 and part 2 during May 1952. Effort was made to conduct the two parts in identical fashion and to keep the greenhouse conditions comparable. The five antibiotics (aureomycin hydrochloride, bacitracin, procaine penicillin, streptomycin sulfate, and terramycin hydrochloride) were used at concentrations of 5 and 20 ppm except that streptomycin which was used in both parts was used at 15 ppm in the first part. All plants were harvested at the end of four weeks.

Table 4 gives the average dry weight of replicate units of 16 plants each, for controls and for those units treated with high or low levels of aureomycin, streptomycin, and terramycin. Table 5 gives the same type of data for bacitracin, penicillin, and streptomycin and the control used in part 2.

The results were similar in both parts of the experiment. Differences in growth between treated and untreated plants were not significant. There were no significant differences among antibiotics nor were the two levels of application of antibiotics significantly different. The difference between the growth of plants treated with streptomycin at 5 and 20 ppm in part 2 approached significance at the 5 percent level.

Table 4. The average dry weight of replicate units, of 16 plants each, from seven blocks of field corn (CB 8907W), for controls and for those units treated with high or low levels of aureomycin, streptomycin, and terramycin.

Antibiotic and level ppm		Average dry weight gm
Aureomycin	5	8.746
"	20	9.086
Streptomycin	5	8.786
"	15	9.121
Terramycin	5	8.847
"	20	8.911
Control		9.100

Analysis of variance.

Sources	d.f.	Mean square	F
Between blocks	6	8.89	13.698**
Between treatments			
Levels			
Control vs. antibiotics	1	0.203	0.313
Aureomycin 5 ppm vs. aureomycin 20 ppm	1	0.405	0.624
Streptomycin 5 ppm vs. streptomycin 15 ppm	1	0.395	0.607
Terramycin 5 ppm vs. terramycin 20 ppm	1	0.015	0.023
Treatments			
Aureomycin vs. terramycin	1	0.009	0.014
Aureomycin plus terramycin vs. streptomycin	1	0.029	0.045
Interaction: blocks x treatments (error)	36	0.649	
Total	48		

** Significant at 1 percent level.

Table 5. The average dry weight of replicate units, of 16 plants each, from nine blocks of field corn (CB 8907W), for controls and for those units treated with high or low levels of bacitracin, penicillin, and streptomycin.

Antibiotic and level (treatment)	ppm	Average dry weight gm
Bacitracin	5	9.071
"	20	8.574
Penicillin	5	9.056
"	20	9.313
Streptomycin	5	8.601
"	20	9.284
Control		8.872

Analysis of variance.

Sources	d.f.	Mean square	F
Between blocks	8	2.42	4.62**
Between treatments			
Levels			
Control vs. antibiotics	1	0.095	0.018
Bacitracin 5 ppm vs. bacitracin 20 ppm	1	1.11	2.12
Penicillin 5 ppm vs. penicillin 20 ppm	1	0.299	0.572
Streptomycin 5 ppm vs. streptomycin 20 ppm	1	2.101	4.02--
Treatments			
Bacitracin vs. streptomycin	1	0.13	0.025
Bacitracin plus streptomycin vs. penicillin	1	1.092	2.088
Interaction: blocks x treatments (error)	48	0.523	
Total	62		

** Significant at 1 percent level.
-- Approaching significance at the 5 percent level.

CONCLUSIONS

Nickell (1952a) stated that terramycin applied to higher plants, particularly sweet corn, at a concentration of 5 ppm induced increased early growth as indicated by greater plant height and dry weight of treated plants.

This study, using dry weight of the aerial portions as the criterion, conducted as four experiments and involving four species of plants (beans, sweet corn, wheat, and field corn, with most of the work done on the latter) and the application of five antibiotics (aureomycin, bacitracin, penicillin, streptomycin, and terramycin) at a range of concentrations from 5 to 20 ppm, gave no significant increases in early growth. The possibility that soil microorganisms provided sufficient antibiotics for the growth attained was not investigated.

These results are in accordance with the findings of Mitchell (1953) who used terramycin in a range of concentrations from approximately 1.25 to 20 ppm in studies conducted primarily on early growth in field corn.

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SOME EFFECTS OF VARIOUS ANTIBIOTICS
ON THE EARLY GROWTH OF CERTAIN CROP PLANTS

by

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INTRODUCTION

The growth of plants is of fundamental importance to agriculturists and to students of the plant sciences. Growth commonly implies a permanent increase in the size of the plant as the result of the incorporation of materials from the environment. When attempts are made to analyze growth it is useful to consider two classes of substances, nutritional substances, and growth regulating substances. The latter are used in extremely low concentrations.

The concept of hormones or native chemical regulators of plant growth has been definitely established for many years. More recently it has been shown that many chemicals not native to the plant influence growth in ways similar to, if not identical with, that induced by hormones. From the time it was learned that organic compounds not synthesized by the plant could influence plant growth, plant physiologists have been constantly seeking additional compounds or groups of compounds which cause this effect. Vitamin B_1 applied to the soil was reported to have this effect on higher plants in 1938 but later experimentation has shown that in practically all cases the plant synthesizes its own in sufficient quantities. Recently it has been postulated that antibiotics stimulate growth in higher plants.

PURPOSE

This study had as its purpose the subjecting of this hypothesis to critical experimentation to determine its validity.

MATERIAL AND METHODS

The antibiotics used were highly purified forms of aureomycin hydrochloride, bacitracin, procaine penicillin, streptomycin sulfate, and terramycin hydrochloride. The experimental plants were a single and a double cross field corn, wheat, sweet corn, and snap bean, all with high germination.

The antibiotics were applied in aqueous solutions from 5 to 20 parts of antibiotic activity per million parts (ppm) of water. The solutions were sprinkled on the soil daily, the day of planting and the three days following, except in one experiment involving the time of application of the antibiotic where this was done to half the experiment at planting and to the other half one week after planting. All plantings, treated and untreated, received the same amount of water and were provided with free drainage at all times.

EXPERIMENTATION AND RESULTS

The first experiment was of an exploratory nature. It included all five antibiotics (aureomycin, bacitracin, penicillin, streptomycin, and terramycin) applied at a concentration of 5 ppm the first four days of the experiment. Six flats each of wheat, snap beans, and single cross field corn were treated, of which five were experimental and one control. Beans and corn were harvested at four weeks and wheat at six weeks. No consistent influence on growth over controls was shown by plants treated with any of the antibiotics.

The second experiment dealt with time and rate of application of the one antibiotic, terramycin. Three concentrations (5, 10, 15 ppm) were applied, one concentration to a flat, to half of the plantings (three flats) at planting, and to the other half a week after planting. In each case the treatment extended for four days. No control was used as the treatments were compared against each other. Plants were harvested at four weeks. Analysis of variance showed no differences in growth, based on dry weight, for either differences in concentration or time of application.

The third experiment dealt with sweet corn since growth stimulation the first few weeks after planting had been reported in this, among other plants. Three flats were treated at each of two concentrations (5 and 10 ppm) and three used as controls. Plants were harvested at four weeks. Analysis of variance showed no significant difference in early growth between plants treated with 10 ppm and the controls, while the 5 ppm compared with the control plus the 10 ppm treatment showed a curvilinear inhibition of growth. This was significant at the 5 percent level.

Experiment 4 was an extensive study involving the five antibiotics applied for four days beginning at planting, at two concentrations (5 and 20 ppm) of each of the antibiotics. The experiment was conducted in two parts: in part one aureomycin, streptomycin, and terramycin were used; in part two bacitracin, penicillin, and streptomycin. Each antibiotic was applied at one concentration to an experimental unit, consisting of four 5-inch pots each with four corn plants, in each block. Each block (replicate) contained seven units, six experimental and one control. There were seven blocks in the first part of the experiment, conducted during April 1953, and nine in the second part, conducted in May 1953. Each pot received 100 milliliters of solution per treatment day while controls received the same quantity of water. Effort was made to keep the growing conditions comparable throughout. Plants were harvested four weeks after planting. The results were similar in both parts of the experiment. Differences in growth between treated and untreated plants were not significant. There were no significant differences among antibiotics nor were the two levels of application of antibiotics significantly different.

CONCLUSION

This study, in which the dry weight of shoots was considered the measure of growth, based on two agronomic and two horticultural plants treated with five of the more common antibiotics at concentration ranges of 5 to 20 ppm gave no significant increases in early growth of seed plants.