Dr. Emsweller presented his paper. (Applause)

(Editor's Note: Dr. Emsweller's talk was illustrated with more than fifty slides. His talk, as presented in these Proceedings, has necessarily been edited, but only to the extent necessary to provide continuity in the absence of the illustrative material.)

Recent Advances in Research That May Be Applied to Horticultural Problems

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When one attempts to speak on a subject as broad as indicated by this title he is confronted with the problem of selecting a few items among the many that are available.

Horticulture is a very broad term and one that is difficult to define. To many it concerns all phases of production of horticultural plant materials. In this sense it includes breeding, pathology, physiology, entomology and all the related fields. It is only very recently that a horticulturist was supposed to be informed in all these fields and in fact many amateur gardeners still consider him a source for all information on all sorts of plants.

At the present time research on horticultural plants is being done by many workers who classify themselves as physiologists, geneticists, pathologists, entomologists and cytologists. Modern research is so complex that it is usually impossible for one man to be trained in all the scientific fields that may be utilized in solving any problem. This has led to close cooperation between research workers trained in different fields and most of the recent discoveries in the plant sciences are the result of fine team-work between two or more investigators.

This is the atomic age and in contemplation of the horrible fact that man has learned how to obliterate whole cities at one fell swoop, we lose sight of the tremendous strides that have been made in the same period in the field of plant research.

Tonight it is my privilege to review with you a few of these discoveries that we as plantsmen are vitally interested in, and that are destined to affect our future handling of the plants we grow. Things are happening so fast that most of us are frequently in a state of confusion but I shall try to make this talk as clear as possible and hope that I succeed better than I did on a former occasion when I was giving a series of three lectures to some college sophomores. I was instructed to be factual but non-technical, and the first and second lectures seemed to me to be getting across very well. On the third day, you can imagine my surprise when I saw a young man seated in the front row before me carrying a large card bearing the letters P. A I. K I thought it was some sort of fraternity initiation stunt, but finally my curiosity overcame me and I asked him what P. A. I. K. stood for. He replied, "It means Professor am I confused?". "But", I said to him, "Surely you know that confused is not spelled with a K" He replied, "Professor you don't know just how confused I am".

Among the many revolutionary developments in plant research of the past decade, we find the tremendous forward strides that have been made in controlling insect pests and plant diseases. By now practically everyone is familiar with the aerosol bombs used for controlling insects in greenhouses as well as in our homes. The aerosol method of applying insecticides was developed at Beltsville and a public service patent was issued, so that no one manufacturer could control or monopolize the method. Prior to the development of the aerosol method of dispersal of insecticides it required several hours to efficiently spray a 150 foot greenhouse and the control effected always left something to be desired. The same area of greenhouse space is now treated in about one and one half minutes, and an entire range of a greenhouse can be handled in a relatively few minutes whereas it formerly required an entire day.

It is difficult for us to realize just what has and is happening in the insecticide and fungicide field. Up to now we have tested only a tiny fraction of the various compounds that have potential possibilities. It is also interesting to note that as these new compounds became available, the aerosol method of application also made its appearance. The aerosol application of hexe-ethyl-tetro-phosphate to greenhouse roses meant an increase of almost 100 percent and caused one particular grower to drop plans for a new greenhouse. These results mostly reflect what happened when red spiders were eliminated. The increase of roses during the months of July, August, September, and October were especially spectacular.

A more recent development is concerned with the use of some of the anti-biotics in controlling plant diseases. You are all familiar with the tremendous strides that have been made in combatting human diseases since the anti-biotics have come into use. There are as you know many bacterial diseases of plants and one of these is commonly known as halo-blight of beans. In preliminary tests, the organism was cultured in petri-dishes and after strong growth was established, a small wafer of filter paper impregnated with an anti-biotic was placed in the center of each petri dish. The bacteria were killed as was evidenced by the cleared circle around each wafer of impregnated filter paper. Following these laboratory tests, infected plants in the field were treated with a dust containing an anti-biotic. While practically all the different anti-biotics used killed the bacteria in the petri dishes, they were not all effective when applied to the plants. Such results explain why all scientists are very cautious and insist in thoroughly proving an hypothesis before making a positive statement. Field trials with certain materials have been successful, and these results have greatly stimulated work on other bacterial diseases of plants, and probably opened a new field, the exploration of which may lead to invaluable results.

At Beltsville in the Division of Ornamental Plants and Diseases we are fortunate in having several fellowship grants for students to work on a particular research problem of special interest to the organization granting the funds. The students take their course work at the University of Maryland and carry on their research with us at Beltsville. One of these fellowships was granted by the American Rose Society for research on black spot of roses looking toward eventual breeding for resistance. The first phase of this work has now been completed by Mr. W. R. Jenkins.

Emphasis has been placed on a further study of *Diplocarpon rosae*, the fungus causing black-spot. It was necessary to determine whether all populations of the fungus were the same in their ability to cause the disease, or whether there were different pathogenic races.

First of all it was necessary to find a medium on which the fungus would grow well and produce enough spores to use in inoculation tests. Formerly the disease could be carried only on growing rose plants. Finally a culture medium of canned green pea extract containing one per cent sucrose and two per cent agar was found to be satisfactory for growing the fungus in test tubes. The fungus grew well and produced a plentiful supply of spores for inoculation tests.

A method for artificial inoculation was developed in which detached rose leaflets were inoculated with one drop of a spore suspension. The suspension was obtained by washing a test tube of the fungus growing on green pea-agar. The leaflets were held at 75° F. for eight days, after which they were rated according to the diameter of the black spot lesion. A resistant rose does not show any spotting. This technique now makes it possible to test literally hundreds of plants in a day.

So far twenty rose varieties and species have been used to test the fungus populations that have come from collections of black spotted rose leaves obtained from all over the country. The work to date has shown that pathogenic races of this disease do exist, and this explains why a rose reported to be resistant to black spot in one area is often found infected when planted in another area. This complicates the breeding program, since resistance should be found to all races of the disease before the over-all program can be said to be effective.

It was my good fortune to visit Europe a year ago last September and again the past spring in April. On the first trip I was one of several Americans invited to present papers at the International Horticultural Congress held in London from September 8 to 15, 1952. On this trip it was possible for me to have a few days in Holland, Germany and France.

In April of this year, I was invited to be a member of the International Jury for the International Flower Show, held every ten years in Holland and known as "The Flora". I was in Holland for three weeks during the height of the bulb flowering season, and was also able to visit all the research institutions where work was under way on horticultural plants.

While in Holland I had expected to stay in a hotel in Harlem, but I was met at the Schiphol airport near Amsterdam and driven to Heemstede where Dr. and Mrs. E van Slogteren had decided otherwise and I spent a delightful three weeks as a guest in their home in Heemstede.

I was given a car to use while in Holland and I was able to drive all over this fascinating country and see all the research I was particularly interested in. Most of my time was spent at the Flower Bulb Research Station at Lisse, where Dr. van Slogteren was the Director. This station was established solely for research on flowering bulb diseases, and has done some very fundamental work in this field. The good Doctor is revered by the Dutch bulb growers and his laboratory is located in the heart of the flower bulb district and the research is concerned mostly with daffodils, tulips, hyacinths and Dutch iris.

One of the most interesting of the many programs that Dr. van Slogteren was working on was their very exact method of determining the presence or absence of a virus disease in a plant. This method was first proposed some years ago by Helen Purdy Beal at the Boyce Thompson Institute. It remained dormant until a few years ago when Dr. van Slogteren, seeking a rapid method for determining the presence of plant viruses, decided to explore its possibilities.

The method is based on the fact that when plant juice containing a virus is injected into the blood stream of an animal, the blood of the animal forms anti-bodies to counteract the foreign material. It may require from twelve to fourteen injections of the virus juice into an animal before a sufficient amount of anti-bodies are formed They have found that this depends on the diet fed to the animals. Carbohydrates should be kept low, but proteins should be high to keep the animal from becoming fat.

When blood is removed from an animal it is allowed to stand at room temperature for several hours. If the coagulation settles, the plasma is decanted off, if not the coagulation is punctured with a fine sterile needle and it then settles to the bottom The serum containing the anti-bodies may be stored for years at about 25° to 27° F. The serum may be diluted to as much as 1 part serum to 320 parts .9 per cent NaCl.

Both horses and rabbits are being used for this work. The injections in a horse may remain effective for as long as one and one-half years. The blood stream maintains a supply of anti-bodies during this period with a gradual loss taking place from month to month.

Only a small amount of blood is removed from the rabbit and after the serum is decanted it is taken to a laboratory where one of the technicians has leaves from a known virus plant as well as from the test plant. The juice is pressed from leaves of each and placed on microscope slides. These slides are placed side by side and a drop of the purified and diluted serum is added to each. The reaction is immediate. A clumping of the chloroplasts indicates that the plant is infected with the virus.

At the present time Dr. van Slogteren has developed anti-sera for about twenty plant viruses. The method is, as you have seen, very rapid and they can literally test thousands of plants in a day. Practically all seed potatoes in Holland are now run through these tests before they are certified.

This very rapid method of testing plants for virus is certainly an improvement over the tuber indexing in common use with potatoes. Dr. van Slogteren has developed anti-sera for five different potato viruses, and now furnishes all the potato districts of Holland with enough anti-sera to test all potato plants destined for seed. When a hyacinth, tulip, daffodil, iris, lily, or gladiolus is brought to the laboratory one of Dr. van Slogteren's technicians can tell in a few minutes whether it is healthy or carrying a virus.

In Holland I also visited the famous nursery town of Boskoop and saw all the research work being done there at the Nursery Research Station. This is a most unusual town in that the nurseries are built on small islands surrounded by canals. The land has been built up over the centuries by dredging soil from the bottom of shallow lakes and piling it up.

One interesting thing I saw here was their double glass frames used for rooting cuttings. These frames are about 2-½ to 3 feet deep and the lowest glass sash rests just over the cuttings. The second sash rests at the top of the frame leaving an air space of 12 to 18 inches. These frames are used for propagating many types of plants and especially for handling newly grafted rhododendron. They use *Rhododendron ponticum* seedlings as understocks and approach grafts. This community is practically 100 per cent engaged in the nursery business and on all sides of the highway the small canals and nursery islands extend as far as you can see. At the Felix and Dyphuis nursery they had a large area devoted to layering of magnolias.

At Wageningen University I saw many interesting things including experiments showing the effects of removing the foliage from plants at various stages of growth. One of the most striking and responsive plants was the tomato. Complete defoliation of tomato induced flowering on even very small seedlings, and, of course, this would greatly speed up a breeding program.

Returning now to work nearer home, I want to mention some of the interesting things that are being done with plant hormones, or as we now call them, growth regulators I am sure you are all familiar with the use of these regulators in inducing rooting of plants, and controlling premature fruit dropping. Recently it has been found that these regulators can also aid in overcoming sterility in some plants. Most of the Easter lilies are highly self-incompatible and we have never been able to obtain seed on some when we have used their own pollen. Several years ago we started to explore the effects of using growth regulators at the time of pollination. The regulators were dissolved in lanolin and applied to various parts of the flower just at time of pollination. The most successful method was to make a wound at the base of a petal and apply the lanolin mixture on the injured area. We used a large number of regulators and several were effective, but 1% naphthalene acetamide proved the most effective. In the Easter lily variety, Creole, for example, a flower that was treated produced a large seed pod and some seed, the untreated flower failed to form a pod. Both flowers were pollinated at the same time. This treatment has made it possible for us to obtain several lily hybrids that we have always failed with when the regulator has not been used.

The growth regulator treatment has also proved beneficial in breeding of lima beans. It is very difficult to obtain very many seed from lima bean crosses and most of the flowers drop after they have been pollinated. Bean flowers are very small and the treatment of the lanolin-growth regulator mixture is applied by using a needle to scratch it into a wound at the base of the pistil. Even with crosses that succeeded occasionally without the regulator, the amount of seed obtained was greatly increased when the regulator was used.

While in England last year, I visited the John Innes Horticultural Research Station to see the work they were doing with horticultural plants. I was very happy to learn that they had obtained pear x apple hybrids by using our growth regulator treatment. These are the first known apple x pear hybrids and have been proven to be hybrids following cytological examination. The plants are still very small and it will be interesting to see them when they flower.

Just recently Dr. Rick at the University of California has written me that he has obtained certain species crosses in tomatoes by using growth regulators at time of pollination. It is possible this method may produce some plant hybrids that have hitherto been unobtainable.

While we are discussing plant breeding let us consider for a few moments another phase that appears to hold considerable promise for the future. We all know that the hereditary material of one generation is transmitted to the next by means of chromosomes. There are 24 chromosomes in the garden lily. If you look closely, you can see there are 12 different kinds of chromosomes We say there are 12 pairs of chromosomes, and every living cell making up the lily plant will have 24 chromosomes. Twelve of these, that is one of each pair came from the male gamete, and twelve came from the female. When a plant has two of each type of chromosome present we call it a diploid, the prefix "di" meaning two, or here two of each kind of chromosome. If three of each kind are present it is then called a triploid, if four are present it is a tetroploid, etc

For some years it has been known in rare cases that a diploid plant may produce a tetraploid branch, and such a branch may bear larger flowers. A few years ago it was found that certain drugs could be used to double the chromosome number and make tetraploids at will. Tetraploids have been obtained in the garden lily and there are four of each kind of chromosomes present. These tetraploid lilies are made by immersing lily scales in a colchicine solution for from three to four hours The colchicine enters the base of the scale and is present in the cells when the scales are planted outdoors in rows in early fall. Scales handled in this manner soon start to produce adventitious buds or scale bulblets and a fairly high percentage of the bulblets will be found to be tetraploids. So far we have made all the commercial varieties of Easter lilies into tetraploids, and in most instances the flowers have been larger and of greatly increased substance. The tetraploid lilies have been very self-sterile, but finally we have obtained some seed and the seedlings have been fairly fertile. At present we have a population of several thousand tetraploid seedlings to select from. We have also made tetraploids of snapdragons, carnations, poinsettias and daylilies.

In general tetraploids are more vigorous than diploids and bear larger flowers of much greater substance. Almost without exception, however, they produce fewer flowers per plant and most of them flower later than the diploid. It appears however that selection among tetraploid seedlings can improve the yield and also increase earliness.

In addition to ornamentals, at least one tetraploid apple has been produced by colchicine treatment at Beltsville. One of the advantages of a tetraploid apple will be the possibility of producing triploid apples by crossing the tetraploid with diploids. Many of our best apple varieties are natural triploids and the production of varieties with three sets of chromosomes appears very promising in apple breeding.

Grape breeders also have been very active in making tetraploid grapes. The tetraploid grape breeding program at California and at Beltsville is showing that some very fine new varieties will be developed by inter-pollinations within the artificially induced tetraploids.

Another promising use of induced chromosome doubling is in making sterile hybrids fertile. It is well known that many hybrids that produce no seed become fertile when their chromosome number is doubled.

It has not been long since Garner and Allard demonstrated that flowering of many plants was controlled by the length of day. Plants were roughly classified as short or long day plants depending on whether they flowered on a short or long day. The light need not be from sunshine, but can be from a carbon arc, a fluorescent tube, an ordinary mazda bulb, or from other sources. We have underground rooms at Beltsville where plants can be grown from seed to seed without ever being exposed to any daylight. We also have small outdoor houses equipped with artificial lights and with tracks running into the houses for small cars on which plants in boxes or pots may be grown exposed to sunlight for part of the 24 hour period then rolled into the house and exposed to additional illumination for any desired time. By means of these facilities it is possible to study the effect of varying the amount of both daylight and artificial light and to compare the effect of various types of artificial light.

Sugar beet plants, grown in the winter on a controlled 8 hour daylight day do not flower. Our sugar beet breeders wanted to flower these plants so they could make cross pollinations in the winter and speed up their breeding work. The plants failed to flower. A similar lot of plants was given the same 8 hour day of daylight plus 8 hours of artificial light furnished by daylight fluorescent tubes. These plants also failed to bloom although they were getting practically the same length of illumination they get outdoors in the summer when they do bloom. A third lot of plants was also given an 8 hour daylight day plus 8 hours of artificial light furnished by mazda bulbs. These plants flowered and our plant breeders were able to make their cross-pollinations in the winter and thus speed up their work. We do not know why the plants responded in this way, but the amazing thing is that plants do differentiate between different types of light and respond differently.

Our strawberry breeders also wanted to flower their plants in the winter, but could not get flowers on some varieties they wanted to use in their breeding work. When these plants were grown under Mazda bulbs, they flowered with 11 and 11½ hours of light, but failed to bloom with longer periods of illumination.

The effect of light on some plants may not appear until months after the light treatment is applied. In the case of azaleas, the variety Hinodigeri was exposed one year to Mazda light for 9, 12, and 15 and 18 hour periods for 6 weeks. The treatments were applied when flower buds for the next year were being formed. The plants were kept outdoors until cold weather then placed in a greenhouse and forced. Straggly branching growth resulted from the longer exposures to artificial light.

Many plants have been popularly called short-day or long-day plants. This refers to such plants as chrysanthemums that flower in the fall as the days become shorter. Poinsettias also flower at Christmas time because of the short days at that season. We are now, however, calling these plants long night plants. If poinsettias are exposed to short days and long nights they do flower. But if they are exposed to the same short day, and then at midnight are exposed to artificial light for only one minute, they will not flower. The long night then is the important factor.

Recently it has been shown that seeds are very sensitive to the red and infra-red part of the spectrum. There is a stimulating effect of red light and an inhibiting effect of far red light on the germination of lettuce seed and the seed respond to the last light to which they are exposed.

With pepper-grass, a common weed, only one-quarter of a minute of radiation is sufficient to produce some germination and four minutes produced a high germination. All this helps explain why we usually obtain a large number of weed seedlings following cultivation. Stirring up the soil pulls weed seeds up to the surface where they are exposed to light and they then germinate rapidly.

We have recently been doing considerable work on the effect of nutrition on growth and performance of some flowering plants. Flowering bulbs such as daffodils and corms such as gladiolus are excellent to work with because they can be maintained year after year

Let us first look at the work on gladiolus. Results of a 3-year experiment consistently showed that large flowering sized gladiolus when grown on an average garden soil gave better results when no fertilizer was used. In fact, applications of nitrogen produced fewer flowers, *shorter spikes,* and later *blooming.* Very *small corms* and *cormels did,* however, need additional fertility. It must be pointed out that the soil should be a fairly good garden soil. Sandy soils and ones very low in fertility require some fertilizers, but even here applications should be light.

During the course of the fertilizer trials on both gladiolus and narcissus, it was found that certain fertilizers always increased the amount of fusarium rot. On gladiolus the disease is commonly called yellows, and on daffodils it is known as basal rot. In all instances as the amount of nitrogen was increased, the virulence of the disease increased. There were also differences in the effectiveness of various sources of nitrogen in increasing the rots. All forms of organic nitrogen increased the disease more than inorganic or so-called chemical nitrogens. Such results led us to investigate the nutrient requirements of these fusarium diseases. These organisms are themselves small plants and require nutrients just as large plants do. We also have some evidence that high levels of nutrition can increase the virulence of a leaf disease on gladiolus. Heavy applications of nitrogen, phosphorus, and potassium result in an increase of the disease known as curvularia leaf spot. Plants given only water show no disease, those with NPK are lightly infected, but when five times as much NPK was applied the plant was severely infected, and when 25 times as much NPK was used the disease killed the plant. Thus we may eventually be controlling some of our plant diseases by means of better use of fertilizers.

There are many other new developments that I might tell you of, but the hour is late and we have all had three hard days. Perhaps I have tried to cover too much territory in this brief period of time, but I did want you to know that all the startling research is not being done solely by the atomic physicists. What the future holds in plant research is difficult to foretell. We have just begun to open the doors to new fields of work and like treasure hunters, research workers are looking into every corner and every crack to unravel the secrets of Mother Nature.

PRESIDENT CHADWICK: We are all most grateful for the excellent preview of some of the recent developments in horticultural research which will help in the production of horticultural plants. It was very inspiring and we thank you, Dr. Emsweller, very much indeed.

The Third Annual Meeting of the Plant Propagators Society adjourned *sine die.*