Ag and Food Interprets . . .

- **Bacterial control of insects gets new impetus**
- **Growers learning to control quality as well as quantity of output**
- **Nitrogen plants get most attention in overseas fertilizer expansion**
- **Highway men catching on to economy of roadside spraying**
- **Gas chromatography—exciting tool in food and chemical research**

Bacteria Vs. Insects

Successful use of *Bacillus thuringiensis* gives fresh impetus to search for other new microbial insecticides

THE PESTICIDES INDUSTRY, concerned about residues, is eagerly seeking insecticides that are harmless to man and animals. In addition, it is looking for new insecticides to which insects do not become resistant and which do not kill beneficial insects. Mainly for these reasons, insecticide researchers are looking with renewed interest at an unconventional approach—the control of insects by disease-causing microorganisms.

Insect control by pathogenic bacteria has been studied for years by a small, widely scattered group of researchers whose work, some outsiders believed, "was all very interesting, but scarcely practical." However, in the past few years, a mounting body of evidence has pointed to the fact that bacteria, as well as viruses, *can* be used effectively and economically in insect control.

A major step forward came last December with the announcement that Thuricide, a product of Bioferm Corp. of Wasco, Calif., had received a temporary tolerance exemption from the Food and Drug Administration. At the same time, the U. S. Department of Agriculture granted an experimental permit for shipment and large-scale field testing of this new microbial insecticide on a variety of food and forage crops such as alfalfa, cabbage, tomatoes, cauliflower, broccoli, and lettuce.

Tobacco hornworm killed by microbial insecticide dangles from leaf of tobacco plant

Thuricide, which contains live spores of *Bacillus thuringiensis* in an inert carrier, is the first microbial insecticide to receive temporary exemption from FDA. It is also the first commercially produced "living" insecticide approved for use on food and forage crops. Made by Bioferm and marketed by Stauffer, Thuricide—about 30,000 pounds of it—is expected to be used in large-scale field evaluations this year in many parts of the U. S., Puerto Rico, Hawaii, and Central America. Its initial targets will be such leaf-eating insects as the imported cabbage-worm, the cabbage looper, the alfalfa caterpillar, and the diamondback moth. For the past three years, Bioferm and 27 cooperating investigators have developed a great deal of field data on potency, dosage rate, and methods of application.

At the University of California, research on *B. thuringiensis* began back in 1948. The organism itself was first isolated in Germany in 1911 from diseased larvae of the Mediterranean flour moth.

Today, Bioferm is only one of a growing number of U. S. companies doing research on microbial insecticides. Merck, for example, has been working with the same pathogen, *B. thuringiensis,* which it is offering for field testing under the name of Agritrol. This year, Merck is supporting test programs on this material at 22 agricultural experiment stations and universities, both in this country and abroad. Experiments last year at the University of California showed that a high-potency Merck formulation (about 70 billion spores per gram) gave over 95% control of alfalfa caterpillar at dosages as low as 2 ounces per acre. Several other lepidopterous insects are controlled at dosage rates of up to 1 pound per acre.

Rohm & Haas is field-testing insecticidal use of *B. thuringiensis* at its farm in Pennsylvania, and is also having it studied at various state agricultural experiment stations. This pathogen is also being investigated by such companies as Nutrilite Products, Eli Lilly, Pabst Laboratories, and various European companies.

Work is also progressing on the control of insects with viruses (AG AND FOOD, March 1956, page 195). In general, viruses are more thorough in their action than bacteria, although possibly not so fast acting. Most observers feel that for the foreseeable future viruses and bacteria will complement rather than compete with one another as insecticides.

Early Setbacks

Use of pathogenic bacteria to destroy insects was seriously considered more than 50 years ago, although at *another Olin Mathieson packaging idea!*

SKID-MASTER

Tough kraft multiwalls...with a non-skid finish you can't see or feel!

Don't sacrifice strength, good looks, or printability for skid-proofing! Skid-Master multiwall bags provide protection against sliding damage with an "invisible" non-skid finish built right into the paper itself! No sticky coatings, tacky sprays, or surface grit...just clean, tough, non-skid kraft! Call or wire Olin Mathieson today: Packaging Division, W. Monroe, La.

OLIN MATHIESON PACKAGING DIVISION

FROSTKRAFT IS A TRADEMARK

the time little was known about insect diseases (AG AND FOOD, August 1956, pages 676–80). Later, attempts were made to control grasshoppers, European corn borer, and other insects with a variety of disease-causing organisms. All these efforts, however, failed through inadequate understanding of the technical and environmental factors involved. Even today, not enough is known to permit effective microbial control of many of these insects.

Prior to the use of *B. thuringiensis*, the only microbial insecticide applied commercially in the U. S. was *Bacillus popilliae*. For years, it has been used, particularly in the East, to control Japanese beetles by infecting the grubs with milky disease. Because this material is not used on food or forage crops, it has required no FDA exemption. One producer, Fairfax Biological Laboratory in Clinton Corners, N. Y., sells about 25,000 pounds of milky disease spore powder annually. It is used mainly on lawns and golf courses in the summer, when the spores are active. One advantage of the organism: it is self-perpetuating.

Much pioneering work on "living" insecticides has been done by researchers in the University of California's department of biological control. One of their initial aims was to find an improved way to control alfalfa caterpillar. Although chemical insecticides control alfalfa caterpillar, they may leave undesirable residues and may kill beneficial insect parasites. The new approach was to use a pathogen obtained from the bodies of alfalfa caterpillars that had died of a polyhedrosis virus disease. Surprisingly enough, about five dead caterpillars yielded enough virus, when properly distributed, to protect an acre of alfalfa. One problem, however, was that when the virus killed the caterpillars they tended to remain on the plant, possibly making it unpalatable when later fed to animals.

When alfalfa is sprayed with *B. thuringiensis*, on the other hand, the dead caterpillars fall to the ground. Furthermore, this bacterial agent is not only faster acting than the virus but can be readily produced in the laboratory in large volume.

Development of Thuricide was a direct outgrowth of this research at the University of California. In describing the action of Thuricide, Bioferm points out that, once an insect such as an alfalfa caterpillar eats enough treated leaf to ingest 40,000 to 80,000 live spores of the bacteria, it is overwhelmed by the disease in a matter of hours, and dies. The cause: paralysis of the intestinal tract or, in some cases, the entire body, followed by a generalized infection.

At Bioferm, Thuricide is produced by growing the bacteria in a culture medium consisting of sugars and proteins. The spores are then removed from the spent nutrients and dried under vacuum. The dry material is ground and mixed with an inert diluent to concentrations ranging from 300 million to 3 billion spores per gram.

The material can be safely stored in powdered form for years without losing its virulence. When needed it is mixed with water and sprayed on plants in much the same way as ordinary insecticides—by airplane, for example. It can also be applied as a dust. In terms of cost, Thuricide is expected to be competitive with conventional insecticides used for the same purposes.

Virtues and Drawbacks

Convinced of the commercial future of microbial insecticides, Bioferm and others point to the outstanding advantages of these materials:

- So far as is known, they are harmless to all forms of life, with the exception of specific insects.
- Being specific, they are harmless to many beneficial insects, such as bees and insect predators.
- They do not leave residues that are toxic to man or animals.
- They do not harm plants.
- There have so far been no proved cases of insects' building up resistance to the disease-causing bacteria.
- The materials are relatively inexpensive.
- They can be used in conjunction with chemical insecticides, possibly making the insect more susceptible to chemical poisoning.
- With some microbial insecticides, control may last for several years.
- Microbial controls may in some instances be spread by natural means from treated to untreated areas.

Admittedly, microbial insecticides also have a number of major disadvantages:

- Pathogenic bacteria may act more slowly than chemical insecticides.
- Microbial action is highly specific so that, if a number of different insects are involved, various pathogens would be required, whereas, with a chemical insecticide, a single compound might do the job (a single spray for an apple tree, for example, might have to contain six or more different organisms).
- With microbial insecticides, application may have to be more carefully timed in relation to the life cycle of the insect.
- Poor weather conditions may interfere with effective control.
- A technique must be developed to produce the pathogen economically in large volume.
- There may be added problems of keeping the pathogen virulent through possibly long periods of storage.
- There is also the problem of spreading the disease widely and quickly enough that the insects involved cannot cause serious crop damage.
- For the present, progress is impeded by the lack of basic and applied knowledge about the use of microbial insecticides.

Many of these problems can be solved, researchers emphasize. However, they do point out that in many applications microbial insecticides may have no special advantages over chemical insecticides. In other uses, particularly where toxic residues must be avoided or where insects have developed resistance to chemical insecticides, microbial control may be the method of choice.

As one industry spokesman comments: "Microbiological insecticides will find their own particular niche in agricultural control. However, it is believed that these agents will complement—and find their place with—chemical insecticides, rather than replace the chemical methods of control. In our opinion, this is definitely a field worth investigating."

Large numbers of microorganisms that cause insect diseases are already known—but only a few have been tested on a large scale as insecticides. Much needs to be learned about better methods of producing these newer microorganisms and of applying them to agricultural crops. With laboratory and field research on microbial insecticides increasing as never before, the pesticides industry appears to be on the threshold of major progress. Says one observer: "Many pathogens today are 'standing in the wings,' just waiting to be developed commercially."

Crop Quality Control

For some crops, growers can control quality as well as quantity; for most others, more research is needed

EVER-INCREASING numbers of farmers these days are learning that there is more to evaluating a crop than weighing it at harvest time; quality also affects the profit picture. Admittedly, the first step toward greater profit for any farmer is to increase his tonnage yields per acre, but there are other considerations as well.

Crops are grown for the useful components which can be obtained from them. Content of some of these components in a crop—protein, sugar, starch, oil, fibers, vitamins, and minerals such as calcium, magnesium, cobalt, and phosphorus are examples —can be changed by changing the plant's environment. Similar changes in environment change the content of some undesirable components, too. Tannin, hydrogen cyanide, coumarin, saponin, and some alkaloids can be increased or decreased. And such changes also can affect the quality as well as the amount of the component —particularly in the case of protein.

The goal of the crop grower, therefore, is to obtain the most of what he wants at the lowest possible cost and with the lowest possible content of what he does not want. It is only relatively recently that farmers have overcome the first hurdle—that of growing *more*—so that they could turn their attention to the next one—that of growing *better* crops.

Research workers, of course, have anticipated that this day would come and are studying more intensively the ways this second goal could be attained. They have many variables to work with:

- Choice of species and varieties of crops.
- Climatic conditions.
- Water and its effective management.
- General crop husbandry.
- Management practices to improve physical soil characteristics.
- Stage of maturity at harvest (some crops have more value when young; others when more mature).
- Fertilizing practices—amounts of available nutrients, their proportions, and when they are applied.

Some experts say that, of all these variables, those involved in fertilizer practices are least effective. Others, far less pessimistic, feel that fertilizers have the major role to play in improving crop quality along with yield. The true picture probably lies somewhere between these two extreme positions.

Some species and varieties are not amenable to improvement by fertilizer use; others, however, are. Climatic conditions, soil types, and similar variables are usually fixed within rather narrow limits for any one area in the country. And researchers have found that they get their best results when they study all the other variables together. Thus, fertilizers turn out to be a most important part of an improvement program but cannot be considered alone.

Research on the nutritional value of various crops is based on existing knowledge of the chemistry of plant growth—a knowledge far from complete. Some ground rules are at hand:

- The proportions of plant effort going toward production of various components of the plant (for example, carbohydrates vs. amino acids or proteins) are functions of, among other things, growth stage and plant foods available.
- Uptake of nutrients from the soil is a selective process. The mere adding of a nutrient to the soil does not necessarily ensure a change of nutrient content in the plant. When it does, the amount of the change is not necessarily a straight-

Some Crops Can Be Made Better

Much field research, using fertilizing practices as a major variable, is in progress across the country to make crops richer in some of the materials humans and animals need for their nutrition or want for other purposes. People working with animal feeds are interested because there is a direct relationship between the protein content of feed and the pounds of feed required to make a pound of meat. Emphasis in forage crops, therefore, lies more in the direction of making them richer in protein, thus reducing the requirement for diet supplements. For example:

- In Colorado, a USDA researcher has developed a "super hay" which contains up to 15% protein. The Colorado work emphasizes nitrogen primarily—because after water, that is the area's first limiting factor, and because production of large quantities of high fiber crops requires supplementation with protein.
- A Minnesota scientist has found that he can produce more protein per acre of corn and alfalfa with phosphate or phosphate-potash combinations.
- In Missouri, well-fertilized red clover has higher protein content than unfertilized red clover. Further, red clover is a better protein producer than is timothy hay, when both get the same fertilization.
- Some other forage crops showing positive results are tall fescue in Kentucky, Bermudagrass and Bahiagrass in Georgia, Johnsongrass hybrids in Mississippi, timothy and birdsfoot trefoil in New York, alfalfa and bromegrass in Nebraska, and wheat varieties all through the Midwest.

In vegetable crops for human consumption, work is also progressing, but emphasis with these crops is on their potential as sources of concentrated vitamins and minerals. For example:

- California scientists are trying to increase soluble solids content of tomatoes, sugar concentrations in melons and table grapes, and starch content in potatoes. In addition, they are studying ways to increase vitamin and mineral levels in tomatoes, olives, and other crops grown extensively in the state.

Similar studies are in progress in other states with crops which are important to the economies of those states.

Food is not the only subject of interest. Studies of cotton growth variables to control fiber characteristics, and of tung, safflower, and other oil-bearing crops to improve both yields and quality are also under way.

Growing for Maximum Return

Getting the greatest dollar value from a crop is a complicated job at best, but adding in the extra consideration of crop quality makes it even more so. Witness these facts from Texas A&M College which bear on the best way to handle a crop of Coastal Bermudagrass:

Protein level in Coastal Bermudagrass can be varied from a base of about 8% up to 16–17% by varying the rate of nitrogen application. Total crude protein content increases continually from the time of nitrogen application up to about the 16th day, remains level for a few days, and then starts to decrease as plant growth tends to dilute the nitrogen contained in the crop. Thus, the grower could choose to cut earlier and have a higher protein content at a loss of some pounds of yield. He could cut later at a lower protein content but a higher tonnage yield of hay.

Assume that he should cut to get about 13% protein in his crop. Assume also that hay is worth $20 a ton, the nitrogen fertilizer costs 13 cents a pound, and that higher protein content in the hay brings no premium. In this case, he should apply 917 pounds of N per acre and shoot for maximum yield. But if additional protein content in the hay has a premium value of 9 cents a pound, he should apply 1378 pounds of N per acre and shoot for maximum protein yield at a somewhat reduced absolute weight yield.

This particular grower also has other possibilities for his crop. Should he feed it to his own stock, and if so, how much can he save in diet supplements by control of protein content? This sample case shows that adding variables makes the farmer's job harder and his use of business principles more necessary than ever before. But it also shows most clearly that his optimum yield may well not be the same as his maximum yield.

forward function of the amount of nutrient added to the soil.

- Chemical make-up of a plant varies from part to part. Seeds, for example, have different compositions from leaves. Even leaves or stalks at different elevations from the ground sometimes vary in composition.
- Chemicals can modify the growth pattern of a plant by hastening or retarding maturity. And the components synthesized by a plant vary with the stage of maturity of the plant.

What makes this whole subject so important is that animals (including humans) cannot synthesize from "scratch," as plants can, many of the chemicals they need. For example, a plant can make from carbon dioxide, nitrogen, and water (assuming, of course, that other nutrients such as phosphorus and potassium are also present to accomplish their roles) all the amino acids essential to its nutrition. But animals must ingest many of the amino acids as such or in proteins in order to have them; they can synthesize some but not all they need. The same is true of many other items animals need, such as vitamins and other complicated organics.

Synthetic sources of these amino acids and other materials (diet supplements) are relatively expensive. For most areas, then, and especially for some less fortunately endowed than the United States, the cheapest and surest source of these materials is plants or animals. And the cheapest way to feed animals is with plants. Indeed, practically all higher animals are now absolutely dependent on plant life for their existence. The dependence may be direct or indirect, but it is absolute.

World Fertilizer Expansion

Underdeveloped countries are pushing fertilizer plant construction, with nitrogen receiving most attention

A PROMINENT FEATURE of today's world fertilizer scene is the tremendous activity in fertilizer plant construction in those areas usually referred to as the underdeveloped countries. In Asia, Africa, and South America, many new plants are being put into operation, erected, or planned. The list, as detailed in the "Annual Review of World Production and Consumption of Fertilizers," published by the Food and Agriculture Organization of the UN, adds up to a situation worth searching consideration by fertilizer-exporting nations and firms.

Nitrogen seems to be getting the major share of attention—in Asia for instance, nitrogen production increased 50% between 1956 and 1958, while phosphate output showed only a slight increase. Most of the nitrogen increase occurred in Japan, which turns out 85% of the nitrogen produced in Asia.

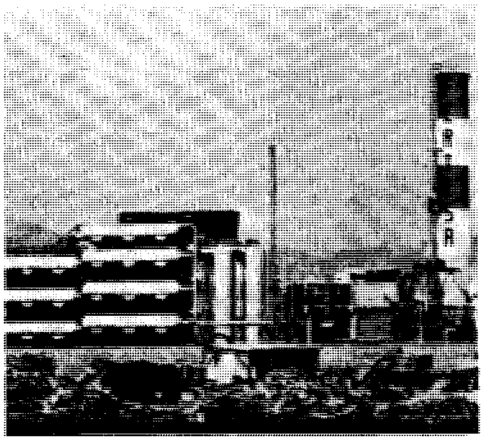
Although nitrogen use is developing at a rapid pace in Asia, the difference between production and consumption is narrowing, because of the installation of new plants. In 1959, it is expected, Asia will produce 1.2 million metric tons (on an N basis), as compared with 813,000 metric tons in 1956. Meanwhile, the deficit now made up by imports is expected to decrease from 280,000 metric tons in 1956 to 174,000 by the end of this fertilizer year.

Among the Asian countries pushing nitrogen expansion is Pakistan, which has one nitrogen plant (for 10,000 metric tons as ammonium sulfate) and plans two more. One is to begin operation in 1960, with a capacity of 100,000 metric tons of ammonium nitrate and 60,000 metric tons of urea a year. In the following year, another 100,000-metric-ton urea plant will begin producing.

In India, a 10,000-metric-ton nitrogen plant is planned for Bombay, and bids have been invited for a urea plant in Madras. In the Philippines, a new nitrogen plant and a new superphosphate plant are operating, and a second super plant is to start soon. In South Korea, two fertilizer plants are reported to be under construction, and a third one is planned. On Formosa, three new government-owned fertilizer plants started up in mid-1958, producing Nitrochalk, nitrophosphates, and urea.

In Japan, which produces more urea for fertilizer use than any other country, capacity for that chemical increased from 435,000 metric tons a year to 788,000 metric tons by the end of last year. In that area, understandably, there are fears of overproduction and overexpansion.

In mainland China, FAO reports, eight plants are either operating or close to completion. Some will be producing phosphate; others will be making nitrogen fertilizers. Red China has elaborate plans for the construction of small fertilizer plants in each of its 180 administrative regions,



A portion of the new nitrogen plant in Peru. At left is cascade of nitric acid absorption tanks

backed up by very small plants in each of its more than 2000 counties. The 180 plants are to produce ammonium bicarbonate, but it is not known whether ammonium bicarbonate is to be used for fertilizer as such or is to be further processed before use as plant food.

In the Near East, Turkey will have a new nitrogen plant operating this year, and Iran is planning a 100-metric-tons-per-day nitrogen plant. In Israel, high grade deposits of potash and phosphate ores have been discovered. During this past year, the Israeli firm, Fertilizers & Chemicals, Ltd., has started producing enriched superphosphate and triple super and is now doubling its nitrogen product facilities. It will have a capacity for 20,000 tons after the expansion.

Central and South America have also been expanding fertilizer production. Perhaps the most intriguing development there is the recent completion of a synthetic nitrogen plant in Peru, a country whose large guano reserves once supplied its own agriculture and that of many other countries with nitrogen fertilizers. These deposits are nearly depleted, and Peru has had to resort to imported nitrogen. In Brazil, nitrogen and phosphate plants are being completed. In Puerto Rico and the Dominican Republic, new fertilizer plants began to operate in 1957, and Puerto Rico hopes to increase its fertilizer output by 50% this year. Plants are being started in Trinidad (for ammonium sulfate and urea) and in Cuba. The Trinidad plant is being built by W. R. Grace.

Africa accounts for barely 3% of the total world consumption of nitrogen and phosphate fertilizers, but expansion plans are afoot there also. It now produces only about 1.5% of the world's total. Nitrogen is produced only in Egypt and in the Union of South Africa, the latter turning out only about a third of Africa's total output. South Africa is enlarging its plant by 70,000 metric tons of ammonia, most of which will be converted to urea (110,000 metric tons). South Africa has four phosphate quarries, which produce a high grade concentrate from low-grade ores for conversion to 19% superphosphate. Another super plant, in Southern Rhodesia, is expected to be producing shortly. Little potash is used in Africa, and all of it has to be imported.

In the older fertilizer-producing areas such as Europe, producing capacity is increasing. Contracts have been let in Greece for a plant capable of turning out enough nitrogen to meet that country's current needs. The Irish government has reportedly approved plans for an ammonium nitrate plant, and a new superphosphate plant is to be built in Cork. Portugal reports plans to increase its ammonia output by 75,000 to 100,000 metric tons. Spain reports that a nitrogen plant is to be erected in the Canary Islands. In The Netherlands, increased capacity at the State Mines plant will consist of urea, ammonium nitrate-calcium carbonate, ammonium phosphate-nitrate, and calcium nitrate.

From behind the Iron Curtain, FAO has received reports that Poland has started production of a phosphate fertilizer from low-grade phosphate rock roasted with magnesium silicate. Romania has put into operation a 100,000-metric-tons-per-year superphosphate plant, and is about to start production at another one.

All this new fertilizer capacity undoubtedly gives concern to fertilizer exporters in the U. S. and Europe, but it will also make it possible for food-deficit areas to produce more for their rapidly increasing populations. It may also help eventually to increase the total world demand for fertilizer.

Roadside Maintenance

Economics gives chemical spraying the nod

UPKEEP of roadsides for safety and appearance is becoming increasingly expensive through rising labor costs as well as increased mileage. Chemical spraying is getting the nod by most state highway people today, as it usually proves cheaper and quicker to spray a mile of roadside than to mow and trim it by hand. Also, a single spraying can frequently replace several mowings over the course of a year. In some areas where soil sterilization has been practiced on road shoulders, no further treatment is necessary for five years.

There seems to be no common approach followed by state highway departments generally. Varying terrain, climate, and wildlife populations require different maintenance procedures. And aims differ across the country. Some states want efficient removal of highway vegetation. Others want landscaping. Some like turf; other prefer low brush and native flowering plants.

All states agree, though, that poison-ivy control—one shining instance of unanimity—shows clear, immediate results: lost time cases among highway maintenance employees plummet. Ohio reports, for example, a 73% drop in cases among "exposed" personnel.

Weed Control in the East

Perhaps typical of some aspects of eastern highway-maintenance programs is that of New York. After 10 or 12 years of tests, the State Public Works Department has completed two years of a sizable operation involving control of brush, broadleaf weeds, and poison ivy, and "chemical mowing" around posts for guide rails and signs.

Out of a total of $1,137,250 (year ending March 31, 1958) spent for all types of grass and weed control—machine, manual, and chemical mowing —on 13,210 miles of highways, some $55,000 went for the chemical control. Herbicide purchases amounted to nearly $60,000 for 1958–59, and for this year will reach about $73,000.

In its 1958 program, New York used a low-volatile ester of 2,4-D for broadleaf control. Applied at the rate of one gallon of ester (4 pounds acid equivalent) to at least 100 gallons of water per acre, the mixture was sprayed on 5346 acres along 1645 miles of highway, at an average of $4.00 per acre. This treatment eliminated at least one mowing, according to senior landscape architect Andrew M. Ditton.

For chemical mowing, 60 pounds of dalapon was added to one gallon of 2,4-D ester in 60 gallons of water per acre. Last spring, before growth reached 9 inches in height, the mixture was applied to a three-foot strip along 1768 miles of guide-rail lines on 4956 miles of highway, and to the area immediately surrounding individual posts. Average cost came to $20.50 per treated mile, but at least one—and in some sections, all—hand mowing was eliminated.

Brush control called for combinations of 2,4-D and 2,4,5-T. For foliage treatment, one-half gallon of each in a total of 100 gallons of water was sprayed at a rate of 100 to 200 gallons per acre. Limited to regrowth of cut brush in areas where discoloration was not objectionable, the solution was sprayed on 337 acres at a cost of $15.80 per acre.

As a combination defoliant and weed control measure, varying mixtures were formulated, totaling 2 pounds of acid in a minimum of 50 gallons of water per acre. These gave good results on 308 acres treated, at average cost of $6.15 per acre. To treat stumps and stubble, the chemicals were mixed, 2 gallons of each in a minimum of 50 gallons of oil per acre. As applied by hand guns, this is an expensive treatment. For 19 acres, costs averaged $104 per acre.

Results of 1957 poison-ivy control in one district indicate 99% kill. Last year, using four pounds of amino triazole in 100 gallons of water per acre, spot treatment along 2200 miles of roadway cost $20 to $25 an acre and showed excellent top kill immediately. Final results will be known soon.

Save the Wildflowers

Connecticut is considered a leader in chemical control of roadside weeds. William C. Greene, landscape engineer for the State Highway Department, sees a three-way need with regard to highway vegetation: establishment, maintenance, and control. It's in the last two categories, he points out, that herbicides are becoming essential tools.

Richard H. Goodwin, director of the Connecticut Arboretum at Connecticut College, deplores needless destruction of attractive ornamental shrubs, trees, wild flowers, and other innocuous—though considered "noxious" in agricultural situations—flowering plants and weeds in the zone behind a road's mowed shoulder.

And broadcast or blanket spray techniques for brush control have to be repeated for good kill. This produces unsightly, though usually temporary, brown swaths along highways. Selective spraying of cut stumps, says Goodwin, will avoid such burning. Selective treatment costs more than a blanket spray, but he claims it is cheaper in the long run because it is far more effective.

For 3200 miles of roads in its system, Connecticut's highway department has 30 rigs available for chemical spraying. This means a little over 100 miles per unit, considered workable for the state's continuing program. Of numerous chemicals evaluated over the past few years, eight are now considered necessary for the "practical program."

Purchase of chemicals for the Connecticut program is increasing each year. Last year's was 20% above that of 1957, and this year's volume is expected to reach about 80,000 pounds, up another 15%. Greene estimates "conservatively" that every dollar spent for herbicides saves—or puts to work in other activities—$10 in labor. He looks forward to the day when "at least 75% of our vegetative maintenance will be performed with chemicals."

Midwest Sprays, Too

The highest expenditures for roadside maintenance in any state reporting are Minnesota's, amounting to about $2.1 million a year. This adds up to $181 per mile, and includes mowing, brush-cutting, and chemical spraying.

Although there is no "formal statewide roadside spraying program," each of Minnesota's 16 maintenance districts sprays as it deems necessary. Last year they used over 63,000 pounds of herbicides—divided among five compounds—throughout the state, 16% more than in 1957.

Ohio's weed spray program began in 1946, with evaluation of the newly available synthetic herbicides on noxious weeds such as thistle and poison ivy. These spot spraying tests were followed in 1951 by general right-of-way treatment on rural mileage in Knox County. This limited program demonstrated the economics of spraying in conjunction with mowing. The spraying/mowing technique saved about $18 per mile over mowing alone.

From 1951 to 1957 Ohio's spraying program expanded rapidly to nearly $250,000, out of a total weed-control budget of $1,376,000. It is estimated that spraying in 1957 saved $600,000 over mechanical mowing alone.

In 1958 the weed-spray program was cancelled, as an economy measure, in favor of major road construction and resurfacing. But money was not saved after all, for mechanical mowing costs shot up 35% ($400,000) and weed-control costs rose from $85.27 a mile to $98.86. Resumption of the full program this year is doubtful because heavy damage to roads by January floods will require considerable unplanned expenditures.

Another Problem Out West

On the West Coast, roadside spraying serves a different function from those in other parts of the country. California represents greater variations in climate than any other state in the West, so its problems may be representative.

Testing of herbicides along Connecticut highways by Amchem Products

Distinct summer and winter types of vegetation abound in many parts of the state. Year-around maintenance is required. Winter grasses are chiefly annuals which mature and become fire hazards during the long rain-free months from April to November. Generally these grasses are mowed several times until maturity eliminates the problem. Maintenance engineer F. E. Baxter points out that such grasses have valuable root systems which serve to prevent erosion of shoulders.

As close as possible to this maintained shoulder, however, the division of highways creates a "fire guard" four to six feet wide. These strips, in which all vegetation is killed, are maintained over 3800 miles of roads throughout the state.

Soil sterilants such as monuron and diuron are frequently used for this purpose. They also find favor around guard rails, posts, culverts, and bridgeheads, to eliminate hand weeding. Where tree roots would be affected by these chemicals, borate/chlorate compounds are applied.

Summer weeds of many kinds germinate at different times, Baxter mentions, and they cannot all be controlled by a single spraying or a single chemical, except in the case of sterilization. To avoid this drastic treatment, noxious weeds are treated, where practicable, with selective chemicals.

The Californians now restrict the use of herbicides to two basic functions: sterilization and selective control. They claim to find mowing less hazardous and less expensive than spraying except where one spraying will do the complete job. This is not

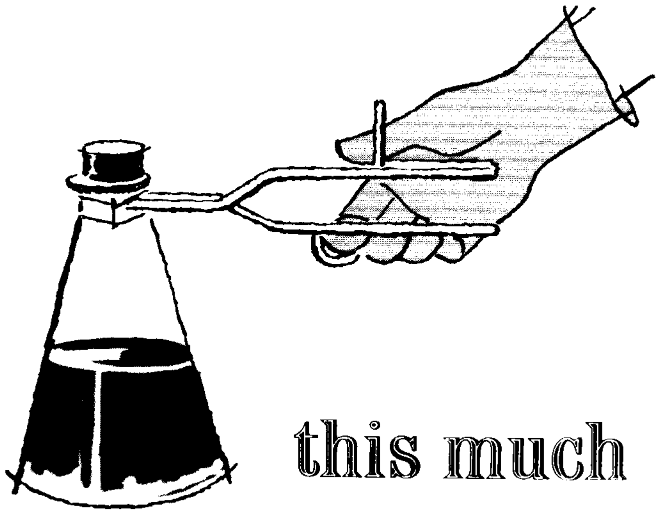
this much 10-52-17

Dissolve one ounce of Victor Take-Hold® in a gallon of water and you have the perfect transplanting solution for seedlings and setouts.

High-analysis (10-52-17), Take-Hold plant food speeds formation of early root structure . . . helps seedlings overcome "setback shock" at transplanting time . . . resulting in earlier development. Nurserymen and commercial growers like to be in this preferred position of commanding "early bird" prices.

Producers of commercial fertilizers are in a preferred position, too, when they specify Victor P.F.S. (phosphatic fertilizer solution), for Victor—a leading producer of P.F.S.—offers fast and frequent tank car and tank truck delivery from five production points, strategically located from coast to coast.

For a fast start to a solution of *your* problem—either plant food or phosphatic fertilizer solution—contact Victor's technical service department. Or write on your company letterhead for a copy of our new bulletin "Handling and Storage of Phosphoric Acid." It's an easy way to learn why *it pays to see Victor*. Victor Chemical Works, Box 572, Chicago 90.



this much Methyl Parathion...

A little Victor methyl parathion puts the *cide* into those pesticides that knock boll weevils and other cotton pickin' pests for a loop.

Cotton farmers and pesticide formulators both bank on the fatal charm of Victor methyl parathion – whether used as a dust, a wettable powder, or an emulsifiable concentrate.

Perhaps you'd like to unload some of your problems . . . make your product more marketable, more economical to produce. You're in the driver's seat, of course, but selecting Victor phosphates, formates, and oxalates can pay dividends—as they have for many others in more than 40 industries. Write on your letterhead for literature of the chemical you are interested in. We'll have data on your desk before you can say, "It *pays* to see Victor."

Victor Chemical Works, Box 572, Chicago 90.

VICTOR
Dependable Name in Chemicals

usually the case, says Baxter, unless the entire area is sterilized. Soil sterilization is thought to run $80 to $100 per acre in the fire strips.

Not Popular in South

In the South and Southwest, roadside weed control by spraying is not so popular as in other areas. One reason is heavy rainfall which leaches or washes away the chemicals. Another is the sensitivity of certain crops there—cotton, for instance—to the herbicides. And the wide variety of crops makes it difficult to decide upon practical "general purpose" materials.

Typical is the situation in Alabama. Roadside maintenance has a high per-mile cost: $116.80. But chemicals are not being used. Small amounts are being tested, but no large-scale procedures have been worked out.

Gas Chromatography

Improvements bring striking sensitivity, rapid progress against analytical problems related to foodstuffs and farm chemicals

WHY do onions smell like onions? What causes the fish odor of fish? What deserves credit for the unique fragrance of freshly brewed coffee, and what subtle chemistry is to blame for loss of that fragrance when coffee becomes stale?

These and many other questions are being answered in rapid-fire order these days with the aid of a relatively new technique—gas chromatography. Through revolutionary improvements in equipment and methods (themselves considered revolutionary but a few years ago) gas chromatography has brought to the analysis of chemicals, flavors, and odors a sensitivity rivaled only by that of taste buds and noses.

Taste buds and noses are first-rate at detecting over-all differences, but not so adept at separating or positively identifying components; gas chromatography, however, has been proved capable of separating complex mixtures into basic components—sometimes in almost unbelievably minute quantities—and making possible their direct and positive identification. Last month brought word of new applications of gas chromatography in the farm chemicals field, and reports of giant strides in the measurement of flavors and odors.

In the pesticides field, Coulson and his coworkers at Stanford Research Institute reported in April AG AND FOOD (page 250) that gas chromatography is a promising technique for pesticide analysis. Because it can quantitatively separate many pesticides from one another and from other materials extracted from foodstuffs, it should prove highly useful for rapid cleanup and separation in residue analysis. So far, the method has successfully separated such mixtures as lindane-aldrin-dieldrin-DDT and lindane-parathion-dieldrin into their components, in quantities as small as a few milligrams total. Moreover, as research continues and basic data are accumulated, the technique should become useful at the microgram level; it can then be applied as a practical step in systematic pesticide residue analysis.

Major advantage of the method, says Coulson, is its speed. In many cases, it can achieve combined cleanup and separation in minutes. The separation must be followed by conventional measurement techniques, and suitably sensitive, specific, direct detection methods must be devised before complete residue analyses can be performed through gas chromatography. Where spray histories and the chemical nature of the resulting residues are known, however, the residual toxicants can be identified by gas chromatographic elution times, and amounts present can be determined from the magnitudes of the instrument detector signals.

Flavors and Odors

At the Boston ACS meeting, D. A. M. Mackay of Evans Research & Development outlined the use of gas chromatography in the objective measurement of odors—including onion odors. Opening a symposium on natural food flavors in the Division of Agricultural and Food Chemistry, Mackay described the "tremendous increase" in sensitivity for gas chromatography afforded by use of J. E. Lovelock's ionization detector. The new sensitivity, Mackay says, gives a big boost to flavor and odor research by making possible direct sampling studies. This means the equipment is testing the same entities—gases—sampled by the nose. Through its use a 1-ml. sample of air taken from above the surface of freshly chopped onions can give analytical data on par with those obtained by earlier methods which required extensive sample preparation. And rapid changes due to enzyme action are clearly shown.

The sensitive system has been applied to cigaret smoke, to beer and whisky, and to such foodstuffs as cheese, garlic, and tea; in several it has pointed to components never before detected in the odors or flavors of the parent materials.

Adding to knowledge of food flavors, Jack W. Ralls of National Canners Association described the use of gas chromatography for semiquantitative (within 20%) analysis of carbonyl constituents of vegetable flavors. The method here is to prepare 2,4-dinitrophenylhydrazine derivatives of the flavor constituents and then, using α-ketoglutaric acid, regenerate the original aldehydes and ketones directly into the gas chromatography unit.

Combination of gas chromatography with other separatory and analytical techniques, according to George F. Mangan, Jr., of U. S. Bureau of Commercial Fisheries, has helped to establish "fish odor" as a "complex mixture of organic compounds occurring in minute concentration in gross amounts of water." Perhaps the analyst's nose would have suggested this conclusion. But the new techniques have enabled researchers to isolate and identify in haddock odor, for instance, methanol, ethanol, acetaldehyde, dimethyl sulfide, trimethylamine, and a compound thought to be trimethylamine oxide.

To top off this flavor-odor "meal" with coffee, University of Houston's Albert Zlatkis reported that gas chromatography has turned up more than 30 components in volatiles from roasted coffee. The compounds include mercaptans, aldehydes, ketones, esters, acids, heterocyclics, and hydrocarbons. Of particular interest is evidence for some low molecular weight hydrocarbons—for example, pentadiene (probably isoprene) and a complex mixture of C_4–C_7 olefins and paraffins—reported for the first time as constituents of coffee aroma.

Gas chromatography obviously holds promise for the solution of many problems in food analysis. Further proof of the interest it has aroused and the promise it holds is provided by *Analytical Chemistry*'s latest "Applied Reviews" (Part II of the April issue). In it, food analysis reviewer Kenneth Morgareidge of Food & Drug Research Laboratories calls attention to the "spectacular achievements resulting from the application of the more advanced chromatographic methods, particularly in the vapor phase" to food analysis problems. Parallel progress can doubtless be expected in the analysis of agricultural chemicals, as research continues and as a foundation of basic data is constructed.