Research
FOR FARMERS

WINTER—1960

CANADA DEPARTMENT OF AGRICULTURE

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CANADA DEPARTMENT OF AGRICULTURE
Ottawa, Ontario

HON. DOUGLAS S. HARKNESS, *Minister* — S. C. BARRY, *Deputy Minister*

NOTES AND COMMENTS

Recent press reports have drawn attention to the dangers inherent in the use of agricultural chemicals without first taking full account of the possible hazards to human health. A popular selective weed killer is suspected of being a possible cause of cancer if taken internally. A hormone substance, known to be effective in the rapid fattening of livestock and poultry, may also have carcinogenic properties. Research has done much to increase and improve the products of the farm. Undoubtedly still further improvements lie ahead. But in all our research we must not overlook the fact that most farm-grown food products end up in the human stomach. Besides being appetizing and nutritious they must also be safe. In his article on page 14 Mr. Miles tells something of the problems faced by the research chemist in determining the safety factors governing the use of agricultural poisons.

* * *

There have been innumerable examples of phenomenal yield increases following relatively small applications of fertilizer. A little of the right thing under the right circumstances seems to produce results out of all proportion to the value of the application. The experience of a recent pasture fertilization at the Fort Vermilion Experimental Station is typical. A pasture of brome grass, alfalfa, and creeping red fescue, grazed by cattle, gave no increase in forage production in response to a 30-pound application of nitrogen alone. The same amount of nitrogen plus 30 pounds of phosphorus increased the yield of dry matter by 1700 pounds per acre. But when ammonium sulphate was applied in quantity sufficient to equal 30 pounds of nitrogen and 30 pounds of sulphur per acre, forage production was increased by more that two tons per acre.

* * *

And on this same subject of pasture fertilization, interesting results are reported by two widely separated points, Lennoxville, Que., and Lacombe, Alta. At Lennoxville the protein content of timothy forage was almost doubled by applying nitrogen at the rate of 160 pounds per acre. Source of nitrogen proved important in this test with some forms giving little response. At Lacombe, a cultivated pasture given an application of 400 pounds of ammonium phosphate, produced 394 pounds of beef per acre and gave a daily gain rate of 2.4 pounds. Similar pasture without fertilizer made only 192 pounds of beef at a gain rate of 1.84 pounds per day.

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Cover Photo—Apples being treated with infra-red radiation in an experimental blanching tunnel at the Plant Research Institute, Ottawa.

(See story, page 13.)

Effects of mutation on the common blight organism *Xanthomonas phaseoli*. *Left:* Comparison between healthy bean plant (left) and one inoculated with common blight organism (right). *Right:* Similar comparison except that diseased leaf had been inoculated with an altered (mutant) strain of blight organism. Note severity of disease symptoms in first picture and slight symptoms in second photo.

Bacteria, Heredity and Plant Diseases

C. Quadling

We may abruptly become aware of the presence of bacteria which can attack man when, for example, we get a sore throat or a cut finger becomes infected. The activities of bacteria associated with the soil and with plants are less dramatic in impact but are just as important. For example the legume bacteria, or Rhizobia, in cooperation with their host plants are responsible for the fixation and addition to the soil of many tons of atmospheric nitrogen each year. Bacterial diseases of plants, though rarely of epidemic proportions, are also of considerable economic importance.

It is a matter of every-day experience that each organism we see, animal or plant, arises in some way from a similar pre-existing creature. Expressed in a different way, we may say that each generation hands on an essential legacy, its heredity, to its descendants. As a first step towards understanding why a baby rabbit grows into an adult rabbit, and not for instance a horse, we have to assume that all organisms receive a legacy of "biological instructions" or information from their parents. The branch of science that deals with the study of this legacy, encompassing all the heritable characteristics of an organism, is called genetics and the practitioners are the plant and animal breeders.

The results of breeders' efforts are all around us: many of our crops now bear little resemblance to their less productive wild ancestors and the same is true of our domestic animals. The practical reasons for taking an interest in useful creatures is obvious. It is less easy to see why geneticists should concern themselves with bacteria. Nevertheless, bacteria are in many respects ideal material for fundamental biological research. By comparison with plant and animal tissues bacteria grow rapidly and can easily be cultivated in the laboratory under controlled conditions. Because bacteria are so small it is possible to work with numerically huge populations; for example a culture growing in a laboratory test tube may contain more individual bacteria than there are human beings in the world. Within the last twenty years an increasing interest has been taken in the genetics of bacteria and of other microbes like molds and yeasts. The information gained from such studies on bacterial heredity has been of great importance to the whole science of genetics; but apart from this we have learned a lot about bacteria themselves and how to use them as tools in investigations in other branches of biology like plant pathology. Unfortunately most workers in bacterial genetics have been concerned with bacteria of medical importance like those of the *Salmonella* group which cause food poisoning. We do not as yet have much information about the genetics of bacteria of agricultural importance, like *Rhizobium* or the plant pathogens.

At Ottawa we are doing some research into the genetics of *Xanthomonas phaseoli*, a bacterium which causes "common blight" of beans. We are working on the genetics of the nodule bacterium, *Rhizobium*. Where fundamental things like genetic or biochemical

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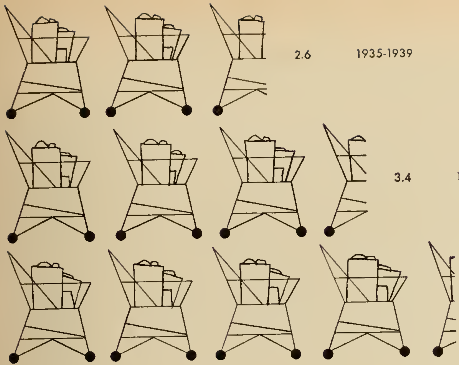
mechanisms are concerned there are usually striking similarities of behavior between different groups of organisms. So, we set out to determine if *Xanthomonas* was as stable genetically as other and more thoroughly studied bacteria. This we did by measuring the rate at which sudden heritable changes, called mutations, occurred in our cultures. We measured the rates of occurrence of several different mutations affecting, for example, drug resistance of the bacteria and their resistance to attack by a bacterial virus. As expected, our results show that mutations in *Xanthomonas* occur in a manner and at rates similar to those reported for groups of bacteria, that have received more intensive study in the past.

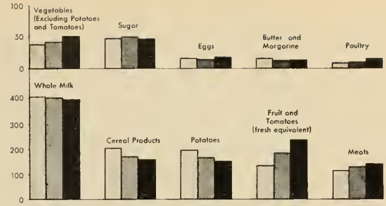
Besides mutation, there is another way in which bacteria can acquire changed heritable characteristics. This is by a process of bacterial hydridization, technically known as "genetic exchange". This occurs in different ways with various groups of bacteria. Essentially it is a process by which bacterial cells can exchange parts of their genetic mechanisms to produce new strains having a combination of parental characters. This process is analogous to the production of the mule, by mating a horse and donkey. As yet, there are only a few reports of such genetic exchange occurring amongst bacteria of agricultural importance but the prospect of extending these studies is exciting. For example, it may be possible to use hybrids between bacterial strains to get some clues on why a particular type of bacterium attacks one variety of plant rather than another. There is also the interesting possibility that the ability of bacterial strains to undergo genetic exchange may indicate the closeness or otherwise of relationship between them; it seems very likely that amongst bacteria, as amongst plants and animals, only related forms are able to hybridize.

We have mentioned two processes, mutation and genetic exchange, by which bacteria can acquire different heritable properties. Here are some of the ways in which such bacteria, with changed or unusual properties, can be put to work as research tools. In biochemical research, mutants that are unable to carry out particular chemical processes are often used to help unravel the complex abilities of normal organisms. Because mutant organisms usually differ from the normal in some sharply defined character, such as coat color in animals or resistance to lethal effect of antibiotics in bacteria, mutants can be used to investigate the effects of alterations in a single bacterial character on the development of complex things like disease. When bacteria grow in plants they are entirely dependent on the host plant for the supply of nutrients they require for growth. Because of this several workers have studied the nutritional requirements of plant-pathogenic bacteria. These requirements are usually simple, but

(*Concluded on page 16*)

Effects of mutation on the common blight organism *Xanthomonas phaseoli*. *Upper:* Trifoliate leaf of bean inoculated with common blight organism and showing large numbers of leaf-spot symptoms. *Lower:* For comparison a similar leaf inoculated with blight bacteria of a mutant strain that requires a vitamin for growth. About one hundred times more bacteria were used here than were used in leaf above; even so leaf spots are few in number. This mutant strain of blight bacteria is therefore much less virulent than the blight organisms found in nature.





Above: Consumption per person of specified food classes: 1935-39; 1948-50; and 1955-57. *Left:* Baskets of food which could be bought with one week's income for an average family.

A Look at the Canadian Food Basket

L.E. Drayton

WHILE food prices and incomes have both increased, incomes have led the way. If people had bought the same food in 1935-39 as they do today, a family of four would have received only two-thirds as much for a week's disposable income—or 2.6 baskets, compared with 4.1 baskets in 1958 as shown above.

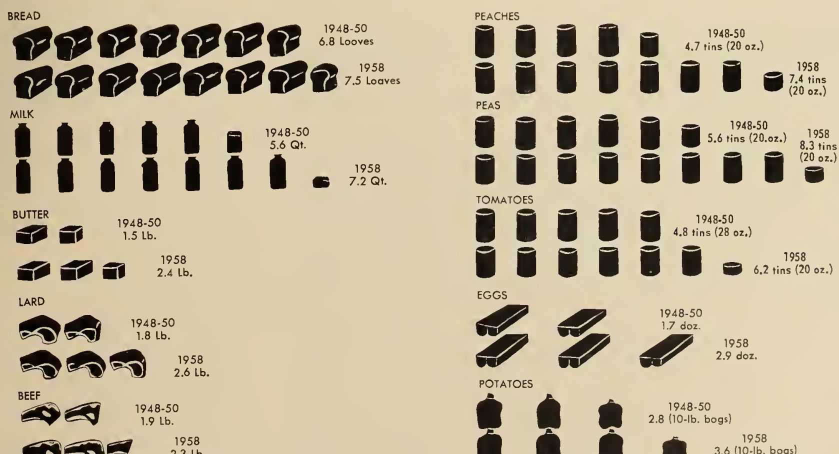
This estimate is based on the assumption that the disposable income for a family of four is four times that of the average individual. To arrive at the per capita figure, the total disposable income of all Canadians was divided by the total population.

The worker may still ask: "Can I buy as much food with an hour's work now as I could 10 years ago". In the charts below, the quantities of various foods which could be bought with an hour's wages in manufacturing industries in 1949 and 1958 are illustrated.

Manufacturing industries were used for this comparison because they employ a large percentage of wage earners in big cities, where data are available on food prices. In small urban centers, mining and lumbering communities, food prices probably have followed the same trend, but may be at lower or higher levels depending on transportation costs and other circumstances.

The foods illustrated below were selected as representative in the food budget. It will be noted that the quantity which an hour's wage will buy has increased for all of them. Similar results would be obtained for most other foods.

Dr. Drayton is Head, Consumption Economics Unit, Economics Division, Ottawa.



Quantities of specific food which could be bought with one hour's wages in manufacturing industries: 1948-50 and 1958.

Applied nitrogen, unless balanced with minerals, encourages lodging in oats.

Nitrogen in Relation to Lodging in Oats

P.O. Ripley

A HIGH NITROGEN CONTENT in the soil either natural or applied has long been associated with lodging of cereal crops. Working on the assumption that there is some direct relationship between nitrogen and lodging, the Canada Department of Agriculture's Research Branch made a study of the effect of this nutrient on lodging in the oat plant. The project showed that nitrogen alone tends to develop growth characteristics that encourage lodging, but it also demonstrated that when nitrogen is balanced with adequate mineral fertilizer applications, these weaknesses are more or less overcome and lodging is reduced.

The Department's experiments were conducted in the greenhouse in glazed pots of one gallon capacity. Here's a brief description of what we did and what was learned.

Nitrogen was applied at rates equivalent to 0, 10, 30, 60, 120 and 240 pounds per acre. In one series no minerals were added with the nitrogen. In another, 120 pounds of P_2O_5 and 100 pounds of K_2O per acre were applied with each rate of nitrogen application. Seven oat plants of the Acton variety were grown in each pot. The treatments were replicated seven times to provide for harvesting at the milk stage of growth and also at maturity.

The yield of oat grain went up with each increase in the rate of applied nitrogen. The increases were greater, and the yields generally higher, where minerals were applied with the nitrogen, than where the latter was applied alone, and yields of straw were increased similarly. Although there was no way of measuring lodging it is not likely that the higher yields are a factor that induces lodging. They are mentioned here to indicate that nitrogen is desirable and will increase yields if lodging can be prevented.

Other records were taken to learn what characteristics may develop that either cause or prevent lodging. The ratio of top growth to root development is considered an important factor. Any treatment that increases top growth may cause the plant to become "top heavy" thus encouraging lodging. On the other hand it might also provide stronger stem growth, tending to prevent lodging. But if greater top growth is not accompanied by increased root growth, lodging is very likely to occur.

In the Ottawa project each increase in the rate of nitrogen alone, up to 120 pounds per acre, produced additional top growth. Pots without added nitrogen produced 22.6 grams of top growth; those receiving nitrogen at 120 lb. per acre produced 34.3 grams, an increase of 51.8 per cent. Where minerals were applied with the

Effect of nitrogen on root type and culm diameter

N per acre	Root type		Culm diameter mm	
lb.	N only	N plus Min.	N only	N plus Min.
0	6.5	3.9	2.0	2.4
10	6.5	3.2	2.0	2.6
30	6.8	2.9	1.9	2.7
60	7.7	3.3	1.9	2.7
120	6.5	3.7	1.9	2.9
240	7.7	4.5	1.8	2.8
Mean	6.9	3.6	1.9	2.7

The author is Director of Program (Soils), Research Branch, Ottawa.

nitrogen, increases were more marked and continued up to the 240-pound-per-acre rate of nitrogen application. Comparative yields of top growth where minerals accompanied the nitrogen were: zero nitrogen, 24.2 gm.; 120 lb. N, 46.8 gm.; 240 lb. N, 54.6 gm. This represents increases of 93.4 per cent and 125.6 per cent respectively.

Root growth was not significantly affected by applications of nitrogen alone. Yield of roots where no nitrogen was added was 3.6 grams per pot, 3.2 grams where 120 pounds were applied and 4.1 with the 240-pound rate. When applied with minerals, a slight increase in root growth was obtained with each increase in nitrogen. The ratio of top growth to root growth in all nitrogen-alone applications averaged 7.40 to 1. When applied with minerals the average ratio was 6.68 to 1.

These data indicate that nitrogen tends to increase top growth at the expense of root growth, making the plant "top heavy" and reducing "root anchorage" to hold the plant upright, thus encouraging lodging (see accompanying photo). Minerals, on the other hand, although increasing top growth, also increase root development. Thus they tend to offset the detrimental effects of nitrogen, increase the beneficial effects, and provide a balance that increases yields and reduces lodging.

Other observations in connection with plant development related to nitrogen applications with and without minerals tend to verify the above conclusions. Succulence or high moisture in plants is often associated with lodging of cereals. In this project nitrogen alone at low rates of application did not increase the moisture in oats harvested at the milk stage of maturity. The moisture was increased slightly, however, where 120 and 240 pounds of nitrogen were applied without minerals. When applied with minerals the increase in moisture was not so great.

Tall or long-strawed plants appear to be more susceptible to lodging than would shorter ones. Although nitrogen increased the total amount of top growth considerably, the increase was due to more extensive leaf growth and larger stem diameters above the first node, since the various rates of nitrogen did not increase the height of the plant. Height measurements were taken at two-week intervals during the growth period and at the time of harvesting but no significant differences in height were recorded.

Two very important factors associated with lodging are type of root system and diameter of culm at the base of the stem. Plants less susceptible to lodging have widely spreading, heavier, and more rigid root systems. A classification sys-

(Concluded on page 10)

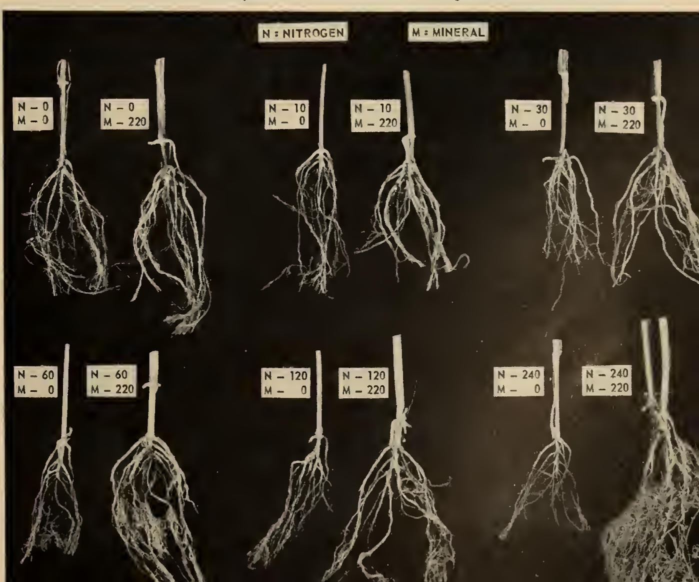
Mysterious Mechanism

The mechanism whereby nitrogen affects lodging is not completely understood. It is said that cereals that are susceptible to lodging are "weak strawed" — inferring that, in some way, the stem of the plant has been weakened or changed.

Various investigators—including several from the Canada Department of Agriculture — have suggested a number of factors that may cause lodging such as heavy rates of seeding, type of root anchorage, culms of small diameter at basal internodes, an abundance of nitrogen, a small amount of sclerenchyma tissue, thin cell walls, and a low percentage of dry matter in the straw. Opinions differ as to the effect of such other factors as erectness of leaf, amount of tillering, length of straw, number of vascular bundles, percentage of lignin, depth of seeding, length of internodes, length of sclerenchyma fibers, and amount of silica. Dr. D. G. Hamilton, Director of Program (Crops), Dr. A. J. MacLean, Soils Research Institute, and Mr. L. M. Casserly, Genetics and Plant Breeding Research Institute — each located at Ottawa — have also done considerable research on problems associated with lodging.

Dr. Ripley's article points out that when nitrogen is balanced with adequate mineral fertilizer applications some weaknesses are more or less overcome and lodging is reduced.

Root and culm development at different rates of nitrogen with and without minerals.



The Pesky Tuber Flea Beetle

A weakness discovered in the life cycle of this pest may lead to halting its spread

F.L. Banham

Top: **Tuber flea beetle feeding on a potato leaf (X 25).** ***Middle:*** **Appearance of larval feeding on peeled and unpeeled potatoes; note dark, thread-like, 'worm-tracks' in the peeled potato and the cracks and generally rough appearance of the unpeeled one.** ***Bottom:*** **Larvae of the tuber flea beetle.**

SINCE the tuber flea beetle was first discovered in the Fraser Valley of British Columbia twenty years ago, it has spread until today it is so persistent and injurious that measures for its control are an accepted part of potato growing throughout most of the southern part of this province. Although the tuber flea beetle is at present confined to southern British Columbia and the northwestern United States, it is gradually spreading eastward and northward.

The rough appearance of potatoes that have been heavily attacked by this pest and the food loss that results from deep peeling to eliminate the 'worm-tracks', renders these potatoes unmarketable for table use. Damage to the tubers is caused entirely by the larvae, which, in feeding, bore into the tubers. Small rough pimples are formed at points on the surface where larvae enter a tuber and cracks are formed where subsurface tunnels converge. Wide cracks often have the appearance of common potato scab.

The first satisfactory control measures against the tuber flea beetle in British Columbia consisted of frequent applications of DDT dust or spray to kill beetles on the foliage—the result of research by the Agassiz Experimental Farm and the Kamloops Entomology Laboratory. For main crop potatoes, five or more DDT applications were necessary at 7- or 10-day intervals throughout the summer, starting when the plants were about two inches high. For early crop potatoes, two DDT applications were necessary; the first about June 1, and the second ten days later. Applications of DDT 5 per cent dust or 50 per cent wettable powder at 1.75 or 2.5 lb. of toxicant per acre were made according to foliage density.

The DDT foliage treatment proved to be reasonably satisfactory when properly timed and carefully applied. Its major disadvantages were the high cost of labor and machinery which resultde from the numerous applications and the possibility of poor timing. In coastal areas where late blight is a serious disease of potatoes, the cost of the foliage treatments may be reduced by combining the DDT with the fungicide.

The author is a specialist in cutworm and flea beetle control at the Department's Entomology Laboratory, Kamloops, B.C.

At Kamloops and Agassiz, investigations were continued to devise a more economical and reliable method of control. These culminated in the development of soil treatments that may be applied at any time before or after planting but prior to foliage emergence. Soil insecticides have proved to be particularly suitable for tuber flea beetle control in main crop plantings in the interior of British Columbia. They are much more dependable than foliage treatments and remain effective throughout the season. Single applications of aldrin, chlordane, dieldrin or heptachlor applied experimentally at the rate of 4, 7.5, 1.5, or 4 lb. of toxicant per acre respectively, and immediately incorporated into the soil have been rated from 80 to 100 per cent effective against the tuber flea beetle. DDT foliage treatments have been rated from 11 to 97 per cent effective. In a long-term experiment begun at Kamloops, single applications of aldrin, chlordane or dieldrin applied at the rate of 4, 10, and 1.5 lb. of toxicant per acre, respectively, and worked into the soil, gave an average of 76 per cent marketable tubers one year after treatment, 80 per cent two years after and 20 per cent three years after treatment. After five years, it was apparent that residues from the original insecticides increased the effectiveness of one-quarter and one-half-rate applications of the same chemicals made four years later, by an average of 66 per cent and 115 per cent, respectively. In addition, soil treatments applied against the tuber flea beetle control other soil-inhabiting pests such as white grubs, wireworms and various cutworms.

Soil insecticides may be applied either with conventional crop sprayers, dusters, weed sprayers, fertilizer spreaders, or seed drills. Specially formulated fertilizer-insecticide treatments may also be used. Immediately following application, the insecticide should be incorporated into the top 2-4 inches of the soil by thoroughly disking, roto-tilling or harrowing. Immediate and thorough soil incorporation maintains insecticide effectiveness by slowing the rate of dissipation.

LIFE CYCLE

The adult tuber flea beetle is black and about one-sixteenth inch long. It is frequently confused with the western potato flea beetle, *Epitrix subcrinita* (Lec.), which also feeds on potato, but whose larvae do not normally attack the tubers.

The tuber flea beetle overwinters in the soil in the adult stage. In caged experiments at Kamloops, B.C., live beetles have been recovered from the soil to depths of twenty-four inches in clay and sandy clay loam soils. In a black peat soil, the beetles did not burrow as deep nor were as many recovered from it. The beetles cease feeding and begin burrowing into the soil about the time of the first killing frost in the fall.

Upon emerging from the soil in late May or early June, the overwintered beetles seek potato plants on which to feed. They feed mainly on the leaves and petioles of their host creating many small holes. Unless very abundant, feeding damage does not appear to destroy the leaves nor does it appear to reduce crop yields. If potatoes have not come up or are not present at emergence, the beetles will feed on the foliage of a number of crop plants and weeds while seeking their preferred host. On several occasions at Kamloops, foliage feeding by heavy populations of beetles has severely damaged large numbers of transplants in tomato fields.

Mating does not occur until suitable host plants have been found. About six days later the females begin laying eggs and continue for a period of ten days. The eggs, 0.5 mm. long, are laid at the base of the potato plants just beneath the soil surface. Minute white larvae, 1 mm. long, hatch from the eggs and seek suitable root hairs and tubers on which to feed. As feeding continues, the larvae tunnel into the tubers in an irregular manner to depths of one-quarter inch; occasionally, they may bore right through a tuber. In twenty days the larvae are approximately 5.5 mm. long and ready to leave the tubers to pupate in nearby soil. After twelve days in the pupal stage, beetles emerge and work to the surface of the soil to begin the life-cycle again. The life-cycle is normally completed in about six weeks.

In the interior of British Columbia, there are normally two generations per year, but in the lower Fraser Valley and Vancouver Island regions, there may be either one, two, or, under very unusual circumstances, three generations. In the interior, adults of the first generation emerge about July 25, and those of the second about September 1.

Where there are two generations of tuber flea beetles per year, the biotic potential of one pair of overwintered adults would number about 3800. This is based on laboratory work conducted at Kamloops, where beetles reared on potato averaged 87 eggs per female. Experiments conducted in outdoor cages indicated that the fecundity of the tuber flea beetle is reduced by about ninety per cent when it is restricted to feeding on tomato only.

With the increased use of sprinkler irrigation systems in the interior of B.C., considerable work has been done at Kamloops on the feasibility of using these systems to apply insecticides for tuber flea beetle control. Emulsible concentrates of insecticides can be applied through sprinkler systems at the time of the first spring irrigation prior to, or following planting. Insecticide may be siphoned into the intake side of an irrigation pump by a simple gravity flow injector regulated to give uniform injection. The major disadvantage of this method is that machinery necessary to incorporate the insecticide cannot be used on wet soil. Depending on the soil type, delays up to 48 hours may occur. At Kamloops, bio-assays and chemical analyses of soil samples taken from treated plots showed

Upper left: **Life history and habit studies of the tuber flea beetle are, in part, conducted in cages in which potato plants are grown.** ***Upper right:*** **A simple gravity injector used to put insecticide, in emulsible concentrate formulation, into the intake side of a rotary irrigation pump. Insecticide for tuber flea beetle control can be applied with a sprinkler irrigation system.** ***Lower left:*** **Emergence cans equipped with glass vials are attached to buried plywood soil tanks to collect overwintered tuber flea beetles.** ***Lower right:*** **Tuber flea beetles, larvae, or pupae are recovered from soil samples by means of a water flotation process employing fine mesh screens.**

that there was no appreciable penetration of insecticide into a soil even with heavy applications of irrigation water.

In the laboratory greenhouse and cold rooms at Kamloops, investigations are currently being conducted to determine more about the overwintering habits of the tuber flea beetle. Knowledge of the state in which the beetle overwinters (i.e. hibernation or diapause) is a very important factor involved in the potential success of this insect, particularly under extreme weather conditions. The beetle's present rate of spread, and the fact that it appears to be affected by neither parasites nor disease, suggests that it may be only a matter of time before this pest invades the potato-growing areas east of the Rocky Mountains. However, further spread may be prevented by a recently discovered weakness in the life cycle. In the laboratory at Kamloops, eight successive generations were reared in one year without any indication of diapause. In the field, beetles go into the soil only when feeding is interrupted by the first killing frost. Normally, only a small percentage survive to emerge in the spring. On this basis, the more extreme winter weather east of the Rockies might prevent establishment of this pest, at least until a diapause strain develops.

Additional studies are under way on the pesky tuber flea beetle. One is to determine more accurately the preferred soil types for overwintering of the adults, and their survival rates in various soils; another involves the prolificity of the insect when restricted to feeding on occasional host plants other than tomato. Why the tuber flea beetle exhibits strong preference for certain potato varieties is a question that remains unanswered too—and preliminary studies to accurately determine and explain the preference are continuing. Finally, investigations on the persistence of certain insecticides incorporated into the soil are being carried on and regular chemical analyses are being made to determine the rates of decline for each material.

Nitrogen in Relation to Lodging in Oats . . . *(from page 7)*

tem based on these factors and set up on a 1-10 scale was developed to indicate the type of root system, with the lower numbers indicating the root development most effective in preventing lodging. In plants susceptible to lodging the culm diameter at the base of the stem is restricted. This is associated with the width of the layer of sclerenchyma near the periphery of the culm and with the size and number of vascular bundles. The effect of different rates of nitrogen on root development and on basal culm diameter in millimeters is shown in the accompanying table. It is also illustrated on page 7.

There was a tendency, although this was not consistent, for rates of nitrogen to depress the desirable development of roots. Where nitrogen was applied alone at high rates, roots tended to be less spreading, smaller and less rigid and therefore provided less support and encouraged lodging. Where minerals were applied with the nitrogen this situation was corrected.

Where nitrogen was applied alone it definitely restricted the diameter of the basal culm thus weakening the straw and encouraging lodging. The mean diameter of the culm was 42.1 per cent larger where minerals were added.

In one instance in this project nitrogen was applied with the phosphorus and potash separately to learn which of the two minerals was most effective in reducing lodging. Both minerals contributed considerably but phosphorus was more effective than potash in this respect.

La lutte contre la rage au Canada

M. Beauregard

Tête de renord dont lo covité crânienne o été ouverte de façon ò exposer le cerveou.

DEPUIS quelques années, le Canada est aux prises avec une épidémie de rage dont la répression comporte des difficultés sans précédent. Contrairement à ce qui s'est produit à quatre reprises depuis le début du siècle, alors que l'infection a sévi à l'état enzootique chez le chien, les animaux sauvages sont à l'origine de l'épidémie actuelle. Jusqu'à date, ce sont les renards qui ont causé le plus de mal. En effet, ces animaux propagent la maladie au sein de leur espèce et s'attaquent ensuite aux animaux domestiques, leur communiquant ainsi le germe mortel. Comme il est impossible d'exercer une maîtrise efficace sur les allées et venues des animaux sauvages, il en résulte de grandes difficultés dans l'endiguement de l'infection.

La rage est une maladie infectieuse causée par un virus neurotrope. Ce dernier, à l'occasion d'une morsure par un animal enragé ou de la contamination d'une plaie vive par de la salive infectée, emprunte la voie des nerfs pour atteindre le cerveau où il produit une encéphalite dont le résultat final se traduit par la paralysie des nerfs moteurs et la mort à brève échéance. Bien qu'elle soit avant tout une maladie du chien, la rage peut contaminer tous les mammifères qui se font mordre par un animal enragé.

La susceptibilité de l'homme à contracter la rage donne à cette maladie une importance particulière et commande la mise en œuvre de tous les moyens propres à en assurer l'élimination complète dès qu'elle sévit quelque part.

Drs. A. H. Corner, A. Robertson et M. Beouregord exominont des sections de roge ou microscope.

C'est dans ce sens que les inspecteurs vétérinaires de la Division de la santé des animaux du ministère fédéral de l'Agriculture ont concentré leurs efforts, si bien qu'aujourd'hui la maladie accuse une régression marquée au pays. Ils ont été admirablement secondés dans leur travail par les autorités provinciales: unités sanitaires et services de la faune.

Lorsqu'on soupçonne la présence d'animaux enragés dans une région donnée, un inspecteur vétérinaire se rend immédiatement sur les lieux pour établir ce qu'on est convenu d'appeler un système d'information. Il convoque à cette fin une assemblée au cours de laquelle il expose la situation aux représentants des diverses autorités de la région concernée. A cette occasion, il leur indique de quelles manières la population peut coopérer au travail d'éradication de la rage et distribue une brochure contenant les renseignements essentiels au sujet de la maladie. Par la suite il utilise les moyens d'information courants tels que les journaux, la radio et dans certains cas, la télévision.

Chaque fois qu'un cas de rage douteux est porté à l'attention de l'inspecteur vétérinaire, il procède à une enquête minutieuse afin de s'enquérir des allées et venues de l'animal suspect et savoir si des personnes ou des animaux, en particulier des chiens, ont été mordus ou contaminés. Selon les

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En haut à gauche: **Préparation d'impressions avec des morceaux d'hippocampe.** ***A droite:*** **Inoculation intra-cérébrale d'une souris.** ***A gauche en bas:*** **Neurone dans lequel on voit deux corps de Négri telsqu'indiqués par les flèches.**

renseignements obtenus, il fait isoler les animaux contaminés ou il prévient les autorités médicales compétentes auprès desquelles il dirige les personnes contaminées. Si l'animal est déjà mort au moment de sa visite, l'inspecteur vétérinaire en expédie la tête à un des laboratoires de la Division de la pathologie animale en y joignant les informations qu'il a recueillies au cours de son enquête et qui sont de nature à orienter le pathologiste dans son travail de diagnostic. Lorsque l'animal vit encore, l'inspecteur voit à ce qu'il soit attaché et isolé pour une période de deux semaines. Si l'animal meurt au cours de cette période, la tête est envoyée au laboratoire pour fins de diagnostic. Quand l'animal ne manifeste rien d'anormal pendant ces quatorze jours d'observation, on peut conclure qu'il n'était pas atteint de rage. On voit par là pourquoi il ne faut jamais tuer un animal chez qui on soupçonne la rage, à moins qu'on ne puisse absolument pas le maîtriser. En le gardant sous observation, on peut suivre la marche de la maladie, qui, répétons-le, est d'environ deux semaines. D'après le comportement de l'animal, il est souvent possible d'en arriver à un diagnostic clinique précis, parce que dans la majorité des cas les symptômes sont caractéristiques de la maladie. De plus, ce délai favorise l'apparation des lésions dans le cerveau de l'animal, étant donné qu'elles se développent surtout durant les derniers jours de la maladie. Ceci est d'une importance capitale lorsque l'on veut obtenir un diagnostic rapide dans un cas où il y a eu contact humain. S'il devient nécessaire de tuer un animal enragé, il faut toujours procéder de façon à ne pas endommager le cerveau de la bête.

Une fois arrivée au laboratoire, la tête de l'animal est ouverte et le cerveau disséqué de façon à mettre en évidence les cornes d'Ammon (hippocampes) à partir desquelles le pathologiste prépare des impressions et les teint pour ensuite les examiner au microscope dans le but d'y déceler les lésions spécifiques de la maladie, communément appelées: "Corps de Négri". Quand il réussit à trouver ces lésions, cela signifie que l'animal en question était atteint de rage. Dans le cas contraire, il est cependant impossible de conclure à l'absence de la maladie puisqu'il arrive parfois qu'on ne puisse trouver de corps de Négri dans le cerveau d'un animal mort de la rage. Il faut alors recourir à l'inoculation d'animaux de laboratoire afin d'obtenir un diagnostic définitif. Toutefois ce dernier procédé n'est employé que lorsqu'il y a eu contact humain. Les animaux ainsi inoculés sont gardés sous observation au laboratoire et, s'ils développent la maladie, on les sacrifie ordinairement à l'état moribond afin de procéder à la recherche des corps de Négri, de la façon décrite plus haut. Les résultats obtenus dès l'examen microscopique préliminaire ou à la suite de l'inoculation d'animaux de laboratoire, sont immédiatement portés à l'attention des autorités médicales concernées lorsqu'il y a eu contact humain. Cette démarche a pour but de compléter les informations qu'elles ont déjà reçues de l'inspecteur vétérinaire lorsque ce dernier a procédé à l'enquête préliminaire du cas, et de les orienter en ce qui concerne le traitement des personnes contaminées.

Malgré son efficacité, l'inoculation d'animaux de laboratoire comporte un inconvénient sérieux. Il faut en effet attendre environ douze à quinze jours avant d'avoir pu observer les symptômes de la maladie et confirmer le diagnostic par examen microscopique du cerveau des animaux inoculés. Des recherches en cours depuis quelques années nous laissent toutefois entrevoir la possibilité de remplacer le test biologique actuel par une méthode histo-chimique utilisant des anticorps rendus fluorescents. Cette méthode permettrait de poser un diagnostic en quelques heures, ce qui serait d'un grand avantage quand il s'agit de déterminer si un animal qui a mordu quelqu'un était réellement atteint de rage, lorsque par ailleurs on n'a pas réussi à trouver de corps de Négri dès l'examen microscopique préliminaire.

Etant donné que les chiens et les chats représentent la principale source de contamination pour l'homme, la Division de la santé des animaux du ministère fédéral de l'Agriculture s'est occupée de la vaccination gratuite de ces animaux partout où elle prévoyait la possibilité pour eux de venir en contact et d'être infectés par des animaux sauvages. C'est ainsi que du 1er avril 1958 au 31 janvier 1959, 333 cliniques de vaccination anti-rabique ont été tenues dans 17 comtés de l'Ontario. On y a alors procédé à l'immunisation de 61,446 chiens et de 30,574 chats et autres petits animaux domestiques.

On ne saurait cependant trop insister sur le fait que la vaccination, comme moyen de répression, n'est aucunement destinée à remplacer le contrôle des chiens. Cette dernière mesure est d'une importance primordiale et la vaccination n'en est pour ainsi dire que le complément. C'est pour cette raison que les ordres sont formels lorsque la maladie sévit quelque part. Les propriétaires de chiens doivent faire enregistrer leurs bêtes, les conduire à la clinique de vaccination et les tenir attachées aussi longtemps que subsiste le danger d'infection. Quant aux chiens errants, il faut les abattre. Lorsqu'un chien ou un chat non vacciné a été mordu par un animal trouvé positif au test de la rage, on recommande l'euthanasie. Si le propriétaire s'y oppose, il faut vacciner l'animal immédiatement et l'isoler durant six mois au cours desquels l'inspecteur vétérinaire fera des visites périodiques afin de vérifier le comportement de la bête. Un chien ou un chat vacciné depuis moins d'un an sera également isolé et visité pendant six mois à la suite d'un contact avec un animal que l'on sait enragé; cependant l'isolement et les visites ne s'échelonneront que sur une période de trois mois si le contact a eu lieu avec un animal chez qui on soupçonne la rage sans pouvoir en obtenir la certitude. Quant aux bovins, chevaux, chèvres, moutons ou porcs qui sont victimes d'un contact avec un animal enragé ou soupçonné de l'être, ils doivent être isolés pendant soixante jours. Le propriétaire peut cependant les faire abattre pour la consommation humaine, pourvu que ce soit dans les huit jours qui suivent le contact.

L'expérience démontre que l'élimination de la rage sylvestre est particulièrement difficile. Il convient cependant d'apprécier le travail des responsables de la lutte contre cette maladie. En effet le nombre de cas positifs a diminué considérablement. D'autre part, si beaucoup de personnes ont été contaminées, on n'a heureusement enregistré qu'un seul cas de rage chez les humains depuis le début de l'épidémie.

Fruit and Vegetable Processing

Blanching by Infra-Red Heat

Apples being treated with infra-red radiation. ***(See also cover photostory on page 2.)***

CANADA is leading the way in research into the use of infra-red heat in the blanching of fruits and vegetables preparatory to freezing and canning.

A scientific team led by Dr. E. A. Asselbergs of the Plant Research Institute at Ottawa has proved that infra-red lamps are superior to steam-water in the blanching of apples, celery, peas and potatoes.

A few benefits:

For apples, celery and peas, infra-red (1) reduces the amount of water, thereby cutting handling and storage costs; (2) does not leach out flavor and nutrients, as in the case of water or steam; and (3) improves texture, flavor and appearance.

For potatoes, it (1) reduces the fat absorption in french fries; and (2) allows better recovery of the raw material.

Canada has been pioneering in this field since 1955 and has the only known laboratory experimenting with infra-red fruit and vegetable blanching. Dr. Asselbergs first became interested in this process while attending university in the late 1940's.

Enquiries have been received from the United States, Yugoslavia, Spain, Belgium, Italy and South American countries.

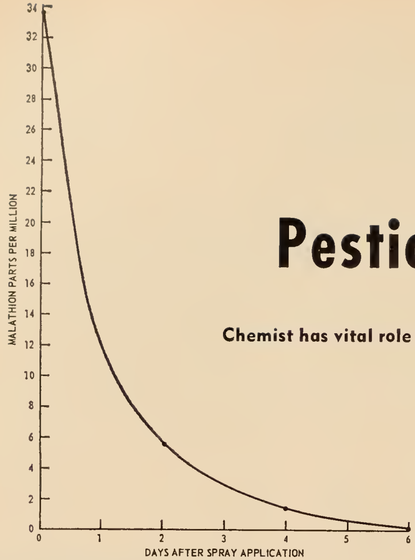
Infra-red blanching of celery is being carried out on a commercial basis by a southern Ontario food processing company. Domestic celery is prepared in September for manufacturing use during the winter—avoiding the high cost of importing. A 20-foot long infra-red tunnel can process more than 1,000 pounds of the finished product per hour.

Apple peeling by infra-red heat is another technique under experimentation at the federal laboratory. Researchers found that the loss of weight through peeling by this process was about two and a half per cent, compared to 15 to 18 per cent through the use of mechanical peeling machines.

The three major types of infrared radiators being used in experiments are calrods, quartz tubes and quartz lamps. The main difference lies in the operating temperature of the filament. In the first two types, the operating temperature is between 1,400 and 1,800 degrees F., while in the third type the filament temperature is 4,000 degrees F.

Infra-red heat is not a sure-fire method of blanching all vegetables. For example, it has so far been unsuccessful with asparagus, turnips and carrots.

"But" comments Dr. Asselbergs, "as we get more basic information we may be able to overcome the difficulties we have met with these vegetables."



Disappearance of malathion residue from alfalfa.

Pesticide Residues

Chemist has vital role to play in putting safety into crop programs

J.R.W. Miles

AT Chatham, Ont., where the Department's Research Laboratory is devoted to the control of insects affecting a variety of crops, insecticides and pesticides come in for special attention. How persistent are these chemicals and what is the safety interval that can be recommended to the farmer so that the insecticide residue will either have disappeared or dropped to a safe low level by the time the crop is offered for sale—these are the questions that the Laboratory's entomologists, with the aid of the analytical chemist, seek to answer.

When an entomologist applies an insecticide to a crop, many factors may influence the insect control. Wind may carry part of the application away, the chemical might have decomposed in the container or may have been decomposed by the fungicide with which it was mixed. These variables are resolved by the analytical chemist. Analysis from the original container can prove the content of the active ingredient. Compatibility studies with other pesticides enable the entomologist to choose the proper fungicide for mixed sprays. Crop samples analyzed soon after the spray has dried show exactly how much active material has been applied regardless of the effect of wind, sprayer speed, or errors in calculation of amounts.

After application to a crop, a pesticide may be diluted by growth of the plant, eroded by wind or rain, volatilized by heat or decomposed by air or sunlight. Samples taken at various time intervals can show the persistence of the in-

Chemist sampling treated corn plots.

The author is an Analytical Chemist attached to the Department's Research Laboratory, Chatham, Ont.

secticide as illustrated in the accompanying graph. Carried through to harvest, these time curves indicate the safety interval that can then be recommended to the farmer. These safety tests are also carried out with sprays at several times the recommended dosages. If no hazards appear from the exaggerated dosages, then no harmful residues should result from even an over-zealous spray applicator when the materials come into common use.

The new phosphate pesticides present a difficult problem for the analyst. Some of them are systemic and a simple rinsing or tumbling with solvent will not recover such an insecticide residue. Usually these materials can be extracted from the plant and its juices only by maceration with a suitable solvent, a procedure that too often results in difficult emulsions. Compounds like Systox and Thimet undergo oxidation in the plant to metabolites much more toxic than the parent compound. The analytical method most used for these materials makes use of the power of the chemicals to inhibit the enzyme cholinesterase present in animal blood. Thus the same factor which causes this condition is used by the analyst as an index of the amount of chemical present in a crop.

Chatham Lab. Analyses

Recent analyses made at the Laboratory have shown that the chlorinated insecticide aldrin converts to dieldrin on crops and in soils. Similarly, heptachlor converts to its epoxide. Analysts must now determine the level of these toxic metabolites besides analyzing for the original pesticides. DDT breaks down slowly into a non-insecticidal non-toxic ethylene derivative which can be analyzed by a modification of the Schechter-Haller method (see accompanying box). The fate of DDT and DDD residues on tomatoes prepared for pressing into juice was the subject of an intensive examination by chemists of the Chatham Laboratory. We found that the residues which persisted on the skins after the washing process, remained with the skins during the cooking and pressing, only minute amounts

Developing Analytical Methods

When tests indicate that a new insecticide shows promise in controlling important pests, the analytical chemist is handed the task of developing an analytical method. Such a method is now necessary before a chemical can be registered for use in crop protection.

To be most useful, an analytical method should only produce its color or reaction with the one chemical it is intended to assay. Non-specific methods that rely on only part of a molecule, such as the chlorine or phosphorus, can be useful where the exact spray history is known, but are not satisfactory for mixtures of pesticides or where the spray history is unknown. The method should also be sensitive in order to detect the few micrograms of insecticide which may be present on a crop at harvest. "Clean-up" procedures must be included to separate the small insecticide residue from large amounts of plant waxes and pigments extracted when the residue is "stripped" from the crop.

The mechanics of an analysis for a pesticide residue would begin with the weighing of the crop samples and removal of the pesticide with a solvent by tumbling in a glass jar, or extraction in special apparatus. After decolorizing of the extract, and evaporation of solvent from an aliquot, reactions with one or more chemicals at controlled temperatures form stable colored products. These colors are measured in a spectrophotometer and compared with those produced by known amounts of the same pesticide.

The popular "Schechter-Haller" method for DDT analysis uses a mixture of fuming nitric acid and concentrated sulphuric acid to insert "nitro" groups into the DDT molecule. After extraction, alkali washes, and evaporations, the nitrated product is reacted with sodium methylate solution to give a purple color. The density of the color indicates the original quantity of DDT in the aliquot. This widely-used analytical procedure has provided valuable information about DDT deposits on crops all over the world. With such a method of analysis, we can trace an insecticide from the time it is applied to a crop, and follow its disappearance during the growing season. We can check for hazardous residues at harvest and determine if residues, ingested by animals with their forage, concentrate in the fat or milk. The fate of harvest residues during the cooking and processing of foods has also been made possible through such analytical methods.

Left: **Author doing final analysis using spectrophotometer.** ***Below:*** **Tumbler apparatus for extracting pesticide residues from crops.**

Chemist sampling corn kernels for pesticide analysis.

being detectable in the tomato juice.

Other crops also present problems. We have made one intensive study of insecticides used on corn. Analyses for a number of pesticides were conducted separately on the plants, husks, and in kernels from treated plots. We found no residues of registered pesticides in the corn kernels but residues still remained on the plants and husks at harvest. This prevents the feeding of such treated plants to cattle.

Investigation of pesticide residues during the commercial dehydration of alfalfa from treated plots showed a buildup of methoxychlor residue. Heptachlor seemed to be driven from the fresh alfalfa at about the same rate as the moisture since heptachlor residues on dehydrated alfalfa were only slightly greater than those on the freshly harvested crop.

Spray in the Soil?

The spray that runs off onto the ground or is returned to the soil when a crop is "disked-in" also receives the attention of the analytical chemist. Arsenic was reported in tobacco long after common use of arsenical sprays had ceased. This was believed due to tobacco plants picking up arsenic from soils contaminated by years of spraying. DDT in the soil of apple orchards does not injure the tolerant apple trees but analyses have shown concentrations high enough to be phytotoxic if the trees were removed and less tolerant crops planted. Sprays applied for control of insects in the soil need specialized analysis because good control is dependent on getting the active material where the pest is living or feeding. Experiments at Chatham showed that half the heptachlor sprayed on the surface of soil disappeared within six hours. Leaching by rain or irrigation could remove a pesticide from the depth where it is needed for control. Analyses show that DDT, however, does not diffuse downward to any extent. Insecticides act differently in sand than in loam. Some insecticides combine a fumigant action with their contact or stomach action.

The chemist-entomologist research team is developing spray programs which control insect pests yet do not leave hazardous residues on crops. These brief directions to the farmer such as "apply at one pound per acre" or "not later than seven days before harvest" are quite often the result of several years of painstaking research.

Bacteria, Heredity and Plant Diseases . . . *(from page 4)*

by means of mutagenic agents like X-rays it is often possible to obtain altered strains of bacteria that require complex nutrients like vitamins or amino-acids from which proteins are built. Such mutant bacteria can be inoculated into host plants and, as might be expected, some varieties of plants do not supply enough nutrients so that the altered bacteria are no longer able to cause disease. Thus we learn something about the factors that make some varieties of plants, but not others, susceptible to bacterial attack.

Other uses of mutant organisms may be mentioned. Some groups of bacterial plant pathogens produce enzymes that attack plant tissues and cause "soft rots". Mutant bacteria have been isolated that cannot produce these enzymes and consequently have proved unable to attack their usual host plants. Such results confirm the importance of these rotting enzymes to plant pathogenic bacteria: unfortunately, the situation is still far from simple for we know of other soil-inhabiting bacteria that produce similar enzymes but are unable to attack plants. Occasionally, mutant characters are used as "tags" or "labels" in experiments in which one wishes to trace the fortunes of a particular strain of bacteria in complex mixtures of organisms, such as are commonly found in soil or on plant surfaces. In the same way as one might recognize a rare plant by its flower color so bacteria can be recognized by unusual physiological abilities and when necessary can be "labelled" for future recognition by the possession of some rare mutant character.

Clearly, one cannot predict future research findings with any certainty but one can make some intelligent guesses about future applications of genetic studies on bacteria of agricultural importance. One application already mentioned is the possible use of "genetic exchange" as a means of testing for relationship between bacteria; another is the possibility of "breeding" bacteria for particular purposes. For example the mold *Penicillium*, which produces the antibiotic penicillin, has been bred for industrial purposes by artificial means and strains obtained that yield much more penicillin than any naturally occurring mold. Similarly, it may be possible to improve, for example, the effectiveness in nitrogen fixation of certain nodule bacteria.

The complex relationship between plants and particular bacteria, whether beneficial like *Rhizobium* or harmful like *Xanthomonas,* depends for its outcome on the heredity of both plants and bacteria and often on environmental conditions as well. Certainly there is much more research to be done on the biology of bacterial plant pathogens, for their disease-causing activities are only one aspect of their existence. One can be equally certain that genetics will continue to contribute both to our knowledge of bacteria as such and to our ability to manipulate them to the best advantage.

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