Research
FOR FARMERS

FALL — 1958

What's New in Cutworm Control?

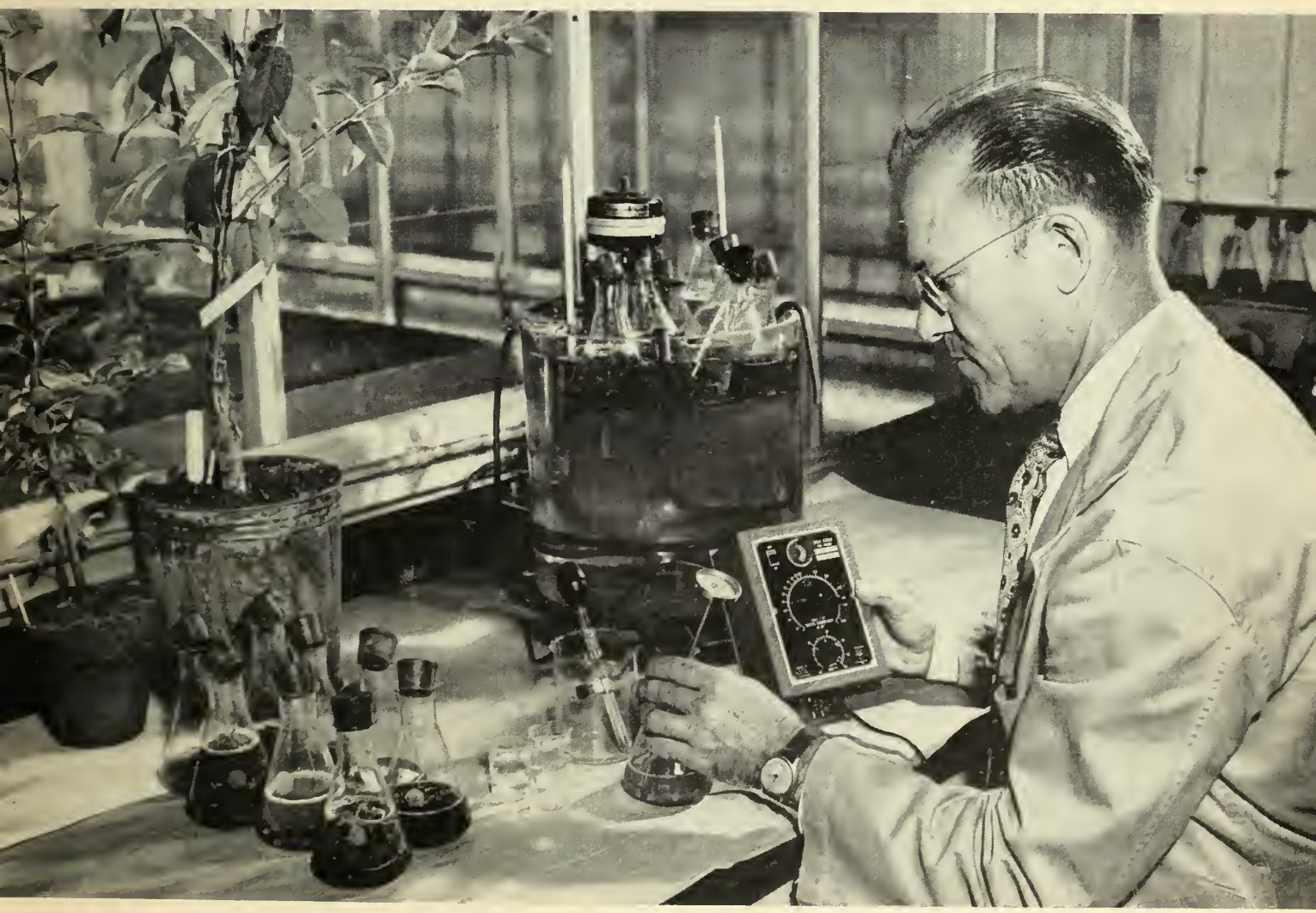
Johne's Disease

Winter Hardiness Research

Growing Grass on Dikes

Clubroot of Crucifers

The Lacombe Hog



CANADA DEPARTMENT OF AGRICULTURE

Research FOR FARMERS

CANADA DEPARTMENT OF AGRICULTURE
Ottawa, Ontario

HON. DOUGLAS S. HARKNESS, *Minister*
J. G. TAGGART, C.B.E., *Deputy Minister*

NOTES AND COMMENTS

While the recent International Genetics Conference held in Montreal may have had little direct interest for farmers, it did have important implications for the future of agriculture. Leading geneticists from all over the world exchanged views on the application of the science to human welfare. Of particular interest were the impressive exhibits of the contributions of genetics to the advancement of agriculture. Canada's exhibit was outstanding. Among the subjects treated were several that have been mentioned recently in these columns, including the development of rust-resistant wheats, induced polyploidy in clover improvement, and production of coumarin-free sweet clover. The Lacombe hog, subject of an article in this issue, was also featured. Manipulation of the genes that determine character has opened the way for spectacular improvements in plants and animals. Agriculture will undoubtedly continue to benefit from the application of genetics as the science advances into the atomic age.

* * *

It isn't often that a new breed of livestock in introduced. And it's even more rare to have a new breed developed in Canada as a result of research in genetics. So the recent introduction of the Lacombe hog, the first breed of swine originated in Canada, marks a unique achievement. Last fall the initial distribution of the new breed was made and again this month another lot of breeding stock is being offered. In its short history the Lacombe has demonstrated its ability to produce plenty of quick-growing, high-quality pigs but its greatest contribution will probably be in cross-breeding. In his article in this issue, Dr. Fredeen tells the story of the development of the breed and of the rigorous standards adopted to assure top quality and performance.

* * *

If winter comes it's sure to be followed by a certain amount of winter injury to fruit trees. Sometimes this proves very costly to growers. Over the years growers have discovered that various cultural practices will help to limit the amount of injury. Amongst such practices are the use of whitewash, sacking or boards to protect against sunscald; low heading of trees to take maximum advantage of snow cover; cover cropping to induce early maturity of the wood; fall irrigation to prevent winter desiccation; and planting orchards on northern slopes to prolong the rest period and retard blossoming. At best, these can only help and perhaps the real answer lies in the development of hardier varieties through breeding and selection. This work is going forward steadily and Dr. Wilner discusses some new developments at Ottawa in his article on page 8.

FALL — 1958

Vol. 3 No. 4

"*Research for Farmers*" is published quarterly by the Canada Department of Agriculture. Its purpose is to help keep extension workers informed of developments in research and experimentation as carried on by the various units of the Department.

Cover Photo—Effects of freezing treatments revealed by electrolytic methods in a study of factors involved in winter hardiness. (See story on page 8.)

Cutworms: Variegated (upper) and Black (lower).

What's New in Cutworm Control?

C. R. Harris AND *J. A. Begg*

CUTWORM INJURY is very familiar to farmers of southwestern Ontario. Such crops as tobacco, tomatoes, corn, and sugar beets are vulnerable to attack. Even relatively small cutworm populations can seriously damage widely spaced row crops; and outbreaks in tobacco can be especially serious. Where damage is severe, whole fields may have to be replanted; replacing individual plants often results in uneven ripening of the crop.

New Controls Developed

In southwestern Ontario a number of species of cutworms are of economic importance but our two major pests are the black cutworm and the variegated cutworm. In developing satisfactory control measures we have been handicapped by the sporadic nature of cutworm infestations. We are not yet able to predict where infestations will occur. In 1956, seven field experiments were undertaken by the Chatham laboratory but cutworms occurred in small numbers in only three of the locations. It was obvious that unless we could be assured of cutworm infestations in field plots, time and effort spent in planning and performing the work would be largely wasted. Therefore laboratory rearing techniques, capable of supplying large numbers of insects as required, were developed for the black and variegated cutworms.

Average length of the life cycle of the black and variegated cutworms is approximately 45 days

The authors are Entomologists with the Department's Entomology Laboratory, Chatham, Ont. Mr. Harris specializes in Toxicology and Mr. Begg in Wireworm and Cutworm Investigations.

New Insecticides Offer Promise

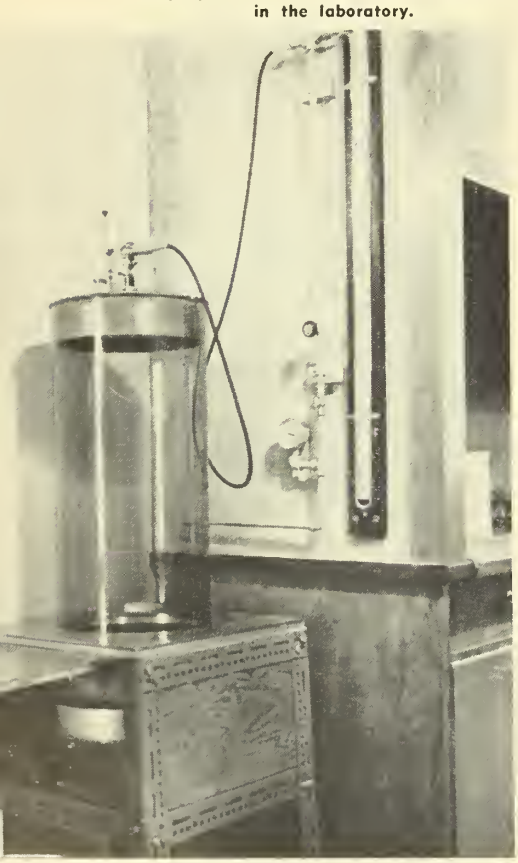
In recent years the introduction of chlorinated hydrocarbon insecticides has provided a new approach to cutworm control. In contrast with the stomach poison action of arsenicals, these materials serve as both contact and stomach poisons. Insecticides used for cutworm control are formulated in different ways, as emulsifiable concentrates, dusts, wettable powders, granules, and insecticide-fertilizer mixtures. In southwestern Ontario, combination cutworm-wireworm control is often obtained by a pre-planting treatment in which an emulsifiable concentrate is used. Dusts and wettable powders are useful for a post-planting treatment when emergency control is needed. Weather affects the action of soil insecticides, but to a lesser degree than it does poison baits. By increasing cutworm activity, warm weather increases the chance of contact with sufficient insecticide to kill the worm, even though the insecticide may not always be mixed evenly in the soil.

Severe cutworm damage (lower) in burley tobacco; close-up of damaged plant (upper right).

at 80 degrees F. Eggs hatch in 4 days and the larval and pupal stages average 27 and 14 days, respectively. In a year, two generations occur naturally; under laboratory conditions it is possible to rear seven generations. Fourth-instar larvae were used for laboratory toxicity tests or infestation of field plots.

To further increase the efficiency of field trials, a laboratory bioassay technique was developed to estimate the toxicity of potential insecticides. Since the new insecticides such as DDT, aldrin, dieldrin, heptachlor, and endrin kill more by contact than stomach action, a procedure was worked out using a spray tower, in which the insecticides were sprayed directly on the insects. By plotting the percentage mortality in groups of test insects against the insecticide concentrations used, we obtained a dosage-mortality curve. The toxicities of 'test insecticides' were compared with the toxicity of a 'standard insecticide'—usually a compound already giving satisfactory field control. The point on the dosage-mortality line usually selected for comparison is the 'LD50' or 'lethal dosage 50'; that is the concentration of insecticide causing 50 per cent mortality in a test group of insects.

Spray tower used for insecticide tests in the laboratory.



Cutworm Chronicle

The black cutworm and the variegated cutworm have two generations a year. Moths emerge from overwintered pupae in April, May, and June. Eggs are laid a few days later and hatch within a week. The cutworm or larva is the destructive stage of the life cycle. The larva grows by molting six or seven times depending on weather and food conditions. When fully grown, it forms a pupal cell approximately three-quarter inch long, by rolling and packing the surrounding soil. The pupal cell prevents desiccation of the pupa during development, which takes place over two to three weeks. Then the moth emerges to begin the second generation. First-generation larvae generally occur through the planting and growing season of May, June, and early July. It is this generation that does the most serious damage. The second generation extends through August, September, and October, with pupae overwintering until spring.

In 1956 and 1957 it was possible to bioassay ten potential insecticides. Of these, five were recommended for field tests in the spring of 1957 and two others for field tests in 1958.

Field Tests

In the field trials the insecticide formulations to be tested were applied on tobacco plots and incorporated into the soil as quickly as possible so that the insecticide would be less subject to weathering. Plants were transplanted either by hand or mechanically. Larvae reared in the laboratory were introduced into the test plots at the rate of one larva per plant. The efficiency of the insecticides tested was measured by the amount of cutworm damage to the plants.

In the 1957 field tests, damage to 'infested' control plots was as high as 40 per cent, while in 'uninfested' or natural control plots damage was negligible. This indicated that if we had not used laboratory-reared insects, field trials would have failed again.

Through these trials we were able to establish control recommendations for five insecticides. We also were able to estimate the speed of action of these insecticides. Satisfactory control was obtained in plots treated with 0.66 pounds of endrin, 1.5 pounds of aldrin, dieldrin, and heptachlor, and 2.4 pounds of DDT per acre, if the insecticides were applied at least one week in advance of planting. Thus far control in the field has compared favorably with that obtained under laboratory conditions.

Future Control Methods

Today, insect resistance to insecticides is a serious problem confronting entomologists. Resistance has not yet appeared in local cutworm populations, but it is reported from some areas. Present-day insecticides generally fall within two classes—chlorinated hydrocarbons such as aldrin, DDT, dieldrin, endrin, and heptachlor, and the organo phosphorus compounds such as parathion, malathion, guthion, and dylox. Present cutworm control measures generally include insecticides in the chlorinated hydrocarbon group. Hence, if resistance develops towards this group of insecticides, we must be in a position to recommend other insecticides, such as the organo phosphates. Should resistance develop to this group also, we shall have to look for new and more efficient materials.

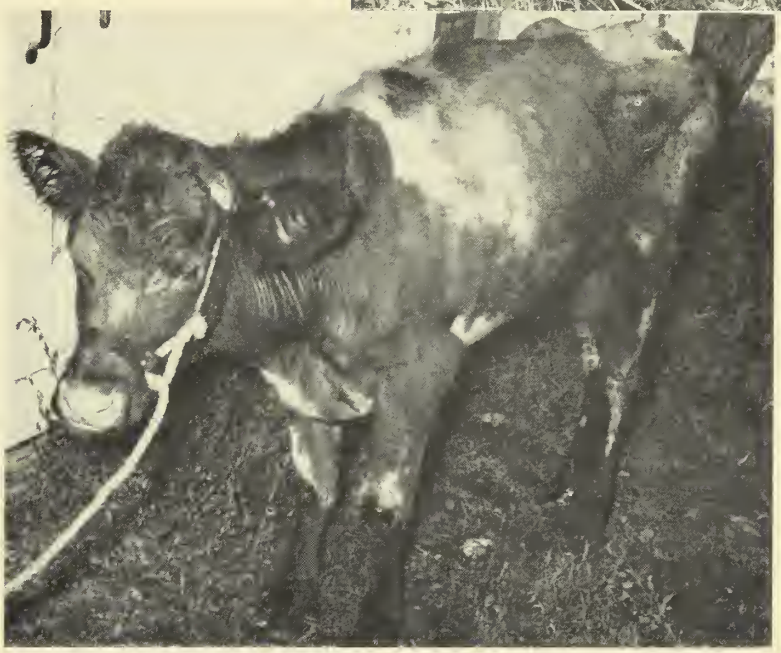
The possibility of developing biological control measures is not being overlooked. In the future it may be possible to culture pathogenic fungi, bacteria, and viruses, and to apply them in much the same manner as insecticides.

In southwestern Ontario approximately 80 per cent of the tobacco soils are treated with insecticide 'in case' cutworms occur. If the areas or years of cutworm outbreaks could be predicted, it would be possible to limit the application to only those areas where needed. Before this can be done we shall need to greatly increase our knowledge of the habits of our cutworm species. Studies along these lines are now in progress at the Chatham laboratory.

Johne's Disease

Detection and Prevention

H. Konst
AND
W. A. Moynihan



A latent case (upper) and a clinical case (lower) of Johne's disease. Latent case reacted to the intradermal johnin and the complement-fixation test, eliminating Johne's bacilli in the faeces; clinical case reacted to the complement-fixation test only. Lower animal died one day after the photo was taken.

JOHNE'S DISEASE, or paratuberculosis of cattle, is a chronic infectious disease characterized by intermittent diarrhoea, progressive weakness, dehydration and emaciation leading almost invariably to death. Although cattle are most frequently affected, this malady occurs also in sheep and occasionally in goats. The causal agent (called Johne's bacillus for its discoverer) sets up an infection in the mucous membranes of the intestines, where it multiplies to enormous numbers, causing variable degrees of inflammation, thickening and irregular folding but never necrosis. The development of these lesions is so slow that symptoms of chronic, intermittent diarrhoea may not appear for many months or even years after infection has been established.

Information gained since 1940 through testing 68 herds comprising 3,395 cattle under the Department's policy for the eradication or control of Johne's disease, indicates that foci of infection are present in practically every province of Canada. Most of the 44 herds found to harbor the disease were in the Fraser Valley district of British Columbia and the southwestern part of Ontario, both areas of comparatively dense cattle populations and intensive cattle breeding. The number of infected herds was somewhat smaller in south-central Saskatchewan, southeastern Manitoba, and in the Eastern Townships of Quebec, including the vicinity of Montreal. The tests revealed only two infected herds in south-central Alberta and two in Nova Scotia. These official test-records do not, however, reflect the true incidence of the disease in Canada. Figures compiled from information received through practicing veterinarians and livestock owners and from positive results reported by various diagnostic laboratories on submitted tissue specimens indicated that during the year ended March 31, 1957, the disease was diagnosed in 805 animals on 56 premises. It is apparent that Johne's disease is on the increase in some sections of the country and may become a serious menace to the livestock industry if all available measures

The authors are with the Department's Health of Animals Division. Dr. Konst is located at the Animal Pathology Laboratories, Hull, Que., and Dr. Moynihan at the Divisional Headquarters, Ottawa.

INCIDENCE OF INFECTION FOLLOWING PERIODIC SERIAL DIAGNOSTIC TESTING AND THE REMOVAL OF THE REACTORS

Serial No. of Test	No. of Infected Herds Tested	No. of Cattle Tested	No. of Reactors	Percentage of Infection
1st	44	2,108	157	7.45
2nd	27	1,489	83	5.57
3rd	9	457	24	5.25
4th	7	460	13	2.82
5th	6	259	3	1.16
6th	6	386	8	2.02
7th	3	140	0	0
8th	3	164	0	0
9th	3	164	2	1.22
10th	3	181	2	1.10
11th	3	199	1	0.50
12th	2	58	1	1.72

Development of Diagnostic Aids for Johne's Disease

Co-author Konst examines cultures of Johne's bacilli adapted to grow on various solid and liquid media in the absence of growth-promoting substances.

In 1928 research workers of the Department's Animal Diseases Research Institute began studies to determine the cultural medium requirements and optimal growth conditions of the bacillus *Mycobacterium paratuberculosis,* the causal agent of Johne's disease. As a result of this work, five old laboratory strains were adapted to a synthetic medium that did not contain special growth-promoting substances which heretofore were generally believed necessary for the luxuriant development of the Johne's bacillus and which were usually supplied by the addition to the medium of the heat-killed cells of *Mycobacterium phlei.* The time required to adapt these strains varied from 17 to 52 months; thus, two strains attained full luxuriance in 1930 and three in 1933. Of six strains, isolated in the period from 1934 to 1939 from different sources in Canada, four became well established on the same synthetic medium within 17 to 35 months (January 1936 to November 1940), while two developed luxuriantly after 13 months on this medium in the presence of potato (January 1940 and 1941).

It was felt that crude johnin prepared from culture filtrates of these adapted cultures, containing no alien bacillary substances, would be of higher specificity. Such crude preparations, however, did not prove sufficiently potent and on further concentration often gave non-specific reactions in normal animals. During the years 1931 to 1935 various methods were tried to remove the factors responsible for non-specific reactions and to increase the potency of the johnin. In January, 1936, trials were commenced to recover the active principles of johnin in the purest possible form from the crude filtrate. These, like the active principles of tuberculin, are associated with the bacterial protein that accumulates in the culture medium during growth and disintegration of the micro-organisms. The method developed for the separation of the purified protein derivative (P.P.D.) from tuberculin was, therefore, utilized. The preparation obtained is known as johnin P.P.D.

In field trials organized by the Health of Animals Division, this product proved superior both in potency and specificity to the earlier crude product. In spite of these improvements, some cross-reactions still occur with johnin P.P.D. in animals sensitized with other acid-fast bacilli, particularly avian tubercule bacilli.

This purified agent has been used since 1937 in the diagnosis of Johne's disease in Canada.

In the development of the complement-fixation test, a somewhat more sensitive technique was adopted than that employed in most routine diagnostic tests elsewhere. Initially a suspension of whole, heat-killed bacilli was utilized as antigen. Since 1957, a polysaccharide antigen prepared from Johne's bacilli has also been used, further studies having indicated that the antibodies in the serum of infected cattle react mainly with the polysaccharide and not with the protein constituents of these bacteria. The sensitivity and specificity of the complement-fixation test has been improved through the addition of this antigen.

---

of control are not used concertedly.

Since 1937, johnin P.P.D. has been used in Canada for diagnosing Johne's disease by the intradermal test method. Unfortunately allergy in early, sub-clinical cases is not always sufficiently established to be detected by this test. This lack is related to the weak and fluctuating degree of sensitization often found in naturally infected animals, believed to depend at least in part on the slow rate of development and the site of active, progressive lesions in this disease. Conversely, in advanced clinical cases the reactivity of the animals to johnin P.P.D. disappears entirely. However, the short-comings of the intradermal johnin test may often be overcome by frequent periodic testing of the animals, followed by thorough cleansing and disinfection of the barns and premises and strict isolation of the reactors until their slaughter.

Following is an example of the success obtained by the practical application of these rules. In a herd comprising 23 animals at the time of the first johnin test, 16 animals had been lost due to Johne's disease during the preceeding 5-year period. Six periodic tests carried out at half-yearly and yearly intervals during the next five years uncovered in the first four tests 8 infected animals. By their removal, combined with strict sanitary measures, the herd was freed of the infection, as judged by the subsequent clean test-record

and the general well-being of the animals.

In the past, the value of the complement-fixation test in the diagnosis of Johne's disease has been examined to only a limited degree. Improvement in the technique of the test and in the antigens used has increased the accuracy of this test in more recent years. Indeed, some workers consider the complement-fixation test in its present form more reliable than the intradermal test. In general, the great majority of animals with well-established and numerous lesions will be serologically positive and continue to react throughout the terminal stages of the disease. Animals with few and less extensive lesions may remain serologically negative, even when shedding Johne's bacilli in the faeces.

Since skin sensitivity appears to develop relatively early after infection, but often disappears in the advanced stages of the disease, the concurrent use of the intradermal johnin and complement-fixation tests has certain advantages over either test method alone. For this reason, since January, 1954, the intradermal test with johnin P.P.D. has been supplemented in Canada by the serologic test in all herds tested under the Department's policy, as well as in imported cattle and animals destined for export to countries requiring certificates of negative johnin tests. This method gives a more accurate picture of the health status of the herds under test and has increased the number of infected, pre-clinical cases detected.

Policy on Johne's Disease

The Health of Animals Division has evolved a policy whereby the diagnostic tests for the detection of infected animals in suspected herds may be carried out by official veterinary officers free of charge on request of the owner. The owner must enter into a written agreement with the Department not to sell, except for immediate slaughter, any reactors to the tests; to strictly isolate those temporarily retained for economic reasons; and to thoroughly clean and disinfect the premises after removal or isolation of the infected animals. No provision is made for the payment of compensation to the owner for animals slaughtered as reactors to the tests.

Under this policy, intradermal tests with the various preparations of johnin, more recently supplemented with the serological test method, have been made for many years in attempts to eliminate Johne's disease from infected herds through detection of early cases.

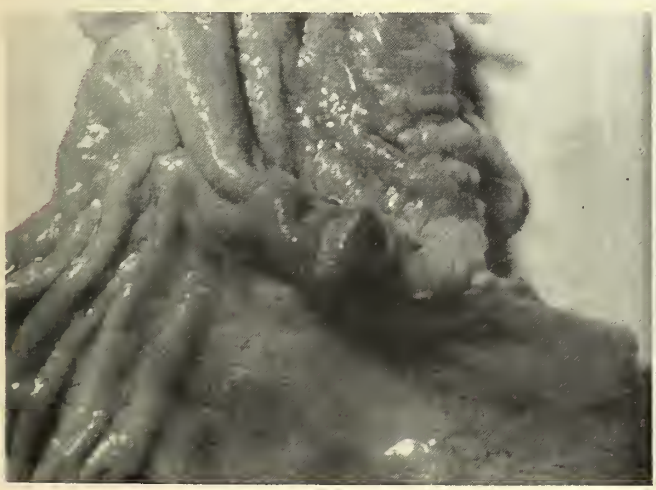
If Johne's disease becomes firmly established in a herd, it is difficult to eliminate. Since infection is almost invariably introduced by an animal in the latent stage of the disease, cautious selection of additions to the herd is advisable. As with other debilitating diseases, well-fed, healthy animals are more resistant to infection. A well-balanced and adequate diet coupled with good hygiene and sound husbandry are the first line of defence against Johne's disease.

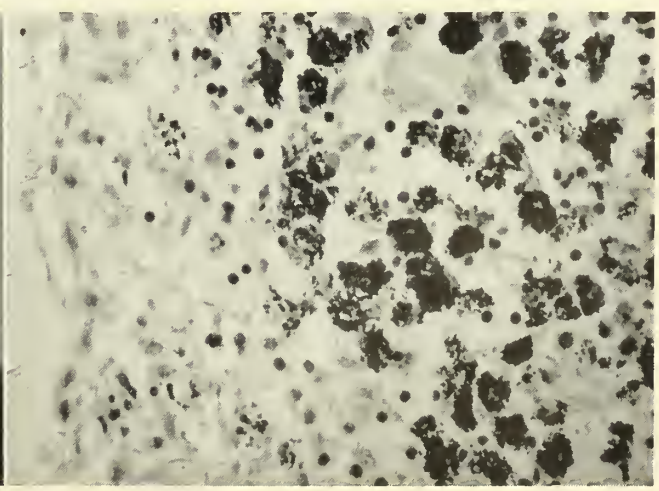
In a herd already infected, speedy diagnosis and removal of all clinical cases will eliminate the heaviest sources of contamination. However, eradication of the disease from the herd can be achieved only by the detection of the latent, pre-clinical cases. Repeated, periodic diagnostic tests have proved of value for this purpose. In view of the evidence obtained that foetal infection is a possibility to be reckoned with, it is now advocated that calves born from clinical cases be slaughtered, because they will develop the disease sooner or later.

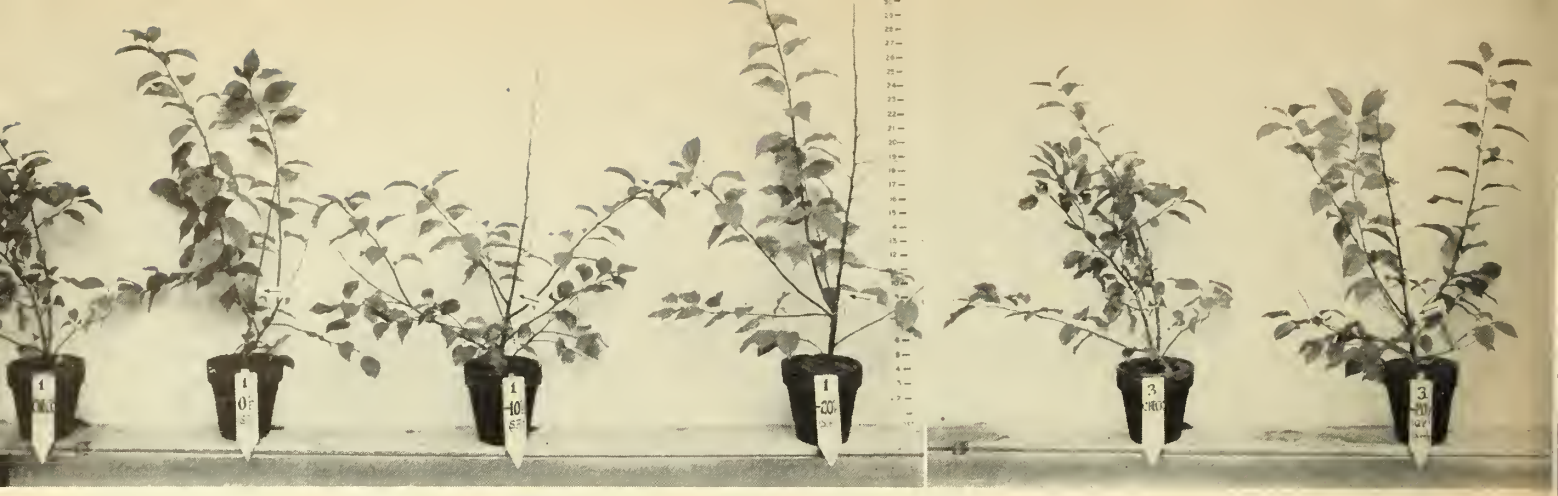
Thorough cleansing and disinfection of the premises forms a vital part of any eradication program, because the Johne's bacilli can survive for many months in soil, faeces, and water. The infective material may accumulate in especially high concentrations in stagnating water of ponds, ditches and water troughs, often contaminated heavily with faeces of diseased animals.

All factors that may be responsible for the persistence of the infection in a herd must be considered carefully if ultimate success is to be achieved with control.

Left: **Typical lesion of Johne's disease in the ileo-caecal valve of the clinical case shown on p. 5.** ***Right:*** **A section of the caecum from the same clinical case. The black areas, stained with carbol-fuchsin, are of Johne's bacilli in the mucous membrane of this bowel portion.**







Differences in injury of hardened shoots of 2-year-old plants of *M. robusta* 5 following freezing treatments. *Left:* Treatments at 0°F, –10°F, and –20°F. Electrical conductance in micromhos of twig tissues after treatments was: Check, 170; 0°F, 370; –10°F, 400; –20°F, 500. *Right:* Freezing of shoots compared with freezing of both shoots and roots. Electrical conductance afterwards was: Check, 170; –20°F freezing of shoots only 550; –20°F freezing of shoots and roots 690. (Arrows indicate new growth below the originally frozen portion.)

Winter Hardi

Apple Trees Being Teste
To Establish Factors Inv

J.

THE most effective means of reducing winter injury of fruit trees is to breed and select hardier varieties that are likely to succeed in a particular region. This necessitates an understanding of certain physiological properties and biochemical changes in plants in relation to frost hardiness. The main objective of our research is to devise reliable laboratory and field tests of tree hardiness under normal and critical conditions; to study environmental factors affecting cold injury; and to determine biological factors associated with cold resistance.

Dr. Wilner is with the Horticulture Division, Central Experimental Farm, Ottawa, where he specializes in the physiology of winter hardiness.

A reliable laboratory hardiness test on the young seedling plants would greatly facilitate and hasten the work of developing hardy commercial varieties of apples. Such a test would obviously result in a considerable saving of field space and labor necessary to maintain the thousands of trees, many of which would be eliminated by a test winter such as Ottawa experienced in 1933-34.

Extensive studies at Ottawa and elsewhere have shown that by following properly controlled artificial freezing treatments good agreement can be obtained between varietal ratings of injuries of plants and their winter survival in the field. In the studies modern refrigerators were used, where plants could be properly hardened and frozen at pre-selected temperatures that could be duplicated when desired.

Processes Involved in Frost Hardiness

Maturity, winter rest, and cold hardening are among the physiological processes involved in increasing frost hardiness of woody plants. *Maturity* of plants begins after growth stops in summer and is usually characterized by a decline in moisture content of tissues, increase in carbohydrates and osmotic pressure, thickening of cell walls, increased rigidity of shoots, etc. Seasonal *winter rest* in plants is developed in late summer or autumn before leaf fall. During the rest period protoplasmic activity of tissues is diminished, and frost hardening is developed in mature tissues when exposed at or near freezing temperatures. The degree of hardening appears to be influenced by the extent and earliness of development of rest. *Hardening* of plants is associated mainly with changes in the physical nature of the protoplasm. The protoplasm of the hardier cell is less brittle and less rigid and thus suffers less mechanical injury when contracted or expanded by freezing or thawing temperatures.

ELECTRICAL CONDUCTANCE OF WATER EXTRACTS AND E
FOLLOWING SPECIFIED TREATMENTS ON OCTOBER 21–24,
WERE GROWN OUTDOORS AND EXPOSED TO 4 DAYS OF
FROM

Varieties	Portion of season's growth	10°
Northern Spy	Terminal	4
	Median	3
	Basal	3
	Average	3
	% Twig killing(3)	1
McIntosh	Terminal	1
	Median	1
	Basal	1
	Average	1
	% Twig killing	
Antonovka	Terminal	1
	Median	1
	Basal	
	Average	1
	% Twig killing	

(1) Electrolytic determinations completed imme
(2) Total electrical conductance of twigs was d
them in water for 2 minutes and is the average of
variability between the four plants.
(3) Survival rating determined after field recove

Left: Differences in injury of 2-year-old plants of M. *Robusta* 5 following outdoor exposure of pots 1 inch below ground (G.C.) ond on top of ground (A.E.), both with and without snow cover (S.C.). Minimum winter temperatures of soil in the root oreos of the four pots shown (left to right) were 26°F, 4°F, −6°F, ond −25°F respectively *Right:* Differences in injury of 1-year-old Antonovko following similor outdoor conditions os for the plonts in left photo.

ess Research

By Electrolytic Methods ed In Winter Hardiness

ner

Numerous tests have shown that differences in injury to woody issues following freezing treat-

F RECOVERY OF TWIGS OF ONE-YEAR-OLD APPLE TREES REVIOUS TO THE ARTIFICIAL TREATMENTS THE PLANTS NG TEMPERATURES AT OR NEAR FREEZING, RANGING ° F.

Treatment		Average	Total electrical conductance
ial freezing for s at temperatures 0° F.	−20° F.		
lytic readings in icromhos[1]			
1250	1250	970	1231(75)[2]
660	750	597	837(25)
460	625	472	669(10)
789	874	679	912
100	100	100	
810	1100	693	1126(100)
480	800	477	837(40)
330	650	367	656(25)
540	849	512	873
100	100	67	
200	925	415	1187(25)
190	650	313	850(50)
180	575	282	689(75)
190	716	336	909
30	100	43	

fter freezing tests.
ed before artificial freezing treatments by boiling The numbers in parenthesis indicate the range of

g growing season of 1958.

Winter Injury Losses

Commercial fruit growers in Canada experienced severe losses during the winters of 1895-96; 1903-04; 1917-18; 1933-34; and 1955-56. In 1933-34 the well-known freeze in Ontario and Quebec reduced the production of apples by 64 and 44 per cent below the 1929-33 averages. The injury resulted from a rapid drop of temperatures on November 11 and 12, which at Ottawa were recorded as 9 and 2 degrees F, before the trees had shed their foliage. The 1956 apple crop in British Columbia was 37 per cent below the 1950-54 average, largely because of winter injury. In the latter case, injury resulted from an unusually early cold spell on November 12 to 16. During this period many apple orchards were in almost full foliage.

ments may be numerically recorded by an electrolytic method (see table). The effects of freezing may be measured immediately by the quantity of electrolytes which has diffused out of the tissues. Other tests to measure freezing injury in plants include the use of vital stains to differentiate living from dead cells; microscopic examination of ice in tissues; extent of tissue recovery and growth following freezing treatments; extent of browning of tissues following thawing, etc.

At present the work is primarily directed to establishing methods for evaluating the relative hardiness of seedlings in apple progenies. The hardiness work is coordinated with that of fruit breeding and plant propagation. The varieties Antonovka, McIntosh, and Northern Spy, all budded the previous summer on *Malus robusta* 5 rootstock, were grown in 8-inch metal containers while the controlled crosses from these varieties were grown in flats. The plants were grown, matured, and hardened outdoors under the same conditions, so that any differentiation in hardiness between these varieties may be attributed to genetic factors. Following outdoor hardening at or near freezing temperatures, the plants were moved to a thermostatically-controlled hardening room, illuminated to simulate natural daylight.

Trees at Ottawa were taken at intervals during late fall, winter, and early spring and tested under various freezing conditions. The freezing unit was supplemented with an insulated box containing thermostatically-controlled heating cable and styrofoam insulation to simulate outdoor winter conditions for roots under snow cover, while shoots were subjected to various low-temperature treatments. The varietal differences in freezing injuries of hardened

Left: Apple varieties winter stored in cold hardening chamber at 32°F plus or minus 3°F with artificial illumination of 32.8 watts per square foot. Hardened condition of plants developed while outdoors is thus maintained during the entire period of testing. *Right:* Author at freezing unit which is equipped with control instruments to maintain desired test conditions of both shoots and roots.

plants were determined by their ability to produce growth when returned outdoors. Such injuries were then related to electrolytic readings determined immediately after freezing treatments.

The results of this study showed the injurious effects on subsequent survival of apple twigs of *M. robusta* 5 when diffusion of electrolytes from hardened tissues exceeded 370 micromhos. Diffusion of electrolytes from tissues below 170 micromhos on the other hand was not associated with any injury to twigs. These results were corroborated by data in the accompanying table following similar studies with Northern Spy, McIntosh, and Antonovka.

The outdoor testing was primarily designed to determine the effects of snow cover on soil temperatures in the root areas and the subsequent winter survival of seedlings. Results of this study suggested a method whereby natural outdoor conditions might be utilized to test the relative and ultimate winter hardiness of roots.

The data in the table are representative of the main findings of studies begun here in the fall of 1956 to establish methods for evaluating the relative hardiness of standard varieties and seedlings of apples. The data indicate mainly that although the total electrolytic conductance of the three varieties before artificial freezing treatments was about the same, the amount diffused from the hardier Antonovka with 43 per cent injury as measured by survival test after artificial freezing, was less than from the relatively less hardy McIntosh with 67 per cent injury, which in turn was less than from the least hardy Northern Spy with 100 per cent injury. Results thus indicated the sensitivity of the electrolytic method to physiological changes in tissues caused by changes in freezing temperatures and the difference in twig injuries which followed these changes.

In this study the differences in diffusion of electrolytes from partly hardened apple tissue appeared to be more indicative of their relative hardiness following 0 degree F temperature than after either 10 degrees F or –20 degrees F. Diffusion was also generally greater in the less mature terminal portions than in the basal portions of twigs.

Testing for hardiness in conjunction with breeding for hardiness is considered at present to be the most practical method for increasing the number of hardy varieties. The effectiveness of this method could be increased with greater knowledge of what constitutes hardiness and of the main causal factors contributing to injury. Attempts will be made to include such fundamental studies in future hardiness research.

Left: Winter hardiness trials of apple varieties and their progenies continued under outdoor conditions. Various temperatures determined with thermocouple wires shown leading from pots to potentiometer in greenhouse. *Right:* Of interest to horticulturists are the progenies of controlled crosses between varieties Northern Spy, McIntosh, and Antonovka grown for hardiness tests and evaluation of parents for contribution to hardiness.

Left: Severe erosion of exposed dike face, Beaumont, N.B. *Right:* Tall wheat grass growing on a dike at Nappan, N.S. Note grass well below high tide level indicated by stake and debris.

Growing Grass on Dikes

Problems in Establishing Grass to Reduce Erosion

F. S. Warren

RESEARCH workers of the Canada Department of Agriculture and the Nova Scotia Agricultural College, Truro, are co-operating in the development of an effective seeding program for the protection of dikes. Work has been concentrated on a search for suitable plant species, the use of soil amendments, and effective cultural methods.

Dikes are costly structures and require protection from erosion. As much as four inches of exposed dike surface may be lost annually because of frost and runoff alone; tide and river erosion can be much more severe. Rock or plank facing prevents erosion, but the establishment of vegetative cover is the most economical method of reducing the cost of dike maintenance.

Originally dikes were built of sods and hence vegetation was natural, but modern methods have made the establishment of grass difficult. Most dikes are built of slow-draining, silty subsoil. Their average pH is 4.5, salt content up to 1.7 per cent and the sides of the dike slope as much as 30 degrees. In addition, much of their surface is subject to varying periods of flooding by salt water during high tides.

Plant Species Investigated

Botanists of the Department at Kentville and of the Nova Scotia Agricultural College have found that most of the species of the natural vegetation of the area are of little value for erosion control because of their habit of growth.

Dr. Warren is a Specialist in Forage Crops and Cereals at the Experimental Farm, Nappan, N.S.

Three species, *Spartina alterniflora, S. patens,* and *Puccinellia maritima* appeared useful since they were providing good natural protection along river banks. The first two could not be used since any seed produced is invariably washed away by the tide. The *Puccinellia* was found growing abundantly in areas frequently flooded by salt water and large quantities of seed have been harvested annually by direct combining. In 1956, for example, 5,600 pounds of seed were obtained from 35 acres. This grass has been particularly useful in seeding the outer slope of the dike. Investigation of indigenous species is continuing with the establishment of small observation nurseries of several promising strains.

In addition to the work with native species many introduced species were rated for salt tolerance. Some 60 lots were seeded in 10-foot strips running crosswise over dikes in several locations. While the majority of these failed to grow satisfactorily, a few were rated slightly tolerant to salt conditions. Among these were some of the cultivated bent grasses and fescues and couch grass, *Agropyron repens.* Tall wheat grass, *Agropyron elongatum,* obtained from the Experimental Farm, Swift Current, Sask., was rated fairly tolerant and an introduction from Holland, *Spartina townsendii,* was rated highly tolerant. Unfortunately, this *Spartina* was not sufficiently winter hardy to be of value.

Tall wheat grass proved readily adaptable and capable of sustaining growth even when subjected to periodic flooding by salt water. Because of its usefulness, seed production of this grass was undertaken at Nappan and since 1954 some 2,700 pounds of seed have been harvested from a $4\frac{1}{2}$-acre plot. All this seed has been used in dike seeding, mainly on the

Harvesting seed of *Puccinellia maritima* on dikeland at Truro, N.S.

more difficult lower levels of the outer slopes.

Concurrently with the species observations, various mixtures of species were compared and standard dike seeding procedure has evolved. The area, from a point about two thirds up the river-side slope and extending over the top of the dike and all the inside slope, is seeded to a mixture of ten pounds per acre each of meadow fescue, perennial rye, crested wheat and brome, plus seven pounds of timothy and two pounds each of red top, Canada blue, white clover, and alfalfa. On the outer slope overlapping the general mixture and continuing down the slope to just below high-tide level, tall wheat grass at ten pounds per acre is seeded. Overlapping this area again from slightly higher than halfway up the outer slope as far down toward the water as possible, *Puccinellia maritima* is seeded at 20 pounds per acre.

Soil Amendment Trials

Because of the nature of the dike soils, plant investigations without accompanying soil improvement work would be useless. Obviously considerable improvement can be effected by using various soil amendments, but any beneficial effect must be equated with the cost. The consistently low pH of the dike soils made lime a requirement in every case. Application rates as high as 20 tons per acre were indicated by soil tests. In practice, applications of 2 to 3 tons per acre were repeated until satisfactory growth was obtained. Soil testing, as indicated in the accompanying table, showed a clear relationship between changes in pH level and the amount of plant growth.

Maritime Dikelands

About the end of the 18th Century, the Acadians diked the low-lying shores of the tidal rivers of the Bay of Fundy so that they could farm these fertile marshes. Because of rising maintenance costs these dikes were neglected with consequent loss of much valuable land. Accordingly, the Canada Department of Agriculture, through the Maritime Marshlands Rehabilitation Administration, assumed responsibility for rebuilding many of the dikes. At present about 75,500 acres are protected. The marshland areas take in portions of some 3,300 farms that total an estimated 500,000 acres.

Hydrated lime is more effective than ground limestone in reducing soil acidity. Rates ranging from $\frac{1}{2}$ to 2 tons per acre were compared on a dike area with an average pH of 3.82. At least $1\frac{1}{2}$ tons were required before any growth was established. Both the $1\frac{1}{2}$- and 2-ton rate raised the pH to 4.5 or higher.

Gypsum was considered to have some beneficial effects on soil structure compared with lime since it tends to coagulate soil particles and, by replacing sodium, removes salt. In reducing salt and permitting good plant growth the effect of rate of application of gypsum was found to be less critical than was pH level. Good growth was general where the average salt content was 3,000 p.p.m. or less.

Growth of Vegetation in Relation to pH of Dike Soils in the Maritime Provinces—1951–55 incl.

Average pH	No. of samples	Amount of growth
6.16	126	good
5.10	72	fair
4.58	72	poor
4.27	26	none

Test plots of Krilium in combination with fertilizer, lime, tapping slag, and run-off slag were laid out on dikes at two locations. Soon after seeding, differences in growth were observed, but these differences were minimized the following year and no particular beneficial effect could be ascribed to the use of Krilium.

All soils of the newly constructed dikes were found to be deficient in available plant nutrients, particularly phosphoric acid. A basic application of 400 to 500 pounds of 3-15-6 is always applied together with manure wherever it can be obtained. Best seeding results were observed following the addition of manure.

Mulches of various kinds were found useful where the nature of the dike warranted their extra cost. Hay was the mulch most generally used, and where it was applied less than one inch thick over new seedings satisfactory establishment resulted. A mulch of bituminous emulsion was sprayed on newly seeded areas in several locations. Rates varied from 1/6 to 1/3 gallon per square yard. Growth was generally noticeably better on the sprayed areas and appeared several days earlier. No differences could be attributed to rate except that the film persisted longer at the higher rate. Cost of material and application at about 10¢ per square yard limited the use of the material to areas where good results could not be expected without extra expense.

(Concluded on page 14)

Left: **Spraying bituminous emulsion on newly seeded outer slope of dike, Westcock, N.B.** ***Right:*** **Side of dike showing catch of grass.**

Clubroot in swede.

Clubroot in cabbage.

Clubroot of Crucifers

A Problem With Swedes, Cabbages and Cauliflowers

G. W. Ayers

CLUBROOT is sometimes a serious problem where swedes, cabbages, and cauliflower are grown. The disease also affects other related crop plants such as turnip, radish, kale, brussels sprouts, broccoli, and rape. Losses are usually confined to farms and truck gardens where these cruciferous crops are grown intensively under a shorter rotation than is general in a more varied cropping program.

The disease organism enters the roots during periods of high soil moisture. Thirty to 40 days after infection the roots become enlarged and distorted, seriously disrupting normal food and water relationships. Affected plants lose vigor, and either die or produce crops of lowered quality and yield. Clubroot spores released in the soil by decay of infected roots may remain infective for 10 years or more. The disease may be sustained indefinitely if susceptible weed hosts are present in the years between cruciferous crop plantings. Crop lands may become infested with clubroot through transfer of spores by spring freshets or by surface run-off following heavy rains. Spores may also be carried to non-contaminated areas in soil adhering to animals and machinery. Manure too, may become contaminated should farm animals feed on infected roots because the infective power of the organism is not altered by passage through the digestive tract. Also if infected plant debris is incorporated directly in the manure, contamination may result.

All commercial varieties of cabbage and cauliflower, wherever grown in Canada, have proved susceptible to clubroot. Swede varieties, on the other hand, vary in reaction from complete susceptibility in certain areas of the Maritime Provinces to complete resistance when exposed to spore inoculum from truck garden areas of Quebec, Ontario, and British Columbia. In our experiments at Charlottetown, Wilhelmsburger has shown resistance to most Maritime inocula but is susceptible to inocula secured from other points in Canada. Laurentian swedes become severely clubbed

The author is a Plant Pathologist at the Science Service Laboratory, Charlottetown, Prince Edward Island.

when grown in clubroot-infested soils of the Maritime Provinces but this variety is usually highly resistant or immune in areas of Canada west of the Atlantic region. These contrasting reactions in swedes and other crucifers used in a comparison of the infective power of various clubroot samples offer substantial evidence of the existence of races of the causal organism. Seven such races have been demonstrated in our work at Charlottetown. Further studies may reveal additional variations in the ability of the clubroot fungus to cause infection in plants of the mustard family.

Breeding Resistant Stocks

Breeding for resistance to clubroot has been on a regional basis; no effort has been made to develop stocks resistant to all known races of the organism. However, swedes bred for resistance to local inoculum at Nappan, N.S., have shown high resistance to inocula collected elsewhere in Canada. With hybrid swede lines, one of the difficulties has been to incorporate resistance and at the same time retain high table quality. This is essentially a problem of the Atlantic region because high quality Laurentian swedes, which become severely clubbed in infested Maritime soils, have a natural resistance to clubroot inocula from Quebec, Ontario, and British Columbia.

Cabbage lines bred for clubroot resistance in Wisconsin also have a wide range of resistance. In

Author attending to cylinders of soil in tanks to study effects of temperature and soil moisture on infection and development of clubbing. Varying amounts of moisture are supplied to developing seedlings by capillary action.

Canada these stocks are highly resistant to all inocula with the exception of those from the Maritime Provinces. There are no known factors for resistance in cauliflower varieties, but plant breeders are now attempting through cross breeding to transfer to cauliflower the resistance of the Wisconsin cabbage. Breeding for resistance to clubroot in cabbage and cauliflower has not advanced to a stage where high quality stocks are available to the grower. Again progress has been slow because of the difficulty of combining resistance with quality.

Chemical Control of Clubroot

Growers prefer to avoid clubroot-infested land but this is not always possible in areas where crucifers are grown as specialized crops. When plants are exposed to pathogenic races of the clubroot organism chemical control should be considered.

There is no satisfactory and inexpensive fungicide or soil amendment for the field control of clubroot in swedes. Lime reduces the infective capacity of the organisms, but heavy applications of 2 to 3 tons are needed on most soils to give any appreciable control. If potatoes are included in the rotation, the excessive use of lime provides conditions favoring common scab. In areas subject to boron deficiency, heavy liming may interfere with the uptake of this element resulting in deficiency symptoms.

With cabbage and cauliflower transplants, control measures will provide considerable protection until late in the growing season. The grower should avoid seedling stocks that show root swellings. Planting such material leads to crop losses and introduces the clubroot organism to areas where it may not have existed previously. If seedlings are produced at home in flats, the soil used may be effectively sterilized by steaming or baking. When seedlings are transplanted to the field, soil drenches of mercury bichloride give further protection. One ounce of the chemical is dissolved in 10 gallons of water and each plant is drenched with one cup of solution at the time of setting in the field. This treatment effectively eliminates the clubroot organism from the immediate vicinity of the young roots, but as the plant develops a more extensive root system clubbing may eventually appear at root extremities.

Growing Grass on Dikes . . . *from page 12*

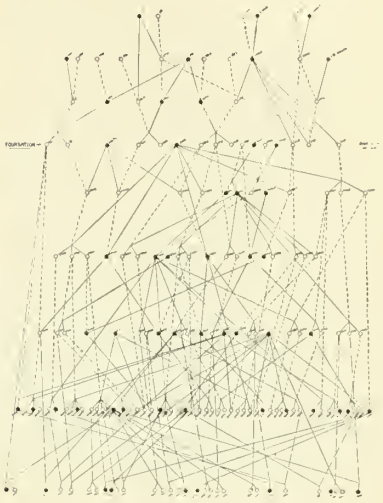
Various methods of seeding have been employed. The results were affected more by the nature of the dike than by the method. Where the dike slope is not too great the Brillion seeder has been useful. On more extreme slopes considerable sliding occurred causing poor seed distribution. Most seeding is done with the cyclone seeder followed by light harrowing.

The fact that rainfall is abundant and well distributed in the area is of great assistance in dike seeding. With the exception of a short period in midsummer, seeding may be undertaken from early spring until late September. Good results have also been obtained where seed was applied on frozen ground very early in the spring. A nurse crop of oats seeded at about one bushel per acre is generally used though frequently good establishment has been obtained without a nurse crop.

While the success of every dike seeding is far from assured, more than 722,000 lineal feet of dike (an area of approximately 9,000 acres) seeded by the Maritime Marshland Rehabilitation Administration is now adequately protected by vegetation. After successful seeding considerable attention is required to maintain the cover. Periodic mowing is highly desirable as grazing at any time may damage the dike face. Other maintenance requirements follow closely those employed in regular farm practice. The results so far obtained demonstrate that the application of research methods can solve a highly specialized problem.

Left: A yearling Lacombe boar.

Below: Incomplete genealogy chart of the Lacombe hog gives indication of complexity of breeding research.



Development of the Lacombe Hog

H. T. Fredeen

In 1957 the Canadian National Live Stock Records Board admitted to registration a new breed of bacon pigs. Named "Lacombe" after its center of origin, this is the first breed of swine developed in this country. It is white in color with characteristic flop ears, possesses good length and depth of side, and is low-set with full meaty hams. Mature boars weigh from 600 to 900 pounds and sows from 500 to 800 pounds. Representatives of the breed are docile and the females are gentle mothers and good milkers.

History

The research that produced the Lacombe dates back to the mid-1940's when the Canada Department of Agriculture initiated a program of swine breeding research to investigate ways and means for the genetic improvement of Canadian swine. Among the methods designated for study was the development from hybrid foundations of strains of bacon pigs suitable for complementing the Yorkshire in commercial swine production. Any strain so developed was to be white in color, of high productive performance, and capable of producing vigorous growthy pigs of good bacon type when crossed with the Yorkshire.

Crossbreeding as a basis for developing new breeds was not a new principle. The majority of our present improved strains originated from crossbred foundations and intensive research was in progress in the United States on the development of special-purpose strains, from hybrid foundations. Results available at that time indicated that the best procedure would be to choose parent breeds of different genetic backgrounds possessing characteristics desired in the new strain; these characteristics to be molded into one breed by the use of crossbreeding followed by a period of selective inbreeding.

Foundation Stock

The parent breeds selected for the development of one foundation at Lacombe were the Berkshire and the Landrace-Chester, the latter being a strain developed by the United States Department of Agriculture. These breeds were genetically distinct from each other and from the Yorkshire, an

Dr. Fredeen is a Specialist in Swine and Beef Cattle Breeding, Experimental Farm, Lacombe, Alta.

Performance of 318 Litters of the Lacombe and Yorkshire Breeds at the Experimental Farm, Lacombe, Alta.

Breed	Number alive		Weight at		Age to market	% A Grades	A. R. Score
	Birth	Weaning	Birth	Weaning			
			lb.	lb.	days		
Lacombe	10.5	8.3	3.1	39.9	172	78	78.4
Yorkshire	9.9	8.0	2.5	34.0	189	82	82.9

important requisite if the foundation was to fulfill the objective of complementing the Yorkshire in a cross-breeding program. The Berkshire with its reputation for high milking capacity, uniformity of back fat and fullness of ham was chosen as the female side of the foundation and ten representatives of this breed were obtained from Ontario. The desired white color and additional bacon characteristics were obtained by the use of five Landrace-Chester boars and two inbred Danish Landrace boars.

Testing and Development

The first litters of the hybrid foundation were produced in 1948. During each of the three subsequent generations, back-crossing and intermating were employed to promote a wide genetic combination of the traits possessed by the parent breeds. In 1952, the herd was closed to outside stock and a program of controlled inbreeding with selection was used to fix the desired type and performance. Approximately 20 boars were used in each generation in order to minimize the rate of inbreeding.

Selection in each generation of this development was based on factors of economic importance. Carcass quality, feed efficiency, and rate of gain were evaluated by entering a sample of each litter on performance test. The remaining pigs of these litters were raised as potential breeding stock and weighed periodically to provide information on their growth. When the performance tests were completed, selections were made using litter performance for litter size and weaning weight, litter-mate performance as a measure of carcass quality and rate of growth, and individual performance for physical soundness, vigor and development. Strength of feet and legs was considered and special attention was paid to number of teats, with 14 being the minimum requirement. Better than average performance was required for all pigs retained as breeding stock.

Throughout its development, the breed has been compared within each season with a strain of Yorkshires developed and maintained at Lacombe. To date the Lacombe breed has compared favorably with the Yorkshire herd in all economic traits considered. This is illustrated by the accompanying table which shows that the Lacombe has excelled particularly in growth rate and has provided very nearly the same quality of carcass. The breed has weaned an average of 8.3 pigs per litter with an average weaning weight of 40 pounds and an average age of 172 days at 200 pounds weight. This rate of growth is 10 per cent faster than that shown by the contemporary Yorkshires.

Percentage Advantage of Lacombe X Yorkshires over Yorkshires in Grade Commercial Herds and at the University of Alberta

Purebred Yorkshire Herd

Herds	Number alive at		Weight at		Rate of Gain to Market	No. of A-grade Carcasses
	Birth %	Weaning %	Birth %	Weaning %	%	%
Commercial	−0.4*	−0.1*	**	11	7	15
University of Alberta	4.0	4.0	26	22	11	13

* Disadvantage of Lacombe × Yorkshire.
** Data not available.

Field Tests

Since 1955 we have conducted field tests to evaluate the crossing performance of Lacombe boars when placed in commercial herds. In these comparisons half of the sow herd were bred to the farmer's own boar while the remaining half were bred to a Lacombe boar. During the past four years a similar test has been conducted at the University of Alberta. The results from these tests are shown in the accompanying table and it is apparent that the Lacombe crosses well with the Yorkshire to produce a vigorous, growthy pig of high carcass quality.

Today the breed traces back to seven of the ten foundation Berkshires and to the seven foundation males. The percentage contribution of the parent breeds is stabilized at 55 per cent Landrace, 23 per cent Berkshire and 22 per cent Chester White. A few animals are still heterozygous for the genetic factor for black color that was introduced by the Berkshire parent but these are being rapidly eliminated by a color-testing program initiated in 1955. This program consists of crossing all purebred Lacombes with Berkshires and any individuals that produce a litter with black or black spotted pigs by this test mating are culled from the breeding herd. All Lacombes have now been registered and propagation of the breed is under way at the Lacombe Experimental Farm with auxiliary herds at the Experimental Farms at Indian Head and Scott in Saskatchewan. The first release of breeding stock was made in October, 1957, when 50 boars were distributed to swine producers across Canada. A second release is scheduled for this fall.

Registration Requirements

A salient feature of the development of the Lacombe was the consistent selection in each generation for traits of economic importance. This principle of selection will be continued by the system of selective registration laid down in the pedigree requirements for the breed. To qualify for registration, individuals must meet certain standards of growth and carcass quality as measured by the standard advanced registry test, in addition to the normal requirements of purity of ancestry. We believe that this registration procedure will be a major contribution to the swine industry.

A 6-month-old Lacombe gilt.