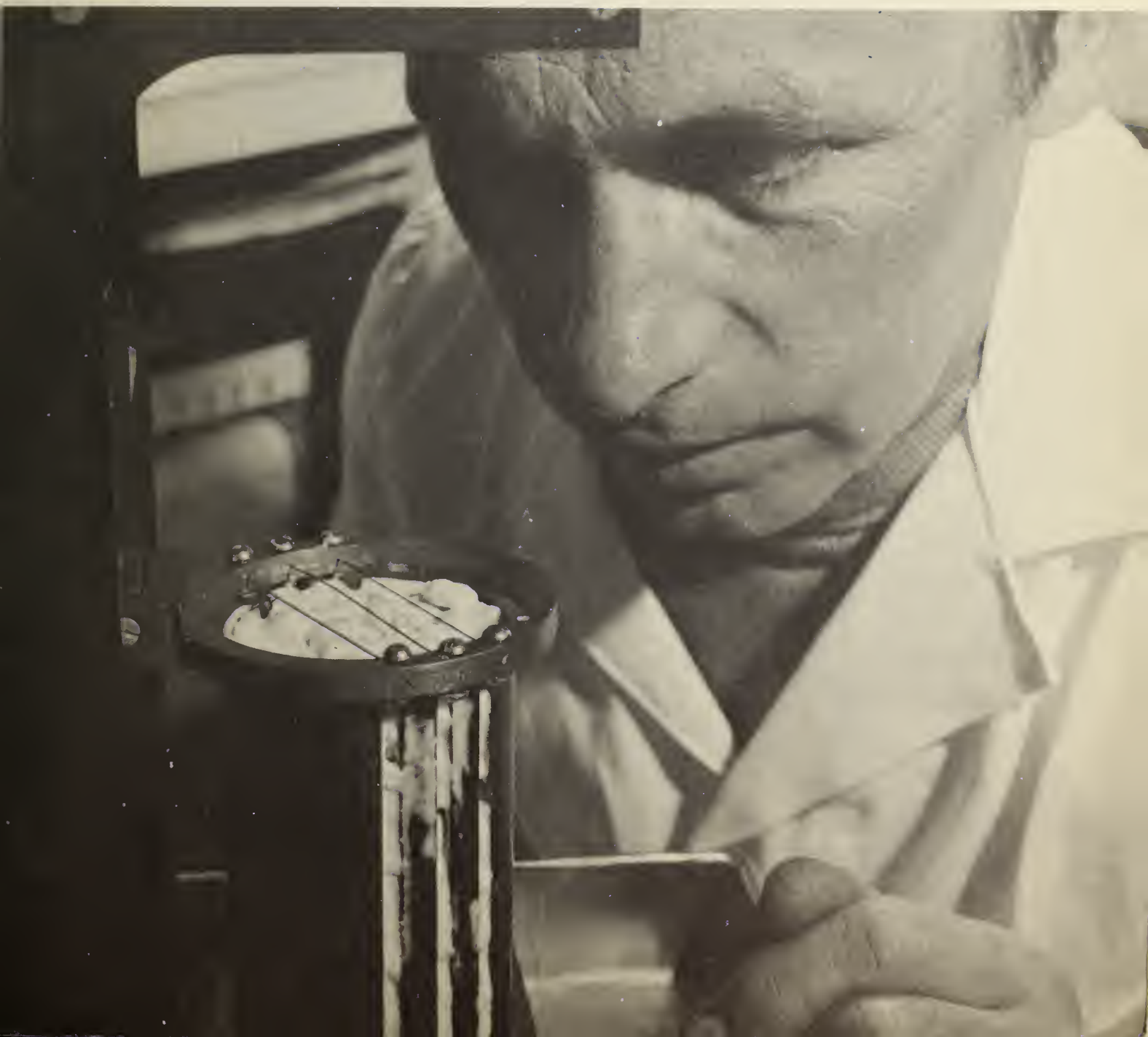
SUMMER 72
ÉTÉ 72

Texture testing techniques help keep food products palatable. See story on page 3.

Les épreuves de texture aident à garder les produits agréables au goût. Voir l'article à la page 3.

CANADA AGRICULTURE



CANADA AGRICULTURE

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CANADA AGRICULTURE is published quarterly to inform extension workers and agribusinessmen of developments in research and other federal agricultural responsibilities.

Contributors may submit articles in either English or French to the Secretary, Editorial Board, Information Division, Canada Department of Agriculture, Ottawa.

La revue trimestrielle *CANADA AGRICULTURE* renseigne les vulgarisateurs et représentants du négoce agricole sur les développements de la recherche et des autres services agricoles du gouvernement fédéral.

Les articles en anglais ou en français doivent être adressés au secrétaire du Comité de rédaction, Division de l'information, ministère de l'Agriculture du Canada, Ottawa.

FOOD RESEARCH INSTITUTE: TEN YEARS OF GROWTH

R. P. A. SIMS

Il y a dix ans, l'Institut de recherches sur les aliments a été formé par la Direction de la recherche du ministère de l'Agriculture du Canada. Le présent article fait, à vol d'oiseau, l'examen des réalisations des travaux des divers programmes impliquant les producteurs, les transformateurs, les consommateurs et les gouvernements tant provincial, fédéral qu'international. Les cultures horticoles et le miel qui avaient la primeur dans les programmes du IRA ont cédé la place aux oléagineux, aux céréales et à la viande. La recherche sur les produits laitiers garde cependant la priorité.

Ten years ago, the Food Research Institute was formed by the amalgamation of the Dairy Technology Research Institute with food-oriented sections from three other institutes. Initially, horticultural crops and honey were important to the FRI program. Now, oilseeds, cereals and meat have replaced them while dairy research continues to receive high priority. Our laboratories which were once dispersed over six buildings are now housed in four.

After an induction period, during which we learned what food research could do for agriculture, we preached the gospel of "Total Agriculture": the involvement of agriculture in all aspects of food from the fertilized seed, through growth, protection, harvesting, storage, to processing, marketing, new product development, distribution and consumer satisfaction. We do not know whether our missionary efforts have helped the adoption of a systems approach to solving agricultural problems, but we rejoice in current developments and look forward to contributing to Project '75[1]. We hope that our resources, which have remained constant over the past decade, will be increased to permit a more effective contribution to the welfare of Canadian agriculture.

FULL FOOD USE

The aim of the Food Research Institute is the optimum utilization of food. To us, food is agricultural produce consumed directly or following storage or processing. We know that in order to sell, raw materials must suit the primary processor and food products must please the purchaser. In the FRI, we therefore serve both the producers of the raw materials and the processors. A staff of 21 professionals supported by 28 technicians and an administrative staff of seven work to this end. Our back-up research defines the properties of the raw materials and the products made from them.

RAPESEED

Our oilseed program is designed to develop additional markets for oilseed protein through its use in human nutrition. For example, the limiting factor in the utilization of rapeseed meal is the presence of mustard oil glucosides and oxazolidethione. To this end, we developed a procedure for removing most of the undesirable material, thus producing a highly nutritious, bland, light-colored rapeseed flour comparable to casein in nutritive value, with reduced fiber content and a protein content of 60 percent or better. Current research comprises work on rapeseed glucosinolates and myrosinase, its carbohydrates, phenolics and proteins, the measurement of chemical and

Dr. Sims is Director of the Food Research Institute, CDA Research Branch, Central Experimental Farm, Ottawa, Ont.

[1]A systems approach to food production and distribution on a commodity basis now under study by the Canada Department of Agriculture.

Andrew Koenig, FRI technician, operates the aqueous extraction stage in the production of rapeseed flour.

Shirlie Howsam and Peter Elliott, FRI technicians, operate the gas chromatograph and mass spectrometer respectively, to identify flavor components in mature cheddar cheese.

manufacturing properties and the utilization of rapeseed protein in food.

SOYBEANS

Full-fat soy milk and full-fat soy flour skim milk powders have been prepared and shown to be nutritionally valuable and highly acceptable as milk substitutes in underdeveloped countries and also as calf and lamb milk replacers.

MILK PROTEIN

The dairy program concentrates on milk protein, its nature, coagulation and utilization in traditional and novel ways. By focussing our research on milk protein, we hope to be able to find new uses for it and, at the same time, reduce the effective cost of milk fat by increasing returns on the solids-non-fat portion of milk.

Cheese is also a concern of the FRI dairy program. We study cottage cheesemaking to learn how to increase yield and improve flavor, texture and shelf-life. The agglutination of bacteria and the effects of homogenization on skim milk are also investigated. Cheddar cheese, without defects, is a true gourmet item commanding a premium price. However, poorly developed flavor or the presence of astingency, bitterness, eatty flavor or fruitiness can make it less than a satisfying purchase. In good industry-government cooperation, we study the causes of these defects and advise industry on how to avoid them. Starter cultures and their bacteriophage are important to us as are the traditional and new milk coagulating enzymes. Research in these areas is conducted on both commercial and laboratory scales. We are also concerned with the development of new dairy products such as milk puddings and low-ash lactalbumin and new basic ingredients such as milk gels. This also involves industry-government communication.

MEAT QUALITY

Our meat program is just starting. We are concerned with the manufacturing properties of meat protein and how these can be exploited in the production of meat products. The contribution of specific muscles, in pre-rigor and post-rigor states, to the manufacturing properties of beef muscle is under study. We are also concerned with meat aroma and flavor and with the role that animal fat plays in meat quality. We cooperate with animal nutritionists, investigating for example, the effect of: diet on meat quality; dietary copper in hog rations; oilseed protein in milk replacers. With poultry breeders we have been studying the inheritance of meat quality, and the effects of rapeseed in turkey rations.

SENSORY EVALUATION

Many private food processing companies seek help in developing specific sensory, chemical or physical methods for measuring raw material or finished product quality. We design methodology appropriate

Dr. C. G. Zarkadas, muscle protein chemist in charge of the Food Research Institute's meat program, removes muscle from fresh beef carcass, to record pre- and post-rigor protein changes (top).

Ghanaian student, Sammy Safo, prepares protein-fortified instant fufu at the FRI, for taste-testing in West Africa (above).

COVER PHOTO Don Beckett, dairy program technician, measures cottage cheese texture at the Food Research Institute, Ottawa.

to their needs and resources. Our training course in sensory evaluation is repeated regularly at industry's request.

FOOD AID TECHNOLOGY

To help vulnerable groups in developing countries, we developed protein-fortified instant fufu and instant etoh for West Africa and instant wheat-fish flakes and noodles for the Caribbean and other areas in need of food for the pre-school child. The wheat-skim milk product, developed for the International Development Research Center (IDRC), is available as a weaning food, as noodles, or as a rice substitute. Our soy milk and soy flour skim milk powders have found acceptance in India. Research on the osmatic dehydration of fruits, done for the IDRC under contract, is now being extended in the Caribbean. Various instant potato-protein mixes, using meat, fish or eggs, were developed for low-income families.

NEW PRODUCTS DEVELOPED

Our Utilization Program is flexible, to help researchers and agencies outside the FRI: We cooperate with CDA plant breeders and with commercial crops breeders' associations; we help the CDA Production and Marketing Branch with food grading problems; at the request of trade associations or the Production and Marketing Branch, we develop new products and processes; we cooperate with the Canadian International Development agency and with other Government Departments to develop new products for specific markets.

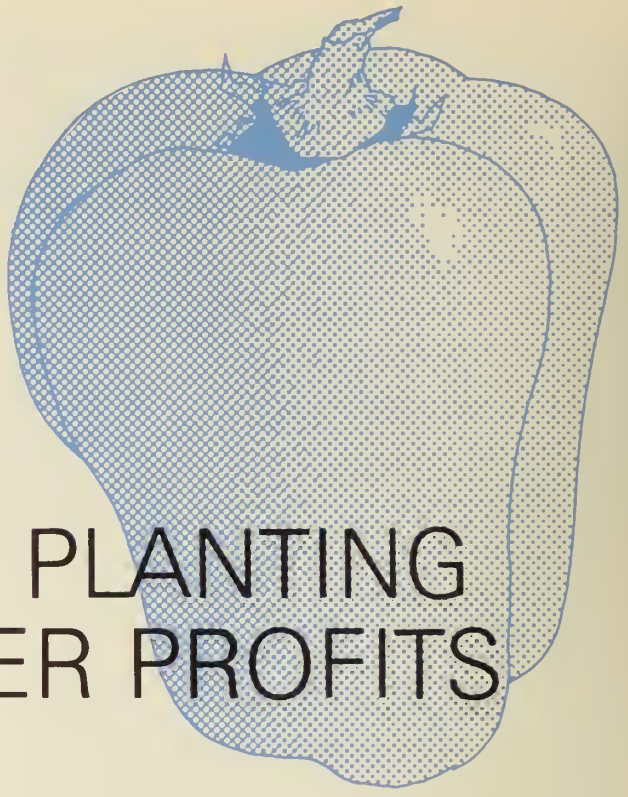
PIONEER PROCESSING

To the Canadian food industry we have given extensive help under our Utilization program. We have pioneered: the use of infrared radiation in food processing for peeling, blanching and cooking; the use of microwave energy for enzyme inactivation and the processing of comminuted (pulverized) meat products. At the other end of the temperature scale, our research on cryogenic freezing has led to the successful development of frozen egg melange and dairy products in granular form. The Canadian potato processing industry benefited from our drum-drying, storage, and texture investigations of potatoes; our development of preformed french fried potatoes also attracted attention. Honey, maple syrup, butter, tomatoes, apples, wheat and poultry are some of the products studied under our Utilization Program.

We encourage industry-FRI cooperation to solve problems and develop products; input from industry is sought in planning our back-up research on the properties of Canadian agricultural raw materials, and in return we provide industry with information from our research on how to use these materials. ■

W. G. KEMP and L. J. WESOLOWSKI

Des essais à la Station de recherche du ministère de l'Agriculture du Canada à Vineland en Ontario, ont démontré que de meilleurs rendements et des profits plus élevés résultent de techniques agricoles d'avant-garde employant une forte population et une plantation équidistante des plants de piments pour des cultivars comme le Vinedale.



HIGH DENSITY PLANTING BOOSTS PEPPER PROFITS

Pepper growers may have good reason to adopt high-density planting in the near future. Economical production is needed for small peppers that have no fresh-market demand but are now being packed by processors. High plant-density offers a means of: increasing yield; decreasing labor hours per acre; significantly reducing production costs of processing peppers.

The cultural practice of high-density planting can lessen labor costs per acre by substituting machinery for man-power, but it requires considerably increased investment in plants. Of course, the extra investment must be adequately rewarded by high output per unit area. Under commercial conditions adequate compensation depends on: (1) the difference in yield when plant numbers vary per acre; (2) the cost of extra plants and planting; (3) selling price, and (4) the eventual difference in fruit quality at various plant densities.

Forces other than plant populations *per se* can strongly influence both the first and last of these factors and must be considered, before changes to high plant-density systems can be contemplated with reasonable assurance of success.

VIRUS INFECTION

Stylet-borne virus diseases are of major importance to the quality and yield-potential of peppers. Cucumber mosaic, tobacco etch, potato Y, and alfalfa mosaic are four of the aphid-transmitted viruses that cause disease in the Ontario pepper crop. Infection by these viruses may occur during early growth, soon after transplanting, and during the development of the fruit. Plants infected early can be badly stunted, producing few fruits.

Reports suggest that plant population density has considerable effect on the incidence of virus diseases in some horticultural crops. The number of infective vectors entering a crop is usually limited, and an increase in plant population reduces the proportion of crop infection from outside sources.

Because the population density-infection ratio may vary with different crops, work was undertaken at the Research Station, Canada Department of Agriculture, Vineland Station, Ontario, to determine whether stylet-borne virus diseases would be minimized or drastically increased at high pepper-population densities. After two years, it is now possible to report some preliminary but promising results.

LATIN SQUARE

In our experiments, the traditional row cropping technique was abandoned, and we compared equidistant cropping patterns which gave uniform distribution of plants over an area. In 1970, and again in 1971, three different pepper populations were established in plots of the same unit area, the same rectangularity, and on the same sites. By spacing the

Mr. Kemp is a vegetable pathologist, Mr. Wesolowski is a vegetable technician, at CDA Research Station, Vineland Station, Ontario.

Experimental field plots used to compare the effect of pepper plant population densities on: yield; virus disease incidence and severity of infection. Plot at left is planted at a density of 43,560 plants an acre. At right, pepper population density is only 4,840 plants an acre.

plants 12 x 12 inches, 24 x 24 inches and 36 x 36 inches, we provided densities of 43,560, 10,890, and 4,840 plants an acre respectively. Each spacing was represented by three plots arranged in a Latin square design.

The standard early cultivar, Vinedale, was transplanted to the plots during the first week of June in both years. The plots were irrigated immediately after transplanting, and again in mid-August. They were kept weed-free by herbicides and some hoeing, but left unprotected against disease and insect damage. Weekly data were collected on: virus disease incidence; distribution in the plots; severity of infection. Aphid counts were also made weekly on 25 leaves from each plot. Yellow-pan water traps were maintained, two feet above the ground in each plot, to monitor the activity of winged aphids throughout the season.

FRUIT GRADING

The first harvest was in the third week of August, when more than 50 percent of the total fruit load was taken; the last harvest was in the third week of September. Harvested fruit were graded as 'marketable' and 'unmarketable' in 1970. In 1971 the culls were further divided into fruit 'with' and 'without' virus symptoms.

Our results clearly demonstrate that high-density planting offers a promising method of increasing both total and marketable yield of the standard early cultivar, Vinedale. The increase can be obtained: on reduced acreage; at no greater cost, and with no likelihood of increased infection from stylet-borne virus diseases.

For example, in 1971 we calculated that by increasing the plant populations from 4,840 to 10,890 to 43,560 an acre, we had increased the total yield from 1.85 to 3.75 to 11.8 tons an acre: a total increase of 10 tons. And the marketable yield had risen from 1.1 to 2.35 to 8.6 tons an acre, respectively.

Of the total yield at the highest density, only 27.1 percent were unmarketable; whereas 37.3 and 40.0 percent respectively, of the harvested fruit were unacceptable at the next and lowest populations. From the total yield, loss caused by virus infection was 10.6 percent at the highest density; 16.4 and 17.1 percent respectively at the two lower densities. Of the unmarketable portion of the crop, losses caused by virus infection represented 39.6, 42.9 and 42.2 percent respectively from the highest to lowest plant population densities.

Although total and marketable yields were not identical in both years because of seasonal variations, a significant yield-increase at the high plant-density level was consistent.

MORE PLANTS: LESS DISEASE

In 1970, the number of plants per unit area naturally infected with foliage symptoms, was not significantly different between densities. The virus incidence in 1971, however, increased significantly at higher densities. Despite this difference, the percen-

Ripe pepper with ring-spot symptoms induced by a stylet-borne virus (top).

Pepper plant shows foliage symptoms induced by a mixture of two stylet-borne viruses (above).

tage of virus-infected plants per unit area decreased, in both years, as the plant population increased. The mean percentage of infection in 1970 and 1971 respectively, was: 4.3 and 14.4 in the plots with the densest population; 42.6 and 39.7 in plots with the lowest plant densities.

The virus disease index, representative of the severity of infection per unit area, was found to be inversely related to plant population. In addition, closely-planted pepper plots required more time than sparsely-planted ones, to become totally infected. This delay in disease-spread is probably responsible for the reduced severity of infection per unit area, at the high population densities.

The three plant-densities had very little influence on time of fruit ripening. However, plants were smallest in the most closely planted plots; larger in the intermediately spaced (24 x 24 inch) planting, and only slightly larger in the most open plots. At any given time, aphid vector infestation, predominantly *Myzus periscae*, was lower per plot, at increased plant-density.

DOLLAR VALUE

Using data from the 1971 experiment we converted the total yield, at each of the three populations, to dollars, and subtracted the estimated cost for plants and planting. The results indicate that the 43,500 population yielded $214 an acre more than the 10,890 population, and $304 more than the 4,840 population. When the loss due to virus infection was subtracted, these returns were reduced to $130 and $188 respectively. Nevertheless, there is substantial dollar increase per acre at the highest density of planting, with or without the subtraction of losses due to virus infection. Financial returns are certainly large enough to warrant consideration on a commercial scale of 12 x 12-inch spacing in a bed system, for cultivars such as Vinedale.

The major limitation, at present, for the acceptance of an equidistant, high-density bed system for peppers of the Vinedale type, is the lack of suitable machinery for transplanting and harvesting. However, transplanters commonly used for other row crops could be modified for this purpose. Though mechanical harvesters are not yet available, harvest aids now used for tomatoes and cucumbers should be satisfactory for 12-inch spaced peppers.

POTENTIAL NEEDS EXPLOITING

According to our results, the current cultural system leaves unexploited the production potential of Vinedale, and probably of many other compact processing-cultivars. Much higher yields and profit from high-density planting of equidistantly spaced peppers appear to be within easy reach of the "avant garde" grower, with no danger of excessive loss because of virus diseases. ■

BRITISH COLUMBIA GROWERS ACCEPT THE CHALLENGE OF PRODUCING VIRUS-FREE SEED POTATOES

N. S. WRIGHT

Les cultivateurs de semences de pommes de terre de la Colombie-Britannique utilisent des techniques d'hygiène et d'isolation, aux niveaux de la ferme et du district, afin de prévenir toute contamination des récoltes provenant de semences libres de maladies.

Until quite recently, even the highest grades of seed potatoes in Canada were fully infected with potato virus X (PVX), or potato virus S (PVS), or both. Scientists at the CDA Research Station, Vancouver, eradicated these viruses from selected clones and thereby increased the yielding potential by about 20 percent. The challenge to replace infected seed potatoes with virus-free stocks is fraught with special problems, because PVX and PVS are rub-transmitted, spread by mere contact between diseased and healthy plants. Under most conditions neither virus causes diagnostic symptoms on potato; they can be detected only by using indicator hosts and serological tests.

Work on eradicating potato viruses, and propagating virus-free stocks, has been in progress at Vancouver since 1967. We now have a collection of virus-free varieties which are available to Elite Seed growers in British Columbia, to Departments of Agriculture, and to Universities in other parts of Canada and elsewhere. Samples have been sent on request to Alberta, Manitoba, Ontario, Quebec, New Brunswick, Alaska, Colorado, Idaho, Maine, Michigan, Montana, North Dakota, Washington and to Argentina, Holland and Russia. The present collection of

Dr. Wright is a specialist in potato diseases and Head of the Plant Pathology Section, CDA Research Station, Vancouver, B.C.

Two Elite seed growers in a crop of virus-free potatoes in the Pemberton Valley.

Virus-free seed potatoes for Holland being loaded aboard ship in Vancouver.

63 virus-free varieties and seedlings includes all those of major importance in Canada and the United States. Others are being treated and will be added to the collection.

ISOLATION CONTROL

Control of rub-transmissible viruses such as PVX and PVS, depends on isolating virus-free plants from infected ones. The threat from potential virus carriers, such as people, dogs, birds, insects and farm machinery, is uncertain but cannot be ignored. Sanitation is an essential part of control, especially when the virus reservoirs are symptomless and therefore not readily avoided. Our research has shown that if PVX and PVS in potato leaf juice are rubbed on wood, iron, rubber, jute, cotton, leather, soil and the human hand, they retain infectivity for up to 24 hours. They are inactivated immediately by a quaternary ammonium compound diluted for use as a dairy disinfectant. Storages, grading tables, machinery, knives, etc., must be disinfected regularly. In the field the risk of contamination is minimized when crops are planted on land that is free of tubers from a previous crop. Also, enough spacing must be left so that contact between plants of different families is avoided, at least until tests show that all are virus-free.

Arrangements for the propagation and testing of virus-free stocks differ from one area to another. In some provinces where the seed potato industry is large, provincial seed farms play a key role. In British Columbia, Elite seed growers propagate the three grades, Elite I, II and III, and make selections annually from the Elite I plot to maintain this three-stage increase system. In 1971, 13 varieties derived from virus-free stocks were produced by nine such growers. Production included: 40 acres of Kennebec; 38 of Netted Gem; 8 of White Rose; 7 of Warba; and 5 or less of Red Pontiac, Norland, Epicure, Early Rose, Red La Soda, Norgold Russet, Sebago, Fundy, and Green Mountain. In 1972, two more Elite and five Foundation seed growers will replace all their present stocks with virus-free seed. They will endeavour to keep their crops free of PVX and PVS as well as the mosaics, leaf roll and spindle tuber viruses, for which tolerance levels already exist in certification standards. In the isolated Pemberton district it is planned that the entire potato crop of 300 to 400 acres will be planted with seed derived from the virus-free program. Similar plans are being made in the Cariboo district between Williams Lake and Quesnel.

TWO PROGRAMS MERGE

The new program for virus-free seed potato production in British Columbia was superimposed on the old Elite seed program which had been operational for several years. Most of the stocks were infected with PVX and PVS, but the program eliminated any which were infected with mild strains of leaf roll, mosaic and spindle tuber viruses, and facilitated the selection of lines which were free of mutations such as giant hill.

In the new program, the individual hills and units which are selected to maintain the Elite I grade are examined for bacterial ring rot, and a representative tuber is grown for the winter virus tests. These include inoculation of tomato, for detecting: spindle tuber; *Physalis floridana* for leaf roll; *Gomphrena globosa* for PVX. Tube precipitin serology is used for detecting PVS and PVM. In the field, tests for PVX and PVS are made at the Elite I level; tests for PVX only are made at the Elite II, III and Foundation levels.

The virus-free program has already made an impact on the modest seed potato industry of British Columbia. Seed growers are finding that, in addition to increased yields, their crops suffer less from black leg and storage rots. These benefits may result from the use in the laboratory, of surface sterilized axillary buds, to obtain the initial virus-free material, and the use of stem cuttings rather than tubers, in the early stages of increase. It is also probable that on the farm, clean storages and sanitary methods help to control bacteria and fungi, as well as viruses. The performance of the new quality of seed has pleased buyers on both the local and export markets. They show their satisfaction in a very tangible way, by placing repeat orders and by entering into production contracts. ■

Examining some virus-free Netted Gem potato tubers, are joint winners of $2,500—the highest possible public Service Merit Award. They are, from left: Dr. Richard Stace-Smith, Dr. N. S. Wright, project leader, and Miss Frances Mellor, scientists of CDA Research Station, and E. F. (Ted) Cole of the CDA Plant Protection Division, all of Vancouver.

TEAM WINS AWARD

In recognition of outstanding research leading to the development of virus free potatoes, the Public Service of Canada has presented its highest award to a team of four researchers with the Canada Department of Agriculture in Vancouver. The $2,500 award went to Dr. N. S. Wright, Dr. Richard Stace-Smith and Miss F. C. Mellor of the CDA Research Station, and E. F. Cole of the CDA Plant Protection Division, Vancouver.

The three scientists worked to isolate, identify and eradicate potato viruses (PVX and PVS), from stock which could then be turned over to Elite potato seed growers. Mr. Cole played a key role in the program of testing for virus in basic stocks, leading to commercial application of the research.

SEED POTATO PROGRAM

Because the potato is propagated by root tubers rather than true seed, the crop is subject to many diseases that would not normally be transmitted. For example, bacterial ring rot, viruses, wilt and blackleg can all be carried over from year to year on potato seed pieces. Such tuber-borne diseases would spread unchecked if some means were not established to break the cycle.

Canada's Certified Potato Program and Regulations have been developed and designed by the CDA Plant Protection Division, not only to guarantee varietal purity, but freedom from certain diseases as well. The program is administered by the CDA Plant Protection Division, and, in cooperation with provincial departments of agriculture and potato seed growers, it maintains standards for disease and varietal purity through five stages of increase: Elite I, Elite II, Elite III, Foundation, Certified. This multiplication scheme not only provides sufficient certified seed for planting to produce Canada's table stock needs, it also permits substantial amounts of seed to be available for export.

The revised Certified Seed Potato Program, adopted in 1969, is gradually having effect, as growers in the various provinces adapt to new standards to improve the quality of Canadian seed for commercial growers in Canada and overseas.

Although Canadian Certified Seed potatoes are virtually free from insect-transmitted viruses such as leaf roll, spindle tuber and mosaic, most varieties are infected with two viruses that are transmitted by rubbing contact. These viruses are known as potato virus X (PVX), and potato virus S (PVS).

Because of their nature, PVX and PVS have been difficult to eradicate from seed stock. However, a research team of scientists at the Canada Department of Agriculture's research station, Vancouver, has now succeeded in freeing potato stocks of PVX and PVS. Dr. Wright's article tells how growers are making use of this scientific development.

P. PARCHOMCHUK

La cueillette des cerises et des pommes a été faite par la méthode des vibrations afin de vérifier la fréquence à laquelle les fruits tombent et le pourcentage de fruits tombés sans queue.

SHAKE-AND-CATCH HARVESTING OF CHERRIES AND APPLES

At the Summerland Research Station we are investigating "shake-and-catch" mechanical harvesting of tree fruits. The harvesting equipment consists of a hydraulically-controlled boom which grasps the tree limb and shakes the fruits on to a canopy from which they are conveyed to a container. This method reduces both the harvesting time and the need for hand labor but causes more fruit damage than hand picking. The work described here was undertaken to determine whether the frequency with which a tree limb is shaken plays a role in the ease of fruit detachment, the amount of damage incurred, and whether the fruit is detached with or without stem.

Laboratory experiments have shown that the motion of a hanging fruit depends upon the shaking speed. The motion can be calculated mathematically and has been shown to depend as much upon fruit weight and diameter as upon stem length and stiffness. Of interest are particular ranges of shaking frequencies which cause two distinct types of fruit-stem oscillation: at certain shaking speeds, fruit and stem oscillate much like a pendulum; at higher shaking speeds, fruit and stem oscillate in opposite directions to give a tilting type of motion. At shaking frequencies that cause either pendulum and tilting types of motion, the amplitude of fruit-stem oscillations becomes very large.

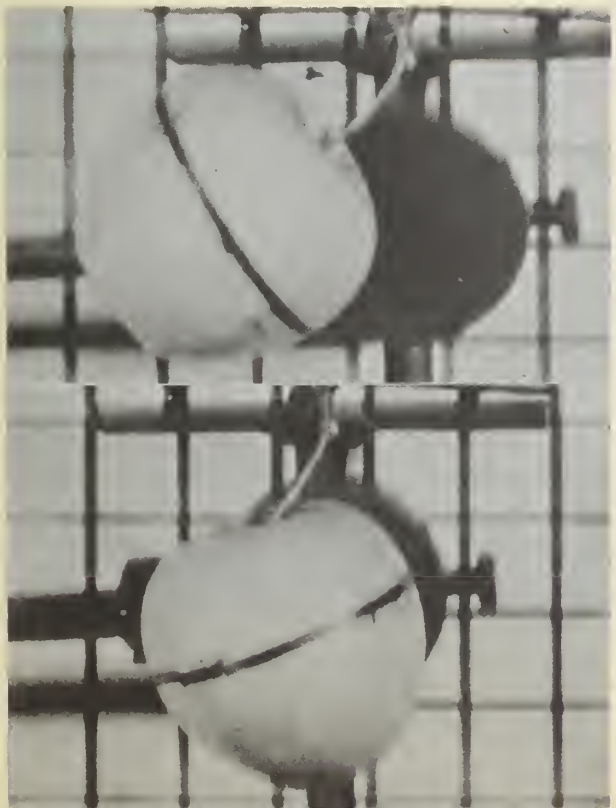
SHAKING FREQUENCY

From these observations, we thought it should be possible to predict the best shaking frequency for detaching various fruits. When a hanging fruit oscillates, the stem is bent back and forth and gradually weakens, causing fruit detachment. Shaking frequencies that cause greatest oscillation of the fruit (*i.e.* frequencies that cause either pendulum- or tilting-type motion) must also cause the greatest bending of the stem and should thus be best for detaching fruit most rapidly. Fruit that is removed most quickly should have less damage from banging against limbs and other fruit. Bending is greatest between the stem and branch for the pendulum type motion; therefore shaking frequencies that cause this motion should be best for detaching fruit with stems attached. The tilting type of motion causes the greatest amount of bending between the stem and fruit and should cause fruit detachment without stems.

The author is an agricultural engineer at the Canada Department of Agriculture Research Station, Summerland, B.C.

Shake-and-catch harvesting of tree fruits: a hydraulically-controlled boom grasps the tree limb and shakes the fruits on to a canopy from which they are conveyed to a container.

High-speed photographs of a vibrating apple show (below) *the pendulum motion in which fruit and stem swing together, and* (bottom), *the tilting motion as fruit and stem oscillate in opposite directions.*



In 1971 these hypotheses were tested for actual field harvesting of sweet cherries and apples. The results were inconclusive, probably because the expected type of motion did not occur under field conditions. Under laboratory conditions the pendulum and tilting types of large amplitude motion are well defined and occur in definite ranges of shaking speeds, but under field conditions it appears that these ranges become wider and overlap. Thus it becomes difficult to predict what type of motion will occur at a particular frequency. Since the large amplitude motion occurs over such a wide range of shaking frequencies, one frequency has little advantage over another in causing fruit detachment by bending. Further field studies of the fruit motion caused by different shaking frequencies are required to determine the usefulness of laboratory predictions.

EFFECT ON CHERRIES

When harvested at fresh-market maturity by the shake-and-catch method, up to 91 percent of the sweet cherries were removed from the tree, and an average of 24 percent were detached without stems. Thirteen percent of the fruit were visibly damaged when inspected shortly after harvesting. Spraying the cherry trees with ethrel, pre-harvest, resulted in a higher percentage of fruit detachment, less fruit damage and a much higher percentage of stemless fruit. With reasonable care in handling, most of the mechanically harvested fruit could be used for the fresh fruit market. The lack of stems presents a problem as fresh-market cherries are sold with stems; however, the possibility of selling fresh cherries without stems should be explored. If harvested when fully mature, sweet cherries are much easier to shake off and come off without stems.

EFFECT ON APPLES

Shake-and-catch harvesting of apples resulted in a much greater damage than that caused by hand picking. Hardy varieties such as Red Delicious and Winesap, had as high as 77 percent good fruit (fewer than 5 bruises under ½″) but Spartans and Golden Delicious had only 45 percent and 32 percent good fruit respectively. Because of the high damage rate, this method of mechanical harvesting would not be acceptable for fresh-market fruit but could be used to harvest fruit for processing. If an efficient method of sorting out the damaged fruit could be developed, it might be possible to salvage the good fruit for the fresh-fruit market. However, the economic feasibility of such a procedure would have to be investigated. The high percentage of stemless fruit for Red Delicious (29 percent) and the high percentage of attached spurs for Golden Delicious are special problems. Pre-harvest treatment with an abscission-inducing chemical such as ethrel, might reduce these problems. ■

CONTROLLING WEEDS IN NEW LAWNS

R. M. ADAMSON

Des études portant sur la lutte contre les mauvaises herbes des pelouses semées au printemps ont indiqué que l'amine 2,4-D peut être appliquée sans danger après la première coupe. Des pulvérisations d'hydroxybenzonitrile faites peu de temps après l'apparition des herbes, que ce soit au printemps ou au début de l'automne, ont permis une lutte plus efficace et plus sûre contre les mauvaises herbes à larges feuilles.

At the CDA Research Station, Sidney, B.C., we have been investigating the chemical control of weeds in newly sown lawns. Ideally, a new lawn should be a thick green sward but all too often it is spoiled by weeds.

The introduction of 2,4-D and other related herbicide sprays for lawn use has been a great boon in reducing broadleaf weed infestation. In new lawns, however, these sprays cannot be applied until the grass is able to withstand the treatment without injury. Frequently, by this time much of the damage from weed competition has already occurred.

One way to ensure freedom from a large weed population is to treat the soil with a short-term sterilant before sowing. This destroys the viability of weed seeds in the surface layers of soil and any reproductive portions of perennial weeds which may be present. Such treatments, however, are expensive and time consuming, and require special procedures and precautions. Except for a few special problems, such as a heavy infestation of quack grass rhizomes, a cheaper and easier solution is desirable.

ALTERNATIVE NEEDED

We have studied the problem of weed control in seedling lawn grasses for several years at the Sidney Research Station. First, we wanted to see whether

Mr. Adamson is a specialist in weed control at the CDA Research Station, Sidney, B.C.

Excellent broadleaf weed control is obtained with ioxynil at half pound per acre when applied 2½ weeks after sowing Highland bent grass seed. (left).

Applying herbicides to experimental lawn grass plots 16 days after a May sowing (right).

2,4-D, the most widely used weed killer for broadleaf weeds in lawns, could be applied earlier than has usually been thought possible, and secondly, we needed to determine whether there might be a safer and more effective alternative. Since lawn grass is frequently sown in the fall, as well as in the spring, in coastal British Columbia, we needed an alternative that could be applied successfully at the same relative stage of grass development at both times of year.

As a result of our studies we have found that applications of 2,4-D amine may be made on spring-sown grass, following the first mowing, rather than waiting until after the second mowing, according to the old rule-of-thumb. By applying 2,4-D after the first mowing, weeds are killed earlier and competition reduced. In the fall, however, grass growth is much slower, and often, particularly if the sowing is delayed beyond early September, the new lawn is not mowed until the following spring. Under these conditions 2,4-D treatments are much less successful: lawn grass seedlings, particularly blue grasses, tend to be more subject to injury, and weed control is less effective.

A group of herbicides known as hydroxybenzonitriles have also been studied. These differ from 2,4-D and related compounds in that they kill broadleaf weeds by direct contact and are not translocated to all parts of the plant. The sodium salt and octanoate ester of ioxynil, and the octanoate ester of bromoxynil have been effective for control of broadleaf weeds in fescue, bluegrass or bent grass seedlings. They have been applied on an experiemental basis on spring sowings when the grass is approximately 1 inch high, usually 2 to 3 weeks after sowing. Many weeds have germinated by this time, but are small and not yet competing seriously with the grass seedlings. Seedling perennial weeds of the hard-to-control type are also killed readily at this stage. These contact sprays have also been effective when applied late in September on grass seeded early in the month.

However, contact sprays are not yet registered for use on lawns in Canada. General use or sale will depend on the manufacturer seeking registration of the products from CDA Plant Products Division, based on proven safe and effective methods of application.

Since these herbicides kill by surface contact, it is important to use them when the weeds are small and tender. If treatment is delayed, weed control efficiency is reduced. This differs from spring applications of 2,4-D, where a delay usually brings one into warmer, drier weather conditions more favorable for control by an absorbed, translocated herbicide.

The merit of early weed control in new lawns is evident. In experimental work at CDA Research Station, Sidney, B.C., certain chemicals have been an aid in achieving this purpose. But the products will have to be registered before they can be generally used. ■

ECHOES
FROM THE FIELD AND LAB

MARKETING COUNCIL From its Ottawa headquarters, the newly established National Farm Products Marketing Council will supervise the organization of national marketing agencies for various farm commodities.

Chairman of the Council is Paul Babey, a prominent farmer from the Edmonton area of Alberta. Real Roy of Boucherville, Quebec, is vice-chairman. He is the director of LeGrade, a packing company operated by Quebec's Coop Fédérée.

Among the other members of the Council are: Ralph Ferguson of Alvinston, Ontario; J. Adrien Levesque of St. Leonard, New Brunswick; Hector Hill of Truro, Nova Scotia and Albert Vielfaure of La Broquerie, Manitoba.

CONSEIL DE COMMERCIALISATION De son bureau chef à Ottawa, le Conseil national pour la commercialisation des produits agricoles supervisera l'établissement et le déroulement des offices nationaux de commercialisation pour diverses denrées agricoles.

M. Paul Babey, cultivateur réputé de la région d'Edmonton en Alberta, en sera le président, tandis que M. Réal Roy de Boucherville au Québec, en sera le vice-président.

Parmi les autres membres nommés il y a M. J.-Adrien Lévesque de St-Léonard, N.-B., M. Hector Hill de Truro, N.-É.; M. Ralph Ferguson de Alvinston, Ont.; M. Albert Vielfaure de La Broquerie, Man.

RENNET RESEARCH[1] Canadian Cheddar cheese, as traditional as maple syrup and rye whisky, is looking to scientists at Canada Agriculture's Food Research Institute in Ottawa for some 20th century help in maintaining its vintage image.

Centrifuging process removes butterfat from aged cheddar cheese, for flavor research in FRI's dairy program.

The cheese still looks and tastes as it did in great-grandmother's day, but deep down in the complicated chemistry of cheesemaking, something has changed. It could be the enzymes.

Enzymes play a vital role in cheesemaking. They change around the chemistry of milk proteins, causing the milk to curd. The commercial preparation used for this purpose by the cheese industry, is called rennet.

Until a few years ago, all cheddar cheese in Canada was made using an enzyme called rennin, supplied by the stomach of very young milk-fed calves. But farmers are now raising calves for baby beef rather than for milk-fed veal and stomachs of older calves produce two enzymes: bovine pepsin and rennin.

The main cheesemaking enzymes, bovine pepsin and rennin, are both in the commercial rennet being used to make Canadian cheddar today. A further enzyme, hog pepsin, has been added in recent years to bolster the rennet supply.

Scientists at the FRI are being asked to determine how much of each enzyme is mixed into the commercial rennet which starts the process of cheesemaking, and what effect each has on curdling the milk.

The two pepsin enzymes appear to do a job similar to that of rennin but what happens to the final quality of cheddar needs to be assessed.

It would be a boon to the cheese industry if pepsin enzymes could be used in larger amounts, because the supply is greater and cheaper than rennin. If not, the Canadian Cheddar cheese industry may be faced with a choice between marketing a very good product in quantity, or producing cheddar as a gourmet delicacy.

The results of FRI's research will provide cheddar producers with the basis for decision

CATTLE-DEER COMPETITION Big game competes with livestock for forage in many areas of Canada. This creates a major integration problem with forage resources on forested lands.

Critical game ranges should be given preference over most other land uses, because game habitats and grazing habits cannot be changed easily. Such areas are not usually large, but they are vital to game survival.

There are three ways of reducing conflict between deer and cattle: complementary, when cattle and deer use a range at different times of year, each browsing different forage plants; supplementary, when cattle use a range only to a degree that does not deprive deer of feed, in some cases cattle may benefit wild ungulates, by grazing on old growth so that later, game can get at the young spring growth.

Female mule deer feeds in Jasper National Park, Alberta.

A sustained yield of big game can often be produced by an understanding of habitat manipulation. For instance, a species of browse such as pasture sage can be maintained in a stand only if bluebunch wheatgrass is kept in a reduced state of vigor, since the grass tends to choke out the weedy sage. The keys to habitat manipulation are therefore: adequate control of livestock; time of use, and distribution on the range. Such practices should lead to increased forage production and increased availability of the browse species preferred by both domestic and wild ungulates.

In making game-vs-cattle management plans, it is important to know the seasonal diet changes of both cattle and deer, and to anticipate the time of year when cattle will start browsing forage species necessary to deer. It is also important to determine whether or not grazing by cattle will affect the later use of a range by deer

A series of experiments have been started in British Columbia by the CDA Research Station at Kamloops, in cooperation with the B.C. Fish and Wildlife Branch and the Grazing Division of the B.C. Forest Service. The experiments are designed to obtain basic information about ranges grazed by both cattle and mule deer during winter and early spring. From the results it should be possible to formulate land-use policies to benefit both range and wildlife managers —A. McLEAN RANGE ECOLOGIST, CDA RESEARCH STATION, KAMLOOPS, B.C.

[1]An article reviewing the work of the Food Research Institute appears in this issue of *Canada Agriculture*.

ECHOS
DES LABOS ET D'AILLEURS

AQUATIC PLANT GROWTH Dr. John R. Allan, plant physiologist (aquatics), and James A. Marsh, technician, both of CDA Research Station, Lethbridge, Alta., have compiled a manual to aid aquatic plant control. Entitled, *Chemical Analysis of Water in Relation to Aquatic Plant Growth*, the booklet is now available from the Lethbridge Station.

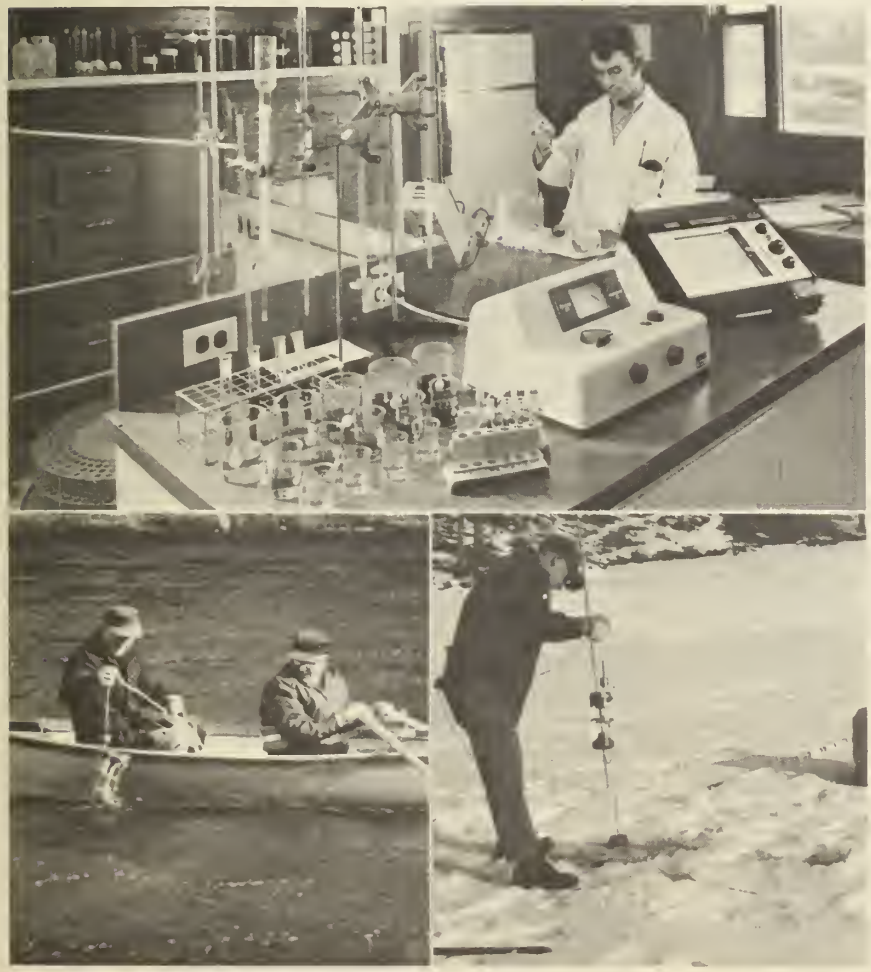
In their introduction, the authors denounce "clumsy and shortsighted attempts to control weeds by the indiscreet use of certain herbicides", and point out:

"To attain successful control of aquatic weeds we must expand our knowledge of the interactions between the aquatic plant communities and their surrounding chemical and physical environment . . . A more thorough understanding of these interactions would enable more effective use to be made of available herbicides."

The authors suggest that the logical first step toward an understanding of the interactions involved in the control of aquatic plant growth, must be the rapid and precise analysis of lake and river waters. They list 12 nutrient ions of major metabolic significance in fresh water, and describe eight trace ions, essential to the growth of aquatic plants, but required only in extremely small quantities.

Acknowledging that much more refined procedures are available at far greater cost, the manual presents information-gathering methods that are 'the best known procedures with respect to accuracy, speed, ease of manipulation and cost of equipment necessary for analysis."

Sample preparation and sampling techniques for water analysis.



APPLE SCAB CONTROL Those who study plant diseases always look for some weak point in the life cycle at which to direct control measures.

The weak point in the apple scab disease cycle is the period during which apple trees are dormant. At that time, diseased leaves from the previous season lie on the floor of the orchard and produce spores which cause new infection when growth resumes in the spring. Preventing such spore reproduction would greatly simplify the problem of controlling apple scab.

Plant pathologists have investigated various methods and many chemical compounds to find a reliable source of control. Initially, sodium salt of dinitro-o-cresol proved effective when sprayed on leaves on the ground in the spring, but disadvantages included the large quantities of chemical and water required, and the difficulty of pulling heavy spray machinery over sodden ground.

Fungicides applied to the foliage before it fell in the autumn provided equally good, or better results: urea is particularly useful for this purpose, because it provides some of the nitrogen required by the trees for the next growing season. However, it is not completely effective and new infection can occur if even a small percentage of spores are produced; mercury fungicides are known to be effective but use is discouraged to prevent the release of more of the hazardous chemical into the environment.

We now know that the development of overwintering spores can be suppressed completely by some newly developed fungicides, applied in the fall before the leaves drop. These compounds appear to be non-hazardous but are not yet fully registered for use. Experiments conducted to date show that a relatively small quantity of chemical will provide satisfactory results if applied either as a mist or as a drench.

When these fungicides become available they should be of great benefit both to orchardists and to gardeners. Orchardists may find post-harvest spraying only necessary or justified when trees are badly infested and show prospects of a heavy spore production the following spring. Gardeners, however, may find that an annual post-harvest application of the fungicides before the leaves fall, may mean a season of scab-free fruit with no further need for mid-season spraying.—D. L. McINTOSH, CDA RESEARCH STATION, SUMMERLAND, B.C.

A TOWER SPRAYER FOR TREE-WALL PLANTINGS

A. D. McMECHAN

Un pulvérisateur à air forcé pour la lutte contre les parasites des arbres fruitiers en espallier ou des arbres fruitiers demi-nains (maximum 12 pieds) a spécialement été mis au point. Le jet d'air chargé d'antiparasitaire étant horizontal, passe au travers des arbres et se dépose uniformément du bas au haut de l'arbre sans passer au-dessus.

The recent trend toward establishing high-density tree-wall plantings of semi-dwarf apple trees presents both an opportunity and a challenge to design spray equipment that will give improved spray distribution in the trees and, at the same time, cut down loss of spray material to the atmosphere above the trees. Such equipment is being developed at the Canada Department of Agriculture, Research Station, Summerland, B.C.

With conventional air-blast sprayers the spray-laden airstream is directed up through the trees from a point close to the ground. If the airstream is strong enough to carry the spray to the tree tops there is, inevitably, a loss of spray chemical above the trees. Also, with this method the spray deposits are usually much higher in the bottom parts of the trees than in the upper parts. From the point of view of pest control the opposite would often be more desirable.

As long as our orchards had a preponderance of large standard trees there seemed to be no easy way to overcome these problems. But in the tree-wall plantings, with tree height limited to about 12 feet, a new approach was possible. Why not build a sprayer almost as tall as the trees, from which the spray-laden airstream could be directed horizontally through the trees? Such a sprayer should greatly facilitate accurate placement of spray material in the trees and should avoid loss of spray above the trees.

SPRAYER BUILT

A sprayer of this type has been built and evaluated at Summerland. This machine has four air outlets, two to each side. The lower outlets are 50 inches long and have an average width of ⅞ inches. The air from these is directed horizontally, and slightly upward, so that most of the spray material emitted from this portion of the machine is deposited in the bottom eight feet of the trees. The upper outlets are 21 inches long and 1 inch wide. The air from these is directed horizontally, and slightly downward, to give good spray coverage in the upper parts of the trees. The air for the upper outlets is supplied by a hydraulically-driven fan which is vertically adjustable through 45 inches, so the sprayer can be matched to tree height. Maximum height of the machine is just under 12 feet. The average air velocity from each of the four outlets is about 105 mph. Total air volume is about 8400 cfm.

Designed to direct its spray-laden airstream horizontally through 12-foot high trees, this tower-type sprayer built at Summerland Research Station, B.C., uniformly distributes spray material with little loss from drift above the trees. A vertically adjustable hydraulic fan permits spray streams to be matched to tree heights.

In several replicated tests, in semi-dwarf tree-wall apple plantings, this "tower" sprayer consistently gave more uniform spray deposits throughout the trees than was achieved with an efficient conventional sprayer under the same operating conditions. Deposits in the upper parts of the trees were higher with the tower sprayer but there appeared to be much less spray drift above the trees. No actual measurements were made on the spray drift.

CODLING MOTH CONTROL

In other experiments the tower sprayer has been used throughout the season for codling moth control in tree-wall apple plantings. Good control was achieved in heavily infested blocks with sprays applied at both 50 and 30 gallons of spray mixture per acre at a travel speed of 3 mph.

The tower type of sprayer will certainly be more expensive to build than conventional sprayers. But we believe the additional cost will be more than justified by increased efficiency of spray application. ■

The author is an agricultural engineer at the Canada Department of Agriculture Research Station, Summerland, B. C.

NEMATODES– A LIMITING FACTOR IN FORAGE PRODUCTION

J. L. TOWNSHEND, J. W. POTTER, J. SANTERRE and C. B. WILLIS

Forage is produced on more than 13 million acres of land in eastern Canada. Of that area, the seven million acres classified as hay have an average yield of only 2.5 tons an acre.

Plant diseases, insects and weeds are recognized pests, and it is currently accepted that forage yields could be improved significantly if optimum fertility, management and pest control practices were followed. However, there is growing evidence that plant-parasitic nematodes also affect forage crops, and that appropriate control measures could further increase forage production.

Three Canada Department of Agriculture research stations—Vineland Station, Ontario; Ste-Foy, Quebec and Charlottetown, Prince Edward Island—have undertaken a joint reserach program to determine the direct and indirect effects of nematodes on forage production in eastern Canada.

Our research has shown that yields from forage legumes can be substantially increased when heavy infestations of the root-lesion nematode, *Paratylenchus penetrans*, are controlled by a nematocide.

OCCURRENCE

We have identified species in eight genera of plant-parasitic nematodes associated with forage le-

Mr. Townshend and Dr. Potter are nematologists at CDA's Vineland Research Station, Ontario; Mr. Santerre is a nematologist at CDA's Research Station, Ste-Foy, Quebec; Dr. Willis is head of the forage section, CDA Research Station, Charlottetown, P.E.I.

LES NÉMATODES– FACTEUR LIMITATIF DANS LA PRODUCTION DE FOURRAGE

J. L. TOWNSHEND, J. W. POTTER, J. SANTERRE et C. B. WILLIS

Dans l'Est canadien, les cultures fourragères occupent plus de 13 millions d'acres. Sur cette superficie, les 7 millions d'acres consacrées au foin ne produisent qu'une moyenne de 2.5 tonnes à l'acre.

Les maladies, les insectes et les mauvaises herbes sont reconnus comme nuisibles, et l'on admet généralement que la production de fourrage pourrait être améliorée de façon significative si les pratiques optimales de fertilisation, de gestion et de lutte contre les parasites étaient respectées. Toutefois, il semble de plus en plus évident que les nématodes parasites des plantes s'attaquent également aux cultures fourragères, et que des mesures de lutte appropriées pourraient accroître davantage la production de fourrage.

Trois stations de recherches du ministère de l'Agriculture du Canada ont entrepris conjointement un programme d'études approfondies pour déterminer les effets directs et indirects des nématodes sur la production fourragère dans l'est du Canada. Ces trois stations sont: Vineland (Ontario), Ste-Foy (Québec) et Charlottetown (Île-du-Prince-Édouard).

Notre recherche a démontré que les rendements des légumineuses fourragères peuvent être substantiellement accrus si l'on parvient à enrayer le nématode radicicole, *Paratylenchus penetrans*, au moyen d'un nématocide.

FRÉQUENCE

Nous avons identifié huit espèces de nématodes parasites des plantes s'attaquant aux légumineuses et

MM. Townshend et Potter sont des nématologues de la Station de recherches de Vineland (Ontario); M. Santerre est nématologue à la Station de recherches de Ste-Foy (Québec); M. Willis est chef de la Section des fourrages de la Station de recherches de Charlottetown (Île-du-Prince-Édouard).

TABLE 1. PLANT-PARASITIC NEMATODES ASSOCIATED WITH FORAGE CROPS IN EASTERN CANADA.

Common name	Scientific name
Root-lesion	*Paratylenchus penetrans*
	P. minyus
	P. crenatus
Pin	*Paratylenchus projectus*
Spiral	*Helicotylenchus digonicus*
	H. canadensis
	H. pseudorobustus
Root-knot	*Meloidogyne hapla*
Stunt	*Tylenchor hynchus claytoni*
	T. nudus
Cyst	*Heterodera trifolii*
Ring	*Criconemoides* spp.
Dagger	*Xiphinema americanum*

TABLE 2. OCCURRENCE OF PLANT-PARASITIC NEMATODES IN FORAGE FIELDS IN EASTERN CANADA.

Nematode	% Fields Infested				
	Southwestern Ontario (49)*	Eastern Ontario (71)	Quebec (96)	Nova Scotia (35)	P.E.I. (91)
Root-lesion	100	100	90	92	100
Pin	85	90	60	75	87
Spiral	80	80	71	53	65
Root-knot	33	79	43	33	81
Stunt	62	51	10	22	73
Cyst	21	37	7	25	71
Ring	3	10	10	22	80
Dagger	10	3	5	6	5

*Figures in brackets are numbers of fields sampled.

TABLEAU 1. NÉMATODES PARASITES DES PLANTES QUE L'ON TROUVE DANS LES CULTURES FOURRAGÈRES DE L'EST DU CANADA

Nom commun	Nom scientifique
Nématode radicicole	*Paratylenchus penetrans*
	P. minyus
	P. crenatus
Nématode acuminé	*Paratylenchus projectus*
Nématode spiral	*Helicotylenchus digonicus*
	H. canadensis
	H. pseudorobustus
Nématode cécidogène	*Meloidogyne hapla*
Nématode provoquant le nanisme	*Tylenchorhynchus claytoni*
	T. nudus
Nématode formant des kystes	*Heterodera trifolii*
Nématode-anneau	*Criconemoides* spp.
Nématode-stylet	*Xiphinema americanum*

TABLEAU 2. FRÉQUENCE DES NÉMATODES PARASITES DES PLANTES DANS LES CULTURES FOURRAGÈRES DE L'EST DU CANADA

Nématode	% des champs infestés				
	Sud-ouest de l'Ontario (49)*	Est de l'Ontario (71)	Quebec (96)	Nouvelle-Écosse (35)	Île-du-Prince-Édouard (91)
radicicole	100	100	90	92	100
acuminé	85	90	60	75	87
spiral	80	80	71	53	65
cécidogène	33	79	43	33	81
provoquant le nanisme	62	51	10	22	73
formant des kystes	21	37	7	25	71
anneau	3	10	10	22	80
stylet	10	3	5	6	5

*Les chiffres entre parenthèses représentent le nombre de champs échantillons.

gumes and grasses in eastern Canada. These are commonly known as: root-lesion; pin; spiral; root-knot; stunt; cyst; ring; and dagger (Table 1). Our survey revealed that many forage fields are infested with several of the genera (Table 2).

For some nematode genera, the pattern of associations is similar among the regions; for others, associations differ, perhaps because of differences in: specific crops sampled; soil types; cropping practices; climate, or a combination of all these factors.

HOST RANGES

The range of forage-crop hosts that supports individual nematode species was difficult to resolve on the basis of field occurrence in our survey, because we found variations in the numbers of forage species present and in the numbers of associated nematode genera. In general, however, we have found that the root-lesion and spiral nematodes attack most forage legumes, grasses and other crops used in rotation; the northern root-knot nematode and the clover cyst nematode are relatively host specific, attacking only forage legumes; the pin nematode thrives on trefoil, ladino clover and timothy; the host ranges of the other nematode species on forage and rotation crops have not yet been clearly defined.

aux graminées fourragères de l'est du Canada. Ces nématodes sont communément appelés: nématode radicicole, nématode acuminé, nématode spiral, nématode cécidogène, nématode provoquant le nanisme, nématode formant des kystes, nématode-anneau, nématode-stylet (tableau 1). Notre enquête a révélé que dans bon nombre de champs de fourrage, plusieurs espèces étaient présentes à la fois (tableau 2).

Dans le cas de certaines espèces de nématodes, le mode d'association est le même dans toutes les régions; pour d'autres, les associations diffèrent, probablement à cause des différences dans les échantillons de cultures particulières, les types de sols, les pratiques culturales, le climat ou une combinaison de tous ces facteurs.

PLANTES HÔTES

La gamme des cultures fourragères, hôtes d'une espèce particulière de nématodes, a été difficile à établir à l'échelle des champs dans notre étude, en raison des variations dans le nombre des espèces fourragères en présence et des espèces associées de nématodes. Nous avons toutefois découvert qu'en général les nématodes radicicoles et spiraux attaquent la plupart des légumineuses et graminées fourragères, et d'autres cultures de rotation; le nématode céci-

Fig. 1. J. W. Potter (left), and J. L. Townshend, sampling a forage field for plant-parasitic nematodes.

LIFE CYCLES

The life cycle of the pin, spiral, stunt, ring, and dagger nematodes is completed in the soil; that of the root-lesion, cyst, and root-knot nematode in the root. Males are not always required for reproduction and in some species are absent. First-stage larvae develop inside the egg, moult, and hatch as second-stage larvae. These larvae then moult three times before becoming adults. Except for the cyst and root-knot nematodes, all stages beyond hatching are thread-like, mobile, and infective. Only second-stage larvae of the cyst and root-knot nematodes exhibit these characteristics as the third and fourth stages become immobile and peanut-shaped, and the females pear or lemon-shaped. Eggs of the root-knot nematode are laid in a gelatinous egg-sac on the root surface; eggs of the cyst nematode are usually retained in the swollen body of the female which becomes a protective cyst. We need more detailed knowledge of the life cycles of several nematodes, particularly of those that complete their life cycle in the soil.

FEEDING

The feeding habits of these nematodes vary but no part of the feeder root system is free from attack. According to the feeding sites, these parasites can be classified into three groups—ectoparasites, semi-endoparasites, and endoparasites.

Fig. 1. MM. J. W. Potter (à gauche) et J. L. Townshend prennent des échantillons de cultures fourragères, pour une étude des nématodes parasites des plantes.

dogène du nord et le nématode du trèfle sont plus sélectifs, ne s'attaquant qu'aux légimineuses fourragères; le nématode acuminé recherche le lotier acuminé, le trèfle Ladino, et la fléole; on n'est pas encore parvenu à définir de façon précise les cultures de rotation et les cultures fourragères hôtes des autres espèces de nématodes.

BIOLOGIE

Le cycle évolutif des nématodes acuminés et spiraux, des nématodes provoquant le nanisme et de ceux en forme d'anneau ou de stylet, s'effectue dans le sol; par contre, c'est dans la racine que s'accomplit le cycle évolutif des nématodes formant des kystes et des nématodes radicicoles et cécidogènes. Les mâles ne sont pas toujours nécessaires à la reproduction; dans certaines espèces, ils n'existent pas. Les larves du premier âge se développent dans l'œuf, muent et éclosent sous forme de larves du deuxième âge. Ces dernières muent trois fois avant d'atteindre l'âge adulte. Tous les nématodes, à l'exception des nématodes cécidogènes et des nématodes formant des kystes, ont à tous les âges qui suivent l'éclosion un aspect filiforme, mobile, et sont infestants. Dans le cas des nématodes formant des kystes et des nématodes cécidogènes, les larves du deuxième âge seules présentent ces caractéristiques; aux troisième et quatrième âges, elles deviennent immobiles et prennent l'aspect de cacahouète, tandis que les femelles ont la forme de poires ou de citrons. Les œufs du nématode cécidogène sont déposés dans un sac gélatineux à la surface de la racine; ceux d'un nématode formant des kystes demeurent généralement dans le corps gonflé de la femelle qui devient alors un kyste protecteur. Nous manquons de connaissances en ce qui a trait au cycle évolutif de quelques-uns de ces nématodes, en particulier de ceux qui restent toute leur vie dans le sol.

ALIMENTATION

Les habitudes alimentaires de ces nématodes varient, mais aucune partie du système radiculaire n'échappe à leurs attaques. Selon la partie qui sert à l'alimentation, ces parasites peuvent être classés en trois groupes: les ectoparasites, les semi-endoparasites, et les endoparasites.

Les nématodes acuminés, ceux qui provoquent le nanisme et ceux qui ont une forme d'anneau ou de stylet sont des ectoparasites et se nourrissent de cellules épidermiques et corticales externes, près des extrémités des racines, dans la région de croissance, dans la rhizosphère, et parfois sur les radicelles mêmes; des lésions ne sont que rarement formées.

Seul le nématode spiral est un semi-endoparasite; il pénètre dans les poils absorbants, à une profondeur d'environ ⅓ de son corps et se nourrit de cellules corticales et du liber. On a observé sur des racines de luzerne des lésions subépidermales.

Les nématodes radicicoles, cécidogènes, et formant

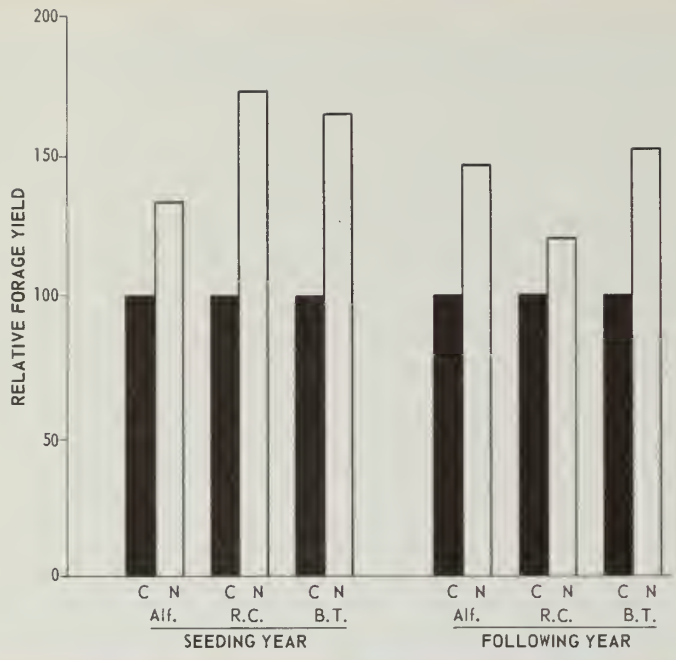


Fig. 2. Relative forage yields (%) from untreated (C) and nematocide treated (N) plots of alfalfa (Alf.), red clover (R.C.) and birdsfoot trefoil (B.T.) in the seeding year and year following seeding in field soil naturally infested with Paratylenchus penetrans.

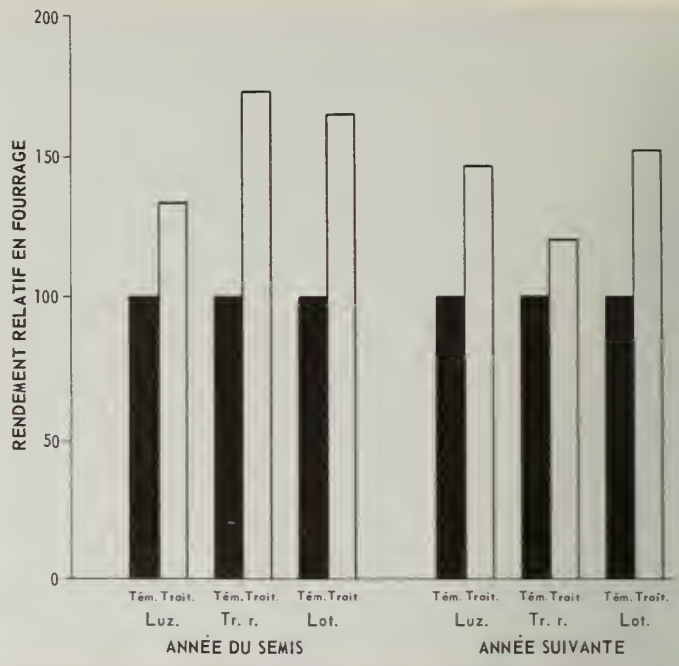


Fig. 2. Rendements relatifs (%) en fourrage de luzerne (Luz.), de trèfle rouge (Tr. r.) et de lotier corniculé (Lot.) obtenus sur parcelles non traitées (Tém.) et traitées (Trait.) avec nématocides, l'année du semis et l'année suivante, en terrain naturellement infesté de Paratylenchus penetrans.

Pin, stunt, ring and dagger nematodes are ectoparasites and feed on the epidermal and outer cortical cells near the root tips, in the region of elongation, in the root hair zone, and sometimes on the root hairs themselves; lesions are seldom formed.

Only the spiral nematode is a semi-endoparasite; it penetrates feeder roots to about one third its body length and feeds on cortical and phloem cells. Subepidermal lesions have been found on alfalfa roots.

Root-lesion, root-knot, and cyst nematodes are endoparasites. The root-lesion nematode penetrates and feeds in the cortex of the root and causes definite root lesions. The cyst and root-knot nematodes enter feeder roots and stimulate the plant to form 'feeding cells' that disrupt the vascular system. Generally there is no root necrosis as the parasites do not actually kill the tissue on which they feed, but in most cases root-knot nematodes stimulate the formation of galls. Both the cyst and root-knot nematodes cause root proliferation. More knowledge is required about the feeding of these parasites, and their relation to their forage crop hosts.

CROP DAMAGE

Forage crops are under considerable stress when both ecto and endoparasitic nematodes are feeding at the same time. In addition to direct effects of feeding, further damage results when the injured roots are invaded by soil fungi that cause root rot.

des kystes sont des endoparasites. Le nématode cécidogène pénètre dans le cortex de la racine et s'en nourrit, et y forme des lésions définitives. Les nématodes formant des kystes et les nématodes radicicoles pénètrent dans les radicelles et stimulent chez la plante la formation de "cellules nourricières" qui bouleversent le système vasculaire. On ne remarque généralement pas de nécroses de la racine car les parasites ne tuent pas véritablement les tissus dont ils se nourrissent; mais dans la plupart des cas, les nématodes radicicoles stimulent la formation de galles. Les nématodes formant des kystes et les nématodes radicicoles engendrent la prolifération des racines. On manque encore de beaucoup de renseignements sur l'alimentation de ces parasites et sur leurs effets sur les plantes fourragères hôtes.

DÉGÂTS DANS LES RÉCOLTES

Les cultures fourragères sont en grand danger si elles sont attaquées à la fois par des nématodes ectoparasites et endoparasites. En plus des effets directs de leur alimentation, les nématodes peuvent causer des dégâts sur les plantes hôtes si les champignons du sol pénètrent par les lésions et y provoquent une pourriture des racines.

Nos recherches ont prouvé que dans l'est du Canada, le rendement des fourrages de luzerne, de trèfle rouge et de lotier, peut être accru, pendant l'année d'ensemencement, respectivement de 34, 73 et 65%.

Our research has shown that in eastern Canada forage yields from alfalfa, red clover, and birdsfoot trefoil in the year of seeding can be increased by 34, 73, and 65 percent respectively, and in the next year by 47, 20, and 52 percent respectively, when heavy infestations of the root-lesion nematode, *P. penetrans* are controlled with a nematocide (Fig. 2). Research has also shown a relationship between the intensity of *P. penetrans* infestation and forage yield in red clover.

Although some information is available on the impact of root-lesion nematodes on forage legumes, further research is needed to determine the effects of other species of root-lesion nematodes on forage crops over the wide range of cultural, soil, and environmental conditions existing in our region of research. No information is available in eastern Canada on the effects of other nematode genera that are known to adversely affect forage crops in other geographical areas.

Survey data, as well as limited experimental data, indicate a positive correlation between levels of root-lesion nematode infestation and root rot. Roots of alfalfa, red clover and birdsfoot trefoil are extensively invaded by *Fusarium* spp. in the presence of high levels of root-lesion nematode infestations of roots. More work is needed to determine whether interactions between nematodes and fungi are additive or synergistic in their adverse effects on production and stand-longevity of forage crops.

FUTURE RESEARCH

As suggested above, forage production in eastern Canada is being limited by direct and indirect effects of nematodes. The interaction involving several nematode genera, disease organisms, forage crops, soil types, cultural practices and environmental differences, are numerous. To achieve successful control we will need to establish a broad research program with a multidisciplinary approach. Individual activities to support this program will include: (1) developing pure cultures of the major species of nematodes on individual forage crops; (2) determining nematode feeding behavior and host-parasite relations in forage crops; (3) establishing nematode life histories; (4) determining nematode host ranges within forage and rotation crops; (5) assessing forage losses from individual nematode species and species complexes; (6) establishing effects of such interactions as: nematode and fungus; nematode and nematode, etc; (7) determining physiological and biochemical changes in the host that result from nematode infestation; (8) developing controls through crop management, the use of nematocides, and/or the development and use of resistant varieties. ■

et l'année suivante, de 47, 20 et 52%, si les champs infestés de nématodes cécidogènes *Paratylenchus penetrans* sont traités au moyen d'un nématocide (figure 2). Ces recherches ont ainsi fait ressortir une relation entre l'intensité de l'infestation de *Paratylenchus penetrans* et le rendement en fourrage du trèfle rouge.

Bien qu'on dispose de certains renseignements sur les effets des nématodes cécidogènes dans les légumineuses fourragères, il nous faut davantage de données pour déterminer les effets des autres espèces de nématodes cécidogènes sur les cultures fourragères en ce qui a trait aux façons culturales, à l'état du sol et à l'environnement dans la région à l'étude. Pour le reste du Canada, on ne dispose d'aucun renseignement sur les effets des autres espèces de nématodes qu'on sait nuire grandement aux cultures fourragères dans d'autres régions géographiques.

Les données d'étude, ainsi qu'un faible nombre de données expérimentales, indiquent une corrélation positive entre le niveau d'infestation par les nématodes cécidogènes et la pourriture des racines. Les racines de luzerne, de trèfle rouge et de lotier sont considérablement infestées de *Fusarium* spp. lorsqu'on remarque une présence massive des nématodes cécidogènes dans leur racine. Il faudra pousser plus avant les travaux d'étude pour savoir si l'interaction entre les nématodes et les champignons est additionnelle ou synergique, dans ses effets sur la production et la longévité des cultures fourragères.

RECHERCHE À VENIR

Comme on le dit plus haut, la production de fourrages dans l'est du Canada est limitée par les effets directs et indirects des nématodes. Nombreuses sont les interactions de plusieurs espèces de nématodes, d'organismes pathogènes des cultures fourragères, de types de sol, de méthodes de culture et de différences de l'environnement. Pour que la lutte soit efficace, il nous faudra mettre sur pied un vaste programme de recherches ainsi que des travaux connexes multidisciplinaires. Parmi ces derniers travaux, on notera: (1) des cultures pures des principales espèces des nématodes dans des types de fourrages isolés; (2) l'établissement du comportement d'alimentation des nématodes et des relations hôte-parasite dans les récoltes fourragères; (3) l'établissement du cycle évolutif des nématodes; (4) la détermination des hôtes des nématodes parmi les cultures fourragères et de rotation; (5) le calcul des pertes de fourrage selon les espèces ou les ensembles d'espèces de nématodes; (6) l'établissement des effets des interactions de nématodes et de champignons ou de nématodes et de nématodes, etc.; (7) l'observation des changements physiologiques et biochimiques qui résultent de l'infestation des nématodes chez les plantes hôtes; (8) la mise au point de systèmes de lutte au moyen de la gestion des cultures, de l'emploi des nématocides, et de la mise au point ainsi que de la plantation de certaines variétés résistantes. ■

C. WANG and J. L. NOWLAND

FRAGIPAN
IN SOILS OF THE MARITIME PROVINCES

La couche dure cassante des sols est très fragile, à l'état sec ou humide. Elle peut résulter du compactage des particules minérales du sol où les particules argileuses jouent le rôle de ponts entre les particules plus grosses. La fragilité de la couche vient de ce que les ponts d'argile se brisent dès qu'ils sont soumis à la pression.

On the gently rolling topography of Cumberland County, Nova Scotia, some of the medium and coarse textured soils are underlaid with a relatively impermeable layer. Some people might call it hardpan but this impermeable layer has now been identified technically as a *fragipan.*

To farmers, this condition restricts the downward movement of water, and seeding is often delayed because excess moisture fails to penetrate. When the soil surface dries out, fragipan prevents plant roots from reaching nutrients and moisture in the subsoil, and plants soon show signs of drought.

At the CDA Research Station, Fredericton, N.B., soil scientists are investigating the nature of the fragipan. If their development is better understood some means may be devised to either prevent their formation or to break up the existing fragipans.

WHAT ARE FRAGIPANS?

Fragipan-like horizons were first described in the 1930's as compact and brittle. They occupied an extensive area in Eastern United States and were first called "silica pans" because of their relatively high silica content. The term "fragipan" was introduced in the late 1940's when scientists realized that the high silica content may have nothing to do with the brittleness of the fragipan.

In 1957, soil scientists (Carlisle *et al.*) described fragipans as "Compact horizons which are hard to extremely hard when dry, and firm to very firm when moist, and display the property of brittleness when both dry and moist". Brittleness when dry and moist is one of the most important characteristics of fragipans. However, practically all the fragipan samples we know slake when soaked in water and lose their brittleness when wet. This "slaking" property may be important from the standpoint of determining the development of this condition.

Other than brittleness and slaking, fragipans are usually characterized by a high content of silt, fine and very fine sand, a low content of clay, organic matter and sesquioxides, high bulk density, and low to very low permeability. They may also show a coarse, straight line pattern on both horizontal and

Dr. Wang is a research scientist and Mr. Nowland is senior pedologist with the Maritimes Soil Survey, CDA Research Station, Fredericton, N.B.

Fig. 1. Clay bridge links two fine silt particles in a fragipan zone of Tormentine soil.

Fig. 2. (Lower left) *The polygonal structure is clearly visible in this fragipan zone of Debert soil.*

Fig. 3. (Below) *Tormentine soil shows strong fragipan although polygonal structure is not clearly defined.*

vertical planes (Figure 2), but this is not always the case (Figure 3). The upper boundary of a fragipan is normally clearly defined, whereas the lower boundary is more diffuse, and may contain bodies of translocated clay.

The extent to which a pan develops, and its depth below the surface, is related to soil drainage. Fragipans are best developed in moderately well-drained and imperfectly drained soils. In non-eroded soils, the upper boundary of fragipan occurs between eight to 30 inches below the surface. In soils ranging from well to poorly drained, the pan is closest to the surface under poorest drainage conditions. Fragipans have never been found in calcareous layers, although many fragipans have a weakly calcareous parent material.

Nowland estimates that Cumberland and Colchester Counties of Nova Scotia alone have at least 300,000 acres of soils with fragipan. This condition is also found in some soils of New Brunswick.

In Nova Scotia and New Brunswick the fragipans normally occur below the B horizons of Podzols and some Brunisols but they also occur within the B horizons of other Brunisols and Gleysols. In Eastern U.S.A., fragipans are additionally found above, below or within the B horizons of Luvisols.

GENESIS OF FRAGIPAN

It is generally accepted by most soil scientists that fragipans are genetic horizons. In other words, the characteristics of fragipans are not mainly inherited from their parent materials but are developed during the process of soil formation. They are known to be components of soil profiles developed in residuum, glacial drifts, lacustrine deposits, loess and alluvium. However, most of the fragipans in the soils of Nova Scotia and New Brunswick have been developed from compact glacial till. They are usually continuous horizons, maintain a relatively constant depth within the profile and a constant spatial relationship to other soil horizons within one kind of soil.

Just how the fragipan developed into such a dense and brittle layer is still not clear. But, the slaking property of fragipans has ruled out silica as a cementing agent. Our hypothesis is that the high bulk density and brittleness of the pan may be a result of close packing of the soil mineral particles, with the clay particles forming bridges between larger particles. The brittleness of the pans is attributed to the clay bridges which break up under pressure. The clay particles will swell when wet and therefore lose their brittleness.

It is proposed to study the differences in the arrangements of soil particles in fragipan and non-fragipan horizons, using the Scanning Electron Microscope to observe the micro-morphological features of these horizons (Figure 1). This may throw some light on the genesis of fragipans. ■

W. F. NUTTALL

PHYSICAL PROPERTIES OF GRAY WOODED SOILS

Les sols sont modifiés par l'incorporation de résidus organiques qui affectent la structure des agrégats, la croûte superficielle et la perméabilité à l'air et à l'eau. Il nous faudra poursuivre l'étude des mécanismes de formation et de stabilisation des agrégats pour en bien comprendre la nature.

Gray Wooded soils are found in the Boreal Forest region of the Great Plains. It is estimated that there are twenty million arable acres and that 10 million acres are cleared and under cultivation. The cultivated Gray Wooded soils are characterized by a surface plow layer which is gray to gray-brown in color (Figure 1).

The soils are lower in organic matter content, generally lower in fertility and have poorer physical properties for the establishment and growth of agricultural crops than adjacent Black and Black-Gray soils. Some of the soils within this group form hard crusts after the spring snow melt or after heavy rainfall. The heavy beat of raindrops puddle the soil by breaking down the soil aggregates and clods. This breakdown in structure greatly restricts the ability of the soil to absorb water. Consequently, flooding and run-off waters may affect crop growth either by drowning or erosion.

Even if the water drains away with little flood damage, the very hard impervious crust which may form on drying can prevent the emergence of small seeded crops such as rape (Figure 2). In addition, since many of the soils do not absorb moisture readily and have poor permeability and infiltration rates, moisture which would have been available had the soil been more permeable is lost and cannot aid in the emergence and growth of crops.

CRUMB STRUCTURE

When discussing soil aggregates and structure, a definition of these terms is necessary to provide a better understanding of the importance of these physical properties.

Both "soil structure" and "aggregation" have been used interchangeably since the type of aggregation in the soil has a direct relationship to soil structure. A soil aggregate can be defined as a naturally occurring cluster or group of soil particles in which the forces holding the particles together are much stronger than the forces between adjacent aggregates.

There is little evidence to show that aggregates have any direct influence on plant growth except by

Dr. Nuttall is with the Soil Fertility Section at the CDA Research Station, Melfort, Sask.

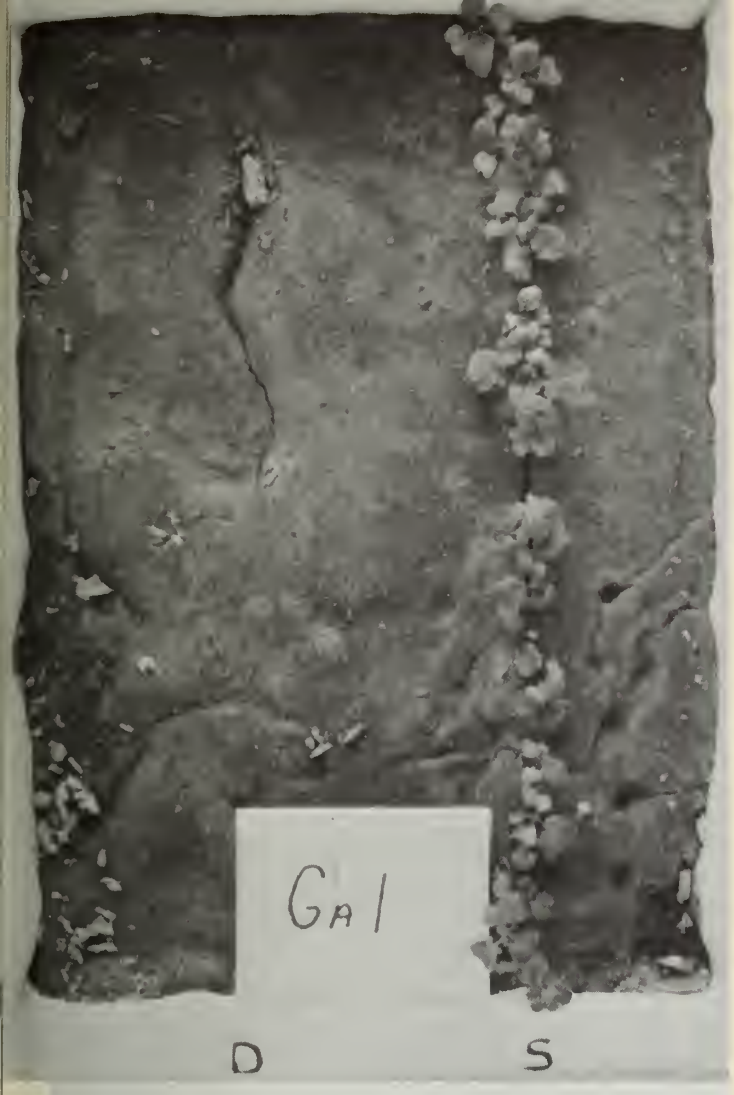
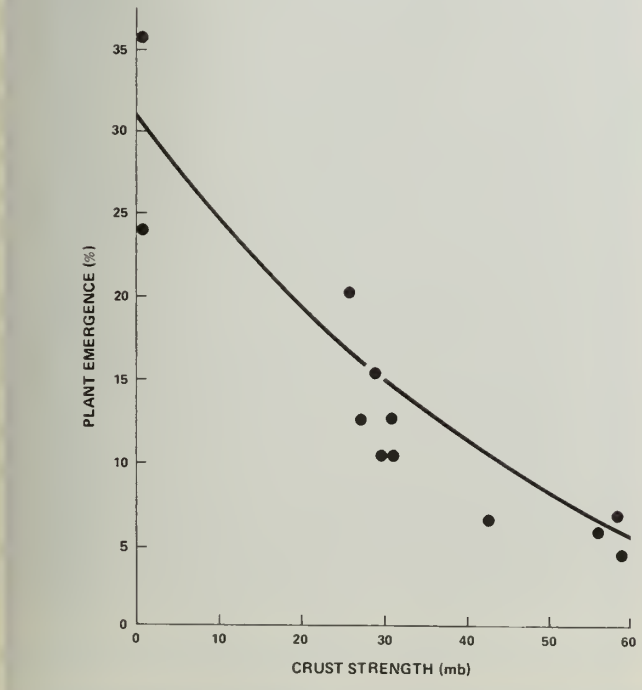


Fig. 1. (Far left) *A Gray Wooded soil sown to rape with few plants emerging. Some soil erosion is evident.*

Fig. 2. (Left) *Rape was seeded in this Garrick loam soil at 1.5 cm (shallow) and 3.0 cm (deep). The crust strength of this soil was high (approximately 60 millibars).*

Fig. 3. (Below left) *Graph showing the relationship between emergence of rape and crust strength in the greenhouse.*



modifying the pore spaces in the soil, which in turn may alter the chemical and physical environment of the soil in which the plant grows. When aggregates are discussed, three important characteristics should be considered: (1) the size and shape of each aggregate, (2) the configuration or arrangement of the aggregates within the undisturbed soil, and (3) aggregate stability.

ORGANIC RESIDUES

Experimental work has shown that in general the incorporation of organic matter in soils having poor structure increases aggregation and aggregate stability. Similarly, incorporation of organic residues such as straw, peat and manure at 25 tons per acre has increased the water and air permeability of Gray Wooded soils and reduced crust strength. In other words, the structure is modified so that water and air move through the soil more readily. Crust strength is weakened as well by decreasing the cohesive forces between soil particles. Because organic residues decompose in the soil, the effectiveness of a single application of manure in improving soil structure will decline with time.

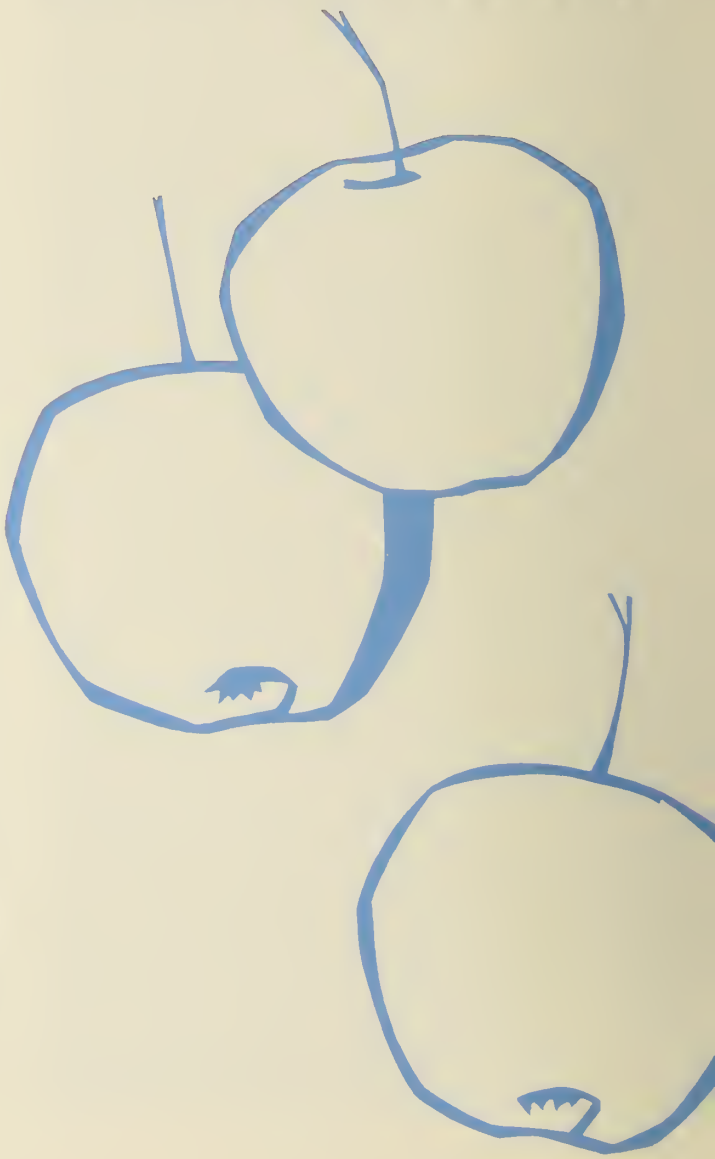
Few experiments have been conducted on Gray Wooded soils to determine how long organic residue treatments are effective in improving soil structure. Experiments in the greenhouse have shown that after five successive crops organic matter treatments still were effective in reducing crust strength and in increasing the water holding capacity (field capacity) of the soils. The crust strength was related to the emergence of rape plants (Figure 3).

Because organic amendments have improved soil structure and because soils high in organic matter content usually have good structure, organic compounds have been postulated as one of the binding materials that hold aggregates together. There is also the evidence that organic compounds modify cohesive forces between clay particles through absorption on the clay surfaces. Organic materials may aid in holding clay particles apart, that is, holding aggregates apart, as well as binding individual particles together to form aggregates. The exact mechanisms involved in formation and stabilization of soil aggregates need to be studied further if a full understanding of this soil characteristic is to be obtained. ■

CALCIUM CONCENTRATE SPRAYS CONTROL SPARTAN APPLE BREAKDOWN

J. L. MASON and S. W. PORRITT

À la suite d'une recherche effectuée à Summerland, en Colombie-Britannique, un programme pratique de six pulvérisations concentrées de chlorure de calcium à un taux de 15 lb à l'acre dans 50 à 80 gallons d'eau, à compter de la fin de juin peut être mis en route pour réduire le flétrissement à l'entreposage des pommes Spartan.



The Spartan apple was produced by the Summerland Research Station and recommended for planting 35 years ago. It has been extensively planted because of its high quality and attractiveness. As production increased it became apparent that under certain seasonal and cultural conditions the Spartan apple was subject to breakdown, a storage disorder which caused serious losses on several occasions and threatened the future of the variety in the Okanagan. The disorder is evident as a diffuse browning of the apple, generally in localized areas of the outer flesh which becomes somewhat dry and mealy.

Storage experiments showed that the cause was neither due to overmaturity of fruit when picked, nor to storage at low temperature. Nor was there any clear association with seasonal conditions. As might be expected, large fruits from vigorously growing trees were most subject to breakdown. Controlled atmosphere storage in 2 percent carbon dioxide and 2-3 percent oxygen has greatly reduced the disorder, but has not eliminated it, particularly in some seasons. Other more fundamental factors, such as mineral nutrition needed to be studied. Preliminary tests indicated that a deficiency of calcium in Spartan apples increased the fruit's susceptibility to breakdown. In 1970, large scale experiments were initiated to determine if calcium sprays applied to trees during the growing season would increase fruit calcium sufficiently to control breakdown.

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Apple, and cutaway sections show symptoms of breakdown in Spartan after storage (top).

Calcium sprays, applied by a concentrate sprayer, control breakdown in Spartan apple (above).

RELATION BETWEEN BREAKDOWN AND CALCIUM CONTENT IN FRUIT FROM EXPERIMENTAL PLOTS

	Orchard 1	Orchard 2	Orchard 3
Breakdown—%			
Unsprayed	33	12	3
Sprayed	8	2	0
Calcium—ppm*			
Unsprayed	202	219	270
Sprayed	229	258	304

*Parts per million

SPRAY PROGRAM

The experiments included three grower orchards and involved 150 trees in each. Six sprays were applied starting at the end of June, with sprays applied every two weeks until harvest. Both calcium chloride and calcium nitrate sprays were applied, each at two rates, with a concentrate sprayer. Samples of fruit were collected from every plot prior to harvest by the growers. Fruit was stored in regular cold storage and in controlled atmosphere (CA) storage, and samples were analyzed for calcium.

The highest rate of calcium chloride, 15 lb per acre, per spray, was the most effective treatment. In the three orchards the percentage of fruits with breakdown after 7½ months in CA storage was reduced from 33 to 8, from 12 to 2 and from 3 to 0. The calcium concentration in the fruits in the three orchards was increased from 202 parts per million to 229, from 219 to 258 and from 270 to 304.

These experiments demonstrated the successful application of research on calcium nutrition which began 7 years ago. First, it was shown that dilute calcium sprays could reduce breakdown as much as 50 percent. Next, it was shown that breakdown in Spartan apples could be produced by reducing the calcium supply to trees growing in nutrient solutions. Later, in a season when breakdown was prevalent, 183 samples of Spartan apples from various industry cold storages were examined for breakdown and analyzed for calcium. Data from this survey showed a strong relationship between low calcium concentration and the incidence of breakdown.

A practical spray program, for six concentrate sprays of calcium chloride, at 15 pounds per acre in 50 to 80 gallons of water, starting late June, is now recommended for the Spartan apple in British Columbia. ■

YES, PLANTS DO SUFFER FROM OVERINDULGENCE

D. G. GREEN, W. S. FERGUSON and F. G. WARDER

L'orge cultivée en sol pauvre en phosphore a développé une telle avidité pour cet élément qu'avec une solution nutritive équilibrée, elle a montré des symptômes de toxicité.

One of the advantages of growing plants in nutrient solution (hydroponic culture) is that the composition of the nutrient medium can be easily controlled. Experimenting with young barley plants (3 to 4 weeks after germination) we observed that growth in a phosphorus-deficient solution resulted in dwarfed, stunted plants. Subsequently, on exposure to complete nutrient solution these P-deficient plants were actually damaged, particularly at the tips of the youngest leaves. Was this damage to these P-deficient plants due to excessive P uptake from the nutrient solution or to localized accumulation in the leaves? Using hydroponics, we were able to manipulate the supply of P available in solution and using an Autoanalyzer procedure, we followed nitrogen and phosphorus uptake and accumulation in the leaf tissue.

We observed that P-deficient barley plants were unable to tolerate levels of P that on continuous exposure resulted in vigorous plant growth. Leaf tip damage occurred 4-5 days after P was supplied to 25-30 day old P-deficient plants. Dry matter accumulation (growth) by P-deficient plants was actually slowed down when P was included in their previously P-zero nutrient solution. Simultaneous uptake of P by P-deficient plants was much less than occurred in the control plants which were fed P continuously.

The P-deficient plants underwent localized accumulation of P (Table 1), resulting in leaf tip damage and stunted growth. The P-deficient barley developed such an active "P-sink" or "appetite" that on exposure to complete nutrient solution these developing leaves accumulated toxic percentages of P. That this accumulation was selective is evident by the failure of percentage N to be affected by P exposure (Table 1). Have you ever heard of a plant suffering from overindulgence before? ■

Dr. Green is plant physiologist, and Mr. Warder soil fertility specialist at the CDA Research Station, Swift Current, Sask. Dr. Ferguson is CDA Research Co-ordinator for soil fertility in Ottawa.

TABLE 1. ACCUMULATION OF N AND P IN THE LEAVES OF P-DEFICIENT BARLEY AFTER 3 DAYS EXPOSURE TO COMPLETE NUTRIENT SOLUTION.

Leaf	Segment	Percent P		Percent N	
	(cm from tip)	P-deficient	P-control	P-deficient	P-control
Unfolding terminal	0- 3	2.8	0.9	4.8	6.0
	3- 6	2.4	0.9	4.9	6.4
	6- 9	2.0	0.9	5.1	6.4
	9-12	1.7	0.9	5.2	6.2
Penultimate	0- 3	2.6	0.8	4.9	6.0
	3- 6	2.4	0.9	5.2	6.5
	6- 9	2.4	0.8	5.3	6.8
	9-12	2.2	0.8	5.3	6.8
	12-15	2.0	0.8	5.3	6.7
	15-18	1.8	0.8	5.2	6.5

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