Research

FOR FARMERS

SPRING — 1965

CANADA DEPARTMENT OF AGRICULTURE

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CANADA DEPARTMENT OF AGRICULTURE
Ottawa, Ontario

HON. HARRY HAYS — *Minister*
S. C. BARRY — *Deputy Minister*

NOTES AND COMMENTS

Surprisingly little is known of what takes place during a tick's blood meal. How does it secure the blood? Is the flesh of the host lacerated or is it dissolved by juices? Does the tick pour saliva into the wound? Does it ever regurgitate the blood meal? The answers are important on account of the harm done by ticks. But one of the difficulties has been in observing its feeding action, as the tick buries its mouth parts in the skin of its host. Dr. J. D. Gregson tells on page 3 how the cheek pouch of the hamster has come to the rescue at the Kamloops Research Station, and what this has revealed about the tick.

* * *

Two reports on sunflowers appear in this issue. One dealing with pollination is by S. H. Pawlowski of the Lethbridge Research Station (page 6); the other is by Dr. E. D. Putt of the Morden Experimental Farm, the traditional home of sunflower breeding in Canada (page 10).

* * *

Fire blight stands in the way of large-scale pear growing in Southwestern Ontario. Dr. R. E. C. Layne explains what is being done about it (page 4)...Dr. L. B. MacLeod and L. P. Jackson go into the difficulty of growing legumes on acid soils owing to the presence of soluble aluminum (page 8)...In Newfoundland they have been leaving ingredients out of fertilizers to discover what difference they make to forage crops on peat soils. A. F. Rayment reports on page 12....Finally, on page 14, Dr. A. T. Bolton of the Ottawa Research Station tells about the continuing campaign to keep strawberries and raspberries free from viruses.

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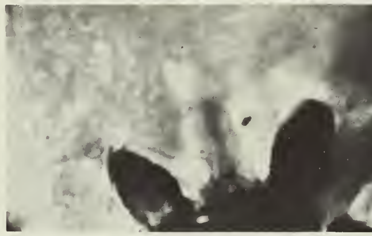
***Cover Photo:* A novel way of finding out how a tick feeds, using the cheek pouch of a hamster (See "The Hamster Turns a Cheek" on facing page).**

A hamster's cheek pouch laid over a transparent container of warm water so that the feeding tick can be viewed under the microscope.



Illuminated from beneath, the mouth parts of the tick are seen alternately to pump blood from the tissue and secrete saliva into it. Occasionally blood is regurgitated into the wound.

The Hamster Turns a Cheek

J. D. Gregson

ONE of the most important groups of creatures which affect the health of man and animals is that of the blood-sucking insects and their allies, the ticks. Harmless for the greater part of their lives, their relatively brief contact with their hosts brings about infection, poisoning, loss of blood and irritation. Volumes have been written on their free-living habits, their choice of food, and the organisms which they may harbor; as much research has been devoted to the effects of their bites and the symptoms and the cure or prevention of the diseases which they can spread. Between these two aspects of cause and effect lies the action of the bite, without which neither the parasite nor the disease would be likely to exist. Yet, important as this act is, surprisingly little is known of what takes place during the blood meal. How is the blood secured—from a vessel or a blood pool? Is the flesh lacerated, or dissolved by juices? Does the parasite pour saliva into the wound; does it ever regurgitate its blood meal (with whatever organisms its stomach may contain)?

Actually there are but six published records of observations on this subject—only one of which pertains to ticks, the most versatile of disease carriers. The reason for this neglect is obvious. Little can be seen of the feeding action when the parasite's mouthparts are buried in the host's skin. The problem was attacked when scientists allowed mosquitoes to feed on the thin ears of mice which were brightly illuminated from beneath. From these experiments, it was discovered that the mosquito's proboscis may seek out and tap a blood vessel, hence the parasite's ability to fill itself quickly with blood.

At the veterinary and medical entomology laboratory at Kamloops, B.C., it became desirable to know how the tick that causes paralysis feeds. Little could be learned from the mouse-ear technique because, unlike the mosquito, this tick is a slow feeder, and the ear became too inflamed and opaque for prolonged studies. Other membranes, such as those of the frog's foot or the bat's wing were unappealing to the tick. A tip was taken from a medical journal in which were described experiments on immunity using the cheek pouch of the hamster. Every boy who has kept one of these pets knows that it can stuff its cheek full of food until it looks as if it had a bad case of mumps, and then turn its pouch inside out, like a pocket lining, to empty it. It appeared that this membrane, when laid out to the side of the mouth of an anæsthetized hamster, could be trans-illuminated to provide a unique view of the capillary blood flow. Only the tick's cooperation was needed.

Fortunately, the ticks showed little distaste for the innerskin of a host on which they normally readily feed. When they were enticed to attach, much was discovered. First, they were seen to pour out an 'attaching' cement which sealed the sucking mouthparts to the membrane.

Then there appeared, within the tissue, a gradual pooling of blood cells which seemed to suffuse through the unbroken walls of capillary vessels. At this blood pool, the tick alternatively drank and secreted saliva. Meanwhile, the spectacular flow of cells within the vessels, resembling traffic in a busy city, continued undisturbed. Not until a few hours after attachment was there a sudden breakdown of certain vessels which caused a haemorrhage at the bite. At intervals, there were seen to pour from the mouthparts of the tick clouds of partially digested blood. A new light was shed on the mechanism of disease transmission and further thoughts have been advanced as to how the particular tick under study is able to paralyse and kill animals as large as humans and cattle.

The feeding sequences were photographed in motion and color for future study and when each was recorded Mr. Hamster simply woke up, stuffed back his cheek pouch, and, being nocturnal, called it a night. The tick? Oh yes, if not removed, that was just an extra tid-bit for services rendered!

Dr. Gregson is Head, Livestock Insect Section, CDA Research Station, Kamloops, B.C.

Using the spray method for inoculating pear seedlings with the bacterium that causes fire blight.

Screening and Evaluating Pear Seedlings for Resistance to Fire Blight

R. E. C. Layne

CLIMATIC and soil conditions in Southwestern Ontario favor large-scale growing of pears. Suitable, low-cost land is available, good markets for fresh and processed pears exist, several fruit and vegetable processing plants are situated in this area and experienced fruit growers are there to do the job. What then is hindering the development of this potentially important industry? It is fire blight, a disease caused by a bacterium named *Erwinia amylovora* which can be isolated from pear trees infected with fire blight.

Survival, growth and major expansion of the pear industry will depend on the availability of suitable varieties resistant to fire blight. Bartlett, the leading commercial variety and the standard of fresh and processed quality in Ontario, is highly susceptible. Other important varieties including Bosc, Clapp Favorite, and Anjou are also highly susceptible. Kieffer is the only commercially important variety with moderate resistance. Present control measures, although helpful, are inadequate.

Recognizing the problem of fire blight and the great potential of the pear industry, the CDA Research Station at Harrow has embarked on an intensive pear improvement program.

The program was started in 1962. The sort of varieties needed would have to be resistant to fire blight, well adapted, productive, have a range of maturity, be suitable for fresh market and processing, and have good storage

Dr. Layne is a fruit breeding specialist with the CDA Research Station, Harrow, Ont.

quality. With these objectives in mind, we have raised several thousand pear seedlings from crosses involving a large number of different parents, each possessing one or more desirable attributes.

Success of this venture will depend to a large degree on the methods used to screen and evaluate resistance of pear seedlings. Because the inheritance of many of these characteristics is complex, large populations of each cross must be grown to increase the probability of obtaining individuals with the desired combination of characters. Since field space is limited it should be devoted only to those seedlings that are blight resistant. Therefore, we use a greenhouse screening program where thousands of young seedlings are screened at the same time and susceptible individuals are eliminated before field plantings are made.

In our investigations, we have isolated the bacterium from pear trees severely infected with fire blight, cultured it in the laboratory, checked for potency and motility, and then grew in bulk to inoculate 7 to 10-month-old pear seedlings. Inoculum consists of a concentrated suspension of bacteria in broth media containing sugar, peptone, potato extract and water.

We have tried two methods of inoculation as shown in the accompanying photographs. Spray inoculation has the advantage of simplicity. Large numbers of seedlings can be inoculated in a matter of minutes. To facilitate infection, carborundum is added to the bacterial suspension and the spray is applied to the seedlings under high pressure. The abrasive action of carborundum creates large numbers of tiny wounds on the leaves and stems through which the bacteria gain entry into the plants. The main disadvantages of spray inoculation are the comparatively low levels of infection obtained and the difficulties of evaluating resistance on plants infected in this manner. Needle inoculation is slow and tedious but much higher levels of infection are obtained. Seedlings are inoculated near the tips of each stem. Movement of the disease down the stem can be accurately measured and the degree of resistance readily assessed. Needle inoculation is the method used, especially when genetic information on resistance is desired.

We determined the fire blight resistance of each seedling by measuring the amount of diseased tissue and expressing it as a percentage of seedling height. Seedlings that blight more than 50 percent are considered susceptible and eliminated. Those that blight less than 25 percent are classed as highly resistant, and those with 25-50 percent blight are moderately resistant. Both groups are planted in the orchard for further study.

We have recently evaluated resistance on several thousand seedlings and have selected several hundred that are either highly resistant or moderately resistant. It remains to be seen whether these seedlings will be resistant under field conditions. It is hoped that one or more of them will possess the desired horticultural characteristics already indicated, in addition to blight resistance, to attain varietal status.

Better methods of inoculation and more accurate control of temperature and humidity following inoculation are needed to eliminate some of the uncertainties now experienced. They could lead to a more accurate assessment of resistance and to a better understanding of the genetics involved.

Close-up of needle inoculating pear stems with the fire blight bacterium.

Author pollinating sunflowers in the greenhouse.

Pollination Requirements of Sunflowers

S. H. Pawlowski

THE capacity of sunflowers to set seed when selfed is quite low. In greenhouse tests at the CDA Research Station, Lethbridge, Alta., we found that approximately 85 percent of the plants produced significantly more seed following cross-pollination than following self-pollination. About one plant in seven was less than 5 percent fertile following self-pollination.

The author is a specialist in oil seeds crop breeding at the CDA Research Station, Lethbridge, Alta.

Sunflowers require the help of insects for cross-pollination to give maximum seed production. Because sunflower pollen is somewhat heavy and sticky it is not effectively transferred between plants by wind. That is why pollen is often seen adhering to the leaves immediately below the flowers from which it dropped.

One might think that the strong winds common to our prairies could transfer pollen, but we have observed that other factors hinder the effectiveness of such a process. One is that sunflower blooms generally face east whereas many winds are westerly during the flowering season. Another is that strong winds tend to turn the heads so that they face away from the wind. Hence the pollen is blown onto the backs of the heads instead of into their faces. Winds also reduce the activity of the insect pollinators that are often limited in number even when the weather is ideal.

The outer florets of a sunflower are the first to open and it takes three to six days before flowering is complete. However, we have observed that stigmas can stay receptive for several days. This is illustrated in Fig. 1. The florets on the left side of the head were self-pollinated and those on the right side were cross-pollinated. Since no fertilization occurred by selfing, the stigmas remained receptive whereas they withered following fertilization. The ability of stigmas to stay receptive over periods of time is especially helpful in reducing sterility that would otherwise occur when weather is unfavorable for insect activity.

Fertilization, or seed setting, induces expansion of the head so that it may accommodate the developing seeds. Fig. 2 illustrates the relative size of the two halves of a self-sterile bloom cross-pollinated on the right side only. It also illustrates the need for a good seed set to get maximum head size in sunflowers.

When there are too few insect pollinators, seed yields are low. Consequently, the increased self-pollination that occurs results in reduction in vigor of subsequent generations. This is not as serious a problem in growing hybrid varieties as it is in growing synthetic varieties. Hybrid seed is used to grow only one commercial crop, whereas synthetic varieties like Peredovik are grown from seed of previous generations. In order to maintain the vigor of a synthetic variety, we would encourage the use of bees to ensure maximum cross-pollination, especially in fields that will be used for seed production.

Sunflowers produce fairly large quantities of pollen, which can be observed on the dehisced anthers and emerged stigma. Therefore, any insect that visits a flower seeking either pollen or nectar will soon be well covered with pollen. Honey bees, bumble bees, and other bees will visit sunflowers. Some small insects that apparently remain on the same flower all day are useful in distributing pollen deposited by other visiting insects.

In addition to the use of honey bees, a few other practices can be followed to increase cross-pollination in sunflowers. The fields should be located away from other crops that may attract insect pollinators. We recommend long narrow fields in preference to large square blocks. It is also best to use the lowest seeding rates that will still give optimum yields. Stands with fewer plants per acre will ensure greater cross-pollination.

Figure 1—A fully open sunflower with stigmas still receptive on the self-pollinated side (left) but withered on the cross-pollinated side (right).

Figure 2—A self-sterile sunflower that has been cross-pollinated on the right half only. Note the relative sizes of the two sides.

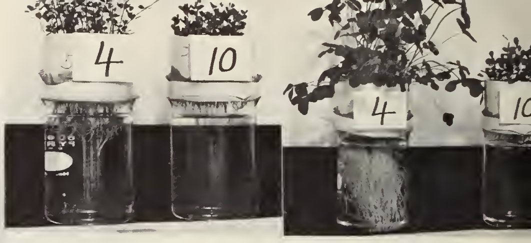


Figure 2—Alfalfa and red clover seedlings growing in nutrient solutions with 1.0 ppm aluminum ion (left) and 2.0 ppm (right).

Left: Figure 1—Red clover seedlings growing in nutrient solutions with (left to right) 0, 0.1, 0.2, 0.5, 1.0 and 2.0 ppm aluminum ion.

Soluble Aluminum in Acid Soils Retards Legume Establishment

L. B. MacLeod

AND

L. P. Jackson

THE primary cause of failure in establishing legumes such as alfalfa and red clover on unlimed or inadequately limed, acid soils is the presence of aluminum in the ionic form. Aluminum is present in all mineral soils but only when in the soluble form does it pose any danger to crops. Aluminum ions cause poor establishment by restricting the growth of roots down into the soil where they normally obtain the nutrients and moisture needed for successful establishment.

Legume seedlings are most susceptible to aluminum injury during the phase of early seedling development when the source of nutrient supply is shifting from the food reserves in the seed to active uptake from the soil. Forage legumes, which have comparatively small seed reserves and which must start to feed from the soil quickly, once germinated, are more susceptible to injury by aluminum than are other crop species having large seed reserves.

The amount of aluminum ion in soil will vary but it depends largely on the pH. For example, at a pH of 4.6 we found the concentration of aluminum ion in Tormentine sandy loam to be 2.22 ppm or 4.5 lb. per acre. When this soil was limed to a pH of 6.5, the concentration of aluminum ion was so low that it could not be measured. The danger of aluminum toxicity is greatest in soils at a pH of 5.0 or lower, since at a pH of 5.8 or above, the amount of aluminum ion present is negligible.

Liming will increase the pH in the surface but it is very slow to penetrate to the subsoil. For this reason, lime amendments may not greatly improve the subsoil environment insofar as the growth of roots is concerned. Since deep rooting of forage species is imperative for sustained production during the months of July and August, when periods of high soil moisture stress may occur, it seemed desirable to have more knowledge of what aluminum ion concentration would restrict rooting or be toxic to roots.

In order to explore further the role of high aluminum ion concentrations on the growth of legumes, we conducted a greenhouse experiment using nutrient solution cultures where the concentration of aluminum ion could be closely controlled.

Alfalfa and red clover were germinated in an inert silica medium in containers with nylon net bottoms (window screening) to allow the roots to grow through. These were placed on top of beakers containing the nutrient solutions so that after germination the only source of nutrients was from the solutions (Fig. 1). Aluminum was supplied to the nutrient solutions at concentrations of 0, 0.5, 1, 2, 4 and 10 ppm, but the concentration of aluminum ions actually present in solution was 0, 0.1, 0.2, 0.5, 1.0 and 2.0 ppm. The nutrient solutions were changed daily to maintain this aluminum concentration. Each species was also seeded in the silica medium and allowed to root in unlimed (pH of 4.6) and limed (pH of 6.5), Tormentine sandy loam soil. Forty days after seeding, the plants were harvested and divided into top and root portions so that the effect of aluminum on both root and top growth could be measured.

The yield of the top and root portions of both alfalfa and red clover were higher with aluminum ion concentrations up to 0.4 ppm than where no aluminum was added. Yield was lower at 1.0 ppm but red clover appeared to be more tolerant of aluminum ion

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Dr. MacLeod is Head of the Soils and Plant Nutrition Section and Mr. Jackson is an agronomist with the CDA Experimental Farm, Nappan, Nova Scotia.

than alfalfa at 1.0 ppm. At 2.0 ppm root growth of both species was prevented (Fig. 2).

Alfalfa and red clover both grew better in limed than in unlimed soil (Fig. 3).

In general, when plants are grown in a sufficient concentration of aluminum ion to cause injury, the element collects in the roots while the tops may have relatively little aluminum present. The most striking characteristic of aluminum toxicity, we have observed, is the stunted root growth with brown or black discolorations and thickenings at the root tips. If the concentration of aluminum ion is sufficiently high to be toxic, the cortex cells in the root become saturated with aluminum. Branch roots cannot emerge through this layer and the result is a series of darkened lumps on the tap root instead of the normal, fully developed branch and fibrous roots. Alfalfa roots grown on Tormentine soil limed to a pH of 5.2 were vigorous with abundant branch roots and showed evidence of nodules containing nitrogen-fixing bacteria (Fig. 4a). Roots grown on unlimed soil (pH 4.6) were small, lacked branch roots, and had darkened lumps which are typical of aluminum toxicity (Fig. 4b).

Our experiments have shown that small rates of lime applied in the immediate vicinity of the seed decreases the aluminum concentration in the vicinity of the roots and allows initial growth. By the time the roots have grown through this protective zone they have passed the critical stage of development and can tolerate higher concentrations of aluminum. The initial rooting stage is the most critical period since the plant becomes more tolerant to the toxic effects of aluminum as it matures.

These experimental results suggest that the use of agricultural limestone can eliminate the danger of aluminum toxicity in the surface soil. A moderate application of limestone will increase the pH of the surface soil sufficiently to reduce the concentration of soluble aluminum and allow unrestricted root growth. After a soil has been limed to a pH of 5.5 to 6.0 and fertilized to provide adequate nutrients, legumes can be readily established in most well-drained soils in Eastern Canada.

However, even though the surface soil is limed, acid subsoils may still restrict deep penetration of roots. This problem will have to be resolved either by liming to greater depths or by the development of varieties that have a greater tolerance for aluminum.

Figure 4a (left)—Alfalfa root grown in Tormentine sandy loam limed to pH 5.2. Note vigorous growth, abundant branch roots and nodulation. Figure 4b (right)—Alfalfa roots grown in the same soil but not limed (pH 4.6). Note smaller size, lack of branch roots and darkened lumps where branch roots have died or failed to emerge.

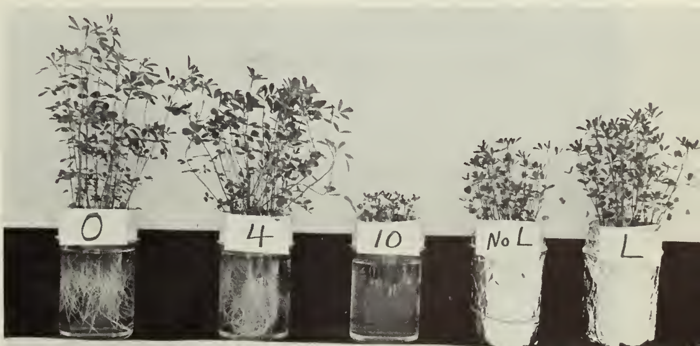
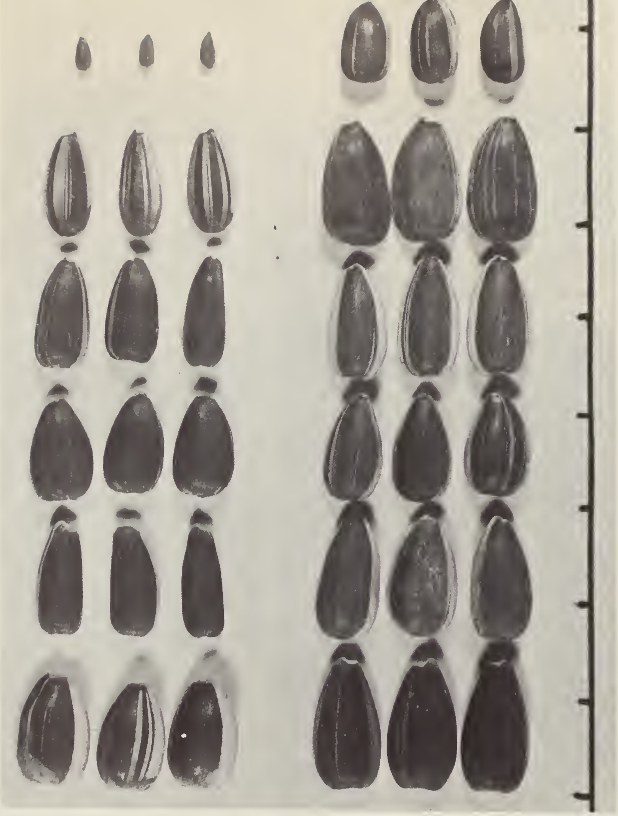


Figure 3—Alfalfa seedlings in (left to right) 0, 1.0 and 2.0 ppm aluminum ion in nutrient solutions, and unlimed (pH 4.6) and limed (pH 6.5) Tormentine sandy loam.



Upper right: Seeds of the wild sunflower (*Helianthus annuus*). Lower right: Seeds of the oilseed hybrid Advent. Others: Groups of three seeds from single plants of the Mennonite variety showing differences in color, shape and size. (Scale is in half-inches).

BREEDING FOR LARGE SUNFLOWER SEED

E. D. Putt

There is an increasing demand for large sunflower seed by the specialty or confectionery trade. This has led to expansion of the crop in Manitoba from 5,000 acres in 1955 to a high of 16,000 acres in 1963. Although plantings declined in 1964 to 11,000 acres because of excess production the previous year, nevertheless the large-seeded crop occupied 23 percent of the total sunflower acreage for Manitoba in 1964. In Minnesota and North Dakota, American states adjoining Manitoba, some 50,000 acres are sown to this crop.

The large seed is roasted, salted and packaged whole for sale from confectionery counters. Large quantities are also dehulled. The dehulled kernels are roasted and sold at gourmet food stands and used in a variety of candies. To be acceptable to the trade, the seed must pass over screens with round holes 18/64 or 20/64 inches in diameter, commonly termed No. 18 or No. 20 screens. Most of the seed used by the oilseed industry passes through such screens.

Prices for seed meeting the specifications of the confectionery trade, averaged about 20 percent higher than for oilseed in the five years, 1958-1962. Some purchasers paid as much as 9 cents per pound for a few of the best samples compared with 4 cents for the oilseed types. Prices for the 1963 crop were more comparable to the oilseed types because of the overproduction. Reduced quantities available from the 1964 crop will lead to an improvement in prices.

Up to the present, Mennonite has been the variety grown in Manitoba for the production of large sunflower seed. It is variable in shape, size and color of seed, and in plant type, being used because it is the only variety with large seed that would mature satisfactorily in Manitoba, and because it yields as well as the varieties grown for oilseed.

A few years ago a selection program was started on this variety at the Experimental Farm, Morden, with the objective of improving the size of seed. The results have been encouraging and indicate that the Mennonite variety, likely because of its variability, is a good base for selecting material with a greater yield of large seed per acre. Using variations of the recurrent selection procedure, strains have been developed, which in the four years of testing at Morden, have given the following results expressed in

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Dr. Putt is a plant breeding specialist at the CDA Experimental Farm, Morden, Man.

terms of seed passing over a No. 18 screen:

Strain	% of total yield	Yield (lb. per acre)	Weight per 1000 seeds (gm)
A	83	1,636	116
B	88	1,730	121
C	83	1,461	127
Check	71	1,293	118

The "B" strain was licensed as the variety Commander in 1964. As an average of 36 trials in the Co-operative Sunflower Tests in the three Prairie Provinces from 1961 to 1963, Commander yielded 719 lb. per acre of seed passing over the No. 18 screen compared with 480 lb. for the unselected check. Its seed was also more uniform in size than the check. In other respects, including days to mature, strength of stem, height, disease reaction and total seed yield, Commander was similar to the unselected check. For these reasons Commander is expected to replace the variety, Mennonite, for production of large seed.

However, one major disadvantage of the varieties, Mennonite and Commander, is their susceptibility to rust. At Morden, we are using the backcross method to transfer rust resistance to the large seed type. The first rust resistant strains were tested in 1961. Some of them gave total seed yields, and yields over the No. 18 screen, equal to or exceeding the Mennonite variety. In 1961, rust was not severe on the check and probably did not reduce its yield. Unfortunately, most of the resistant strains were later maturing. In one of them, variability in maturity similar to the original Mennonite has been retained so that it offers a promising source for selecting earlier maturing material with resistance to rust. At the same time, selection for greater seed size is being practiced in this particular strain as well as for improved tolerance to leaf mottle disease or Verticillium wilt which is the other major disease of sunflowers in Manitoba.

Incidental to the breeding program, we have noticed that spacing of plants in the row has a marked effect on the yield of large seed. In a test where the plants were spaced approximately six inches apart in the row, three strains yielded an average of 1,071 lb. of seed over the No. 18 screen or 54 percent of their total yield. The same strains in an adjacent test where the plants were spaced 18 inches apart, yielded 1,549 lb. per acre over the No. 18 screen or 85 percent of their total. Thus, by using a relatively wide spacing between the plants the grower can increase his output of large seed.

Extreme left: Unselected Mennonite variety. Left: Commander variety selected from Mennonite. Note larger size and greater uniformity in size of seed.

Below: Sunflowers in bloom. This is an important special crop in southern Manitoba.

Fertilizing Peat Soils For Forage Crops In Newfoundland

A. F. Rayment

THE PEAT SOILS of Newfoundland offer a great potential for hay and pasture production when proper amounts of lime and fertilizers are used. After six years of trials at the CDA experimental peat substation at Colinet, we have found the basic lime and fertilizer requirements for establishing and maintaining forage crops on virgin peat without much difficulty.

Newfoundland peats are extremely acid (pH 3.6) and are deficient in all major, as well as minor, nutrients. By withholding in turn lime, nitrogen, phosphorus, potassium and fritted trace elements, we proved the need for each of them in forage production. Also, the resulting deficiency symptoms have been useful in diagnosing field problems.

Without nitrogen fertilizers, grasses were found to establish poorly on virgin peat and produce practically no yield. Properly inoculated legumes grew excellently without nitrogen, but did not yield as well as grass-legume mixtures receiving a complete fertilizer. Legumes sometimes dominated stands when grass-legume mixtures were seeded on virgin peat, even though adequate nitrogen fertilizer had been applied. Presumably, the nitrogen was leached by the heavy rainfall (65″ per year) or was used by micro-organisms that break down the raw peat, but enough grass was established to respond to nitrogen fertilizer the following year. On the other hand, we found that excessively heavy nitrogen fertilization could favor the grass and suppress the clover. Therefore, according to our studies, fertilizer rates supplying no more than 50 lbs. of nitrogen per acre should be used in seeding down grass-legume mixtures, or for spring-dressing hay or pastures high in clovers. However, our investigations revealed that an additional 50 lbs. of nitrogen could be applied in the summer to pastures or aftermath to promote grass growth.

Where grasses were growing alone, as in older hay stands, we found that they responded to nitrogen at rates of well over 100 lbs. per acre, all applied in the spring for only one cut.

In the absence of potassium, grasses and legumes established well but the latter became severely stunted in the second year and were more susceptible to leaf diseases. The leaf margins, especially of red clover, turned brown and died, and by the third year legumes practically disappeared from the stands. We also observed marginal yellowing in grasses, although a number of years of growth was often necessary before the greatest development of symptoms occurred. Though potassium is particularly important for maintaining legumes in the sward, it also increases grass yields, and a yearly application of 100 to 200 lbs. (K_2O) per acre was necessary.

Where phosphorus was not supplied, grasses and legumes failed to establish. Phosphorus (P_2O_5) at 100 lbs. per acre was sufficient to establish excellent stands of grass and clover, but by the second or third year this could be reduced to 50 lbs. per acre per year.

Without limestone, we found that there was practically no legume growth and grass establishment was spotty. However, grasses that did grow, especially reed canarygrass, had increased vigor during the second year, though yields remained low. A distinctive white to yellow streaking occurred in the leaves of reed canarygrass which appeared in patches in the field. While rates of limestone of 1 ton per acre, or even less, were sufficient in most cases to establish forage crops, initial rates of 2 to 3 tons per acre were needed to prolong a balanced sward of grasses and legumes. A relatively high initial liming seems important for maintaining the life of stands and makes the need for reliming less critical.

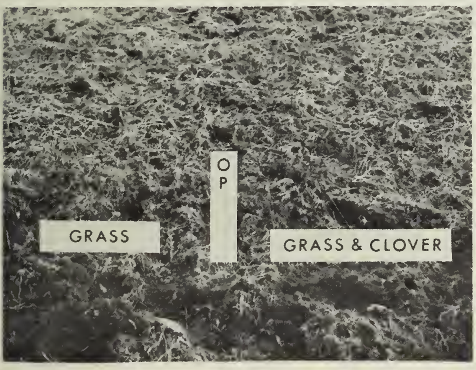
The addition of 50 lbs. per acre of a fritted trace element mixture (F.T.E.) containing 3% boron, 3% copper, 18% iron, 7.5% manganese, 0.2% molybdenum and 7% zinc had no visible effect on the growth of forage crops. However, there was some evidence that dry matter yields of grasses grown alone were slightly reduced by eliminating F.T.E. Grass-legume mixtures remained unaffected.

In tests conducted with "indicator" crops, we showed that certain trace elements (boron, copper and molybdenum) were deficient and that their absence affected the chemical composition of the plants. In grazing studies, we found that mineral deficiencies in animals may result from pasturing peat soils without special supplement, and we therefore recommend that fertilizers containing 2% fritted trace elements be used in the initial years of development.

Fertilizers that supply required nutrients in the correct proportions are now being made available. From our investigations we would suggest, when seeding a grass-clover mixture for hay or pasture, that 6-12-12 + 2% F.T.E. fertilizer at 850 to 1,000 lbs. per acre be used. In the second year, on good grass-legume mixtures, 10-10-20 + 2% F.T.E. fertilizer should be applied in the spring for hay. Further nitrogen dressing should be applied following an early cut of hay to promote second growth. For stands of hay, predominantly grass, 16-8-16 + 2% F.T.E. fertilizer applied at 650 lbs. per acre will produce about 3 tons of field material per acre. For pastures, 10-10-20 + 2% F.T.E. fertilizer should be applied as for hay, and dressings of nitrogen until the end of July to promote recovery. Nitrogen dressings may also be used to stimulate aftermath for pasture.

The author is an agronomist at the CDA Experimental Farm, St. John's West, Newfoundland.

This series of photographs shows what happened to forage crops when the various nutrients and elements were withheld in turn from the fertilizer treatments. Above left: Without nitrogen. Above right: Without potassium.



Without phosphorus

Without lime

Without trace elements

Complete treatment

Above: Screenhouse at the Ottawa Research Station for propagating nuclear stock of strawberries and raspberries.

Left: Author examining virus-infected strawberry plants in a study of virus eradication by heat.

Discoveries and Developments . . .

Virus-Free Strawberries and Raspberries in Eastern Canada

A. T. Bolton

SEVERAL years ago, experts found that viruses in strawberries and raspberries greatly reduced vigor and subsequent yield. Many of these viruses were present in the plants without showing definite symptoms. By 1951, it was very difficult to find a single virus-free raspberry or strawberry plant in commercial plantations in North America. In Ontario, the favorite variety of strawberry, Premier, was found to be virus-infected and, by 1954, most of the plants of this variety were exhibiting a definite lack of vigor. Growers who, some years before, had obtained tremendous yields were experiencing decreases in production which amounted to crop failure. In the provinces of Quebec and New Brunswick, where the variety Senator Dunlap was grown almost exclusively, a similar situation arose.

The strawberry was not the only small fruit to suffer from virus disease. The popular raspberry variety, Latham, was losing vigor rapidly in spite of a certification program that restricted the sale to those canes showing no visible disease symptoms. Since this variety was capable of being infected with certain viruses without showing visible symptoms, it became apparent that field inspection was inadequate. Several other raspberry varieties were found to react in a similar way to virus infection.

In the United States, especially in areas where the insect vectors of virus diseases are plentiful, certification of strawberry plants free of virus diseases was begun about 1951. A few years later, it appeared that similar programs would be required in Canada. Research workers in the Canada Department of Agriculture at Vancouver, Ottawa, and Kentville, N.S., began work to determine the viruses present in strawberries in these areas, and to attempt to obtain stocks of virus-free plants of the important varieties.

By 1960, all of the provinces in Eastern Canada except Newfoundland were making use of virus-free stock produced at Ottawa and Kentville. Ontario, Quebec, New Brunswick and Prince Edward Island developed strawberry certification programs in which they received nuclear* virus-free mate-

Dr. Bolton is a specialist in small fruit pathology at the CDA Ottawa Research Station, Central Experimental Farm.

**The word "nuclear" used in connection with "nuclear virus-free strawberry stock" implies that the plants were propagated vegetatively from tested or indexed virus-free plants under controlled conditions (i.e. screenhouse free from insects, diseases, etc.)*

Right: Virus-free raspberry plants being tested for virus freedom by grafting to the Oriental raspberry species *Rubus henryi.*

Left: Virus-free nuclear strawberry plants being increased in boxes for distribution to agencies approved by provincial departments of agriculture.

rial from the Ottawa Research Station (formerly the Genetics and Plant Breeding Research Institute).

At this Station, plants of some 28 different strawberry varieties are propagated each year in boxes in an insect-proof screenhouse. These plants are distributed each year to agencies approved by the various provincial Departments of Agriculture who multiply them for commercial growers. For example, they will be multiplied, in 1965, in insect-free screenhouses under carefully controlled conditions and distributed, in 1966, as "elite" stock to growers of foundation plants. These foundation plants will be sold to growers of certified plants in 1967 and made available to strawberry producers in 1968. By following this procedure, strawberry plants reach the grower in a virus-free condition and, in most cases, can be maintained in this state for at least two years.

At the Ottawa Research Station, we are constantly maintaining nuclear stocks free from virus disease, and also inactivating viruses in infected varieties so that the resulting virus-free plants may be added to the program. In order to ensure the virus-free condition of plants that do not show symptoms when infected, leaves of these are grafted to plants that will exhibit symptoms of the different viruses. We call the latter indicator plants, and the process of testing, indexing. Plants in the certification program are indexed three times before being sent out as nuclear stock. We use different indicator plants to diagnose different virus diseases.

In 1963, we conducted a survey of strawberry-growing areas in eastern Canada and found that three main virus diseases were present. These were strawberry mottle, veinbanding, and latent C. In our investigations, we found that the strawberry mottle virus can be destroyed by subjecting the infected plant to a temperature of 100°F. in a specially designed heat chamber for a period of 7 to 10 days. But veinbanding and latent C viruses are much more difficult to kill. In an attempt to destroy these viruses, we exposed the plants to temperatures as high as 118°F. for several days. Following these exposures, most of the plants die although a few manage to survive, and among the latter a virus-free plant may be found. In 1964, we obtained virus-free plants of the early variety, Valentine, by subjecting them to a temperature of 108-115°F. for ten days. By this procedure, both veinbanding and latent C viruses were inactivated, and this variety will be available to growers in 1968.

Virus-free raspberries are next. The Ontario and Quebec Departments of Agriculture became interested in a better certification program for raspberry plants about three years ago. Since Latham, the most widely grown variety in eastern Canada, was virus-infected, the success of a new certification program depended upon this variety being made available to growers in a virus-free condition. Attempts to inactivate the viruses in this variety had been made at various research establishments in North America without success. In 1961, at the Ottawa Research Station, when Latham plants were subjected to a temperature of 98° for 75 days and tip cuttings taken from them and rooted in a mist chamber, we found that twelve proved to be virus-free. We also freed the variety, Viking, of virus by this treatment.

In 1962, we planted nuclear stock of virus-free raspberries in an isolated area in Ontario. Canes from this plantation were sold in 1963 as foundation stock to growers of certified stock. Certified virus-free raspberries will be available to growers in Ontario in 1965.

The increased vigor of virus-free raspberry plants is very great. Comparisons of virus-free and virus-infected plants are being made at the CDA Smithfield Experimental Farm and at the Ontario Horticultural Station at Simcoe. Final results of these are not yet available but early observations indicate that we may expect much greater yields and better quality fruit. To ensure a supply of virus-free raspberry canes to growers, nuclear stock is maintained at Ottawa. Plants are grown in boxes in a screenhouse during the summer months. In the fall, these plants are cut off and boxes, containing the roots, are either kept at Ottawa or sent to the Ontario Department of Agriculture. Plants are propagated from these roots during the early spring and sent out to foundation stock growers.

Through these certification programs, reputable growers are assured of high quality disease-free stock of strawberries and raspberries. The demand for certified strawberries has increased each year since becoming available. In 1963, the estimated number of plants produced in Ontario, Quebec, New Brunswick and Prince Edward Island, under these programs was approximately ten million. In general, yields are from 50 to 100 percent higher among producers who use certified plants.

There are still many non-virus-free varieties of both strawberry and raspberry. Experimentation is continuing at the Ottawa Research Station to find new methods of treatment to destroy the viruses without killing the plants. In the meantime, the growers are benefiting from planting virus-free stock of the available varieties.

Right: An indicator plant infected with strawberry mottle virus.

Left: The effect of strawberry vein-banding on the indicator plant.