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A young lamb gives viewers the once-over. See story page 26

Un jeune agneau observe les visiteurs. Voir article page 26.

CANADA AGRICULTURE

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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.

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THE STRANGE CASE OF

POTATO SPINDLE TUBER

R. H. BAGNALL, R. P. SINGH and M. C. CLARK

Le groupe de pathologistes de la pomme de terre de Fredericton cherche depuis 6 ans une réponse au problème de la filosité des tubercules. Les recherches ont montré que l'agent de cette maladie n'est pas vraiment un virus, mais plutôt un métavirus, ou «post-virus». Le diagnostic et la répression de cette maladie s'en trouveront améliorés maintenant qu'on connaît mieux ce microorganisme.

"Large as life"—we all accept this common expression with hardly a passing thought. But how small can it get? That brings us into the foggy area of debate—*what is life?* We do not intend to argue that one out here, for most definitions of living matter are arbitrary in one way or another. Many have been purposely formulated to exclude anything so small as a virus, let alone something yet smaller. And our subject is decidedly smaller—most arbitrarily non-living.

But if you "encountered" an entity that was highly infectious, would cause a recognized disease in plants, and could somehow trigger its own reproduction—wouldn't you expect just a bit of a wiggle?

We can't vouch that it doesn't, but don't go looking about in your garden just yet.

The causal agent of the potato spindle tuber disease is a little bit of ribonucleic acid (RNA); so little that any biochemistry buff versed in Watson and Crick will tell you it can't possibly carry the code for a single enzyme let alone enzymes required to duplicate the structural integrity of an RNA molecule. To be sure, it gets by thriftily—doesn't even seem to have a coat like any self-respecting virus should. Still no go—can't be done by conventional means. The RNA of the potato spindle tuber agent is just too small to know what it is about.

The typical plant virus—meaning practically all of them, for anything else is termed "defective"—consists of a strand of RNA surrounded by a coat consisting of closely packed units or globules or protein. Some viruses are rod-shaped and others spherical, depending on whether the RNA strand is straight or compressed and folded. When viewed under an electron microscope, the rod-shaped virus looks somewhat like a cob of corn, with the protein "kernels" arranged in spiral or helical fashion around the RNA core. A spherical virus comes out looking like a ball of popcorn.

NAKED RNA

That protein coat is needed, for otherwise the RNA would soon fall prey to cellular nucleases—enzymes that abound in plant cells to chop up redundant nucleic acids. But, try as we might, we have not been able to find any protein that is essentially associated with the RNA of the spindle tuber agent. It seems to be just plain naked RNA, and as we said above, very little of that.

Early work at Fredericton indicated that when the RNA portion, alone, was separated from sap of infected plants, it was highly infectious. The infectious unit was not all driven to the bottom of a centrifuge tube spun at 50,000 r.p.m. for several hours—105,000 times the force of gravity. This fact indicated a relatively small "soluble" type of RNA molecule. But it was not suspected at the time just how small.

Techniques for further purification were adapted from those that biochemists have developed in the highly specialized studies of nucleic acids.

In spite of these, the resulting RNA solution was far from pure potato spindle tuber agent, even

Dr. R. H. Bagnall and Dr. R. P. Singh are virologists, and Mr. M. C. Clark is a plant pathologist-biochemist at Agriculture Canada Research Station, Fredericton, N.B.

though it was many times more infectious than crude sap. Moreover, non-infectious sap from healthy plants produced practically as much total RNA as did sap from diseased ones.

Further separation of the RNA fractions was made on the basis of size. This was done by means of gel electrophoresis and density gradient centrifugation. The names sound complicated, but the techniques, themselves, are deceptively simple.

GEL ELECTROPHORESIS

The familiar gelatin "gel" consists of a solid three-dimensional mesh, holding quantities of water like a sponge. The mesh is more elastic, however, and the interspaces vary in size somewhat in proportion to the amount of water. Polyacrylamide gel rather than gelatin is generally used as it allows better standardization of pore sizes. A plug of gel in a small length of glass tubing operates as a sieve when a layer of RNA solution is passed through. The RNA particles are urged on by a bit of electric current—thus "gel electrophoresis".

Total electrostatic charges on RNA's are proportional to their mass, so this factor cancels out, and the size and shape alone control the rate of movement. The smaller molecules move ahead quickly, larger ones lag behind, and still larger ones do not even enter gels of the consistency generally used. The RNA particles are not allowed to pass right through the gel, but once a satisfactory spread has been obtained, the "run" is stopped. The gel can then be sliced into discs and each analyzed separately. When this was done the infectious material was found in the same general region as transfer RNA (t-RNA). These are tiny particles from deep inside the cells. They function by trapping specific amino acids and "transferring" them to templates of messenger RNA (m-RNA) used in the manufacture of proteins.

This size pattern for the spindle tuber RNA was confirmed by means of density gradient centrifugation. Test tubes of sugar solution were set up with concentrated, or dense, layers at the bottom and less dense toward the top, in the form of a gradient. The RNA solution was carefully layered on top and the tubes were spun in the ultracentrifuge for 16 hours. The different RNA particles were thus driven down through the gradient, heavier molecules progressing faster and lighter ones lagging. Again, the infectious particles were found near the levels occupied by transfer RNA's.

This size is simply too small to fit previous ideas of viruses. Yet and again, the normal viruses are known to be persuasive types. In a sense, they have the ability to con the host cell into producing their kin, protein coat and all. Perhaps this little fellow has cut it down real fine. Arriving in the raw without baggage, he demands and gets all the amenities for himself and his heirs.

But we have noted that naked RNA can be attacked by cellular nucleases. How, then, does our little friend survive? One possibility derives from its size similarity to t-RNA's. These latter small molecules spend a good deal of their time attached to proteins, that is to enzymes which couple them to amino acids. The bulky protein protects them from nucleases. Suppose the infectious agent of the spindle tuber disease were an aberrant t-RNA or one which has lost its capacity for coupling with amino acids, but has maintained its ability to attach to one of the coupling enzymes. Might he not use this as a means of protection? And in tying up enzyme molecules, might he not disrupt cellular metabolism so as to cause the spindle tuber disease? Wild guesses. But virus research has come through some pretty woolly country already!

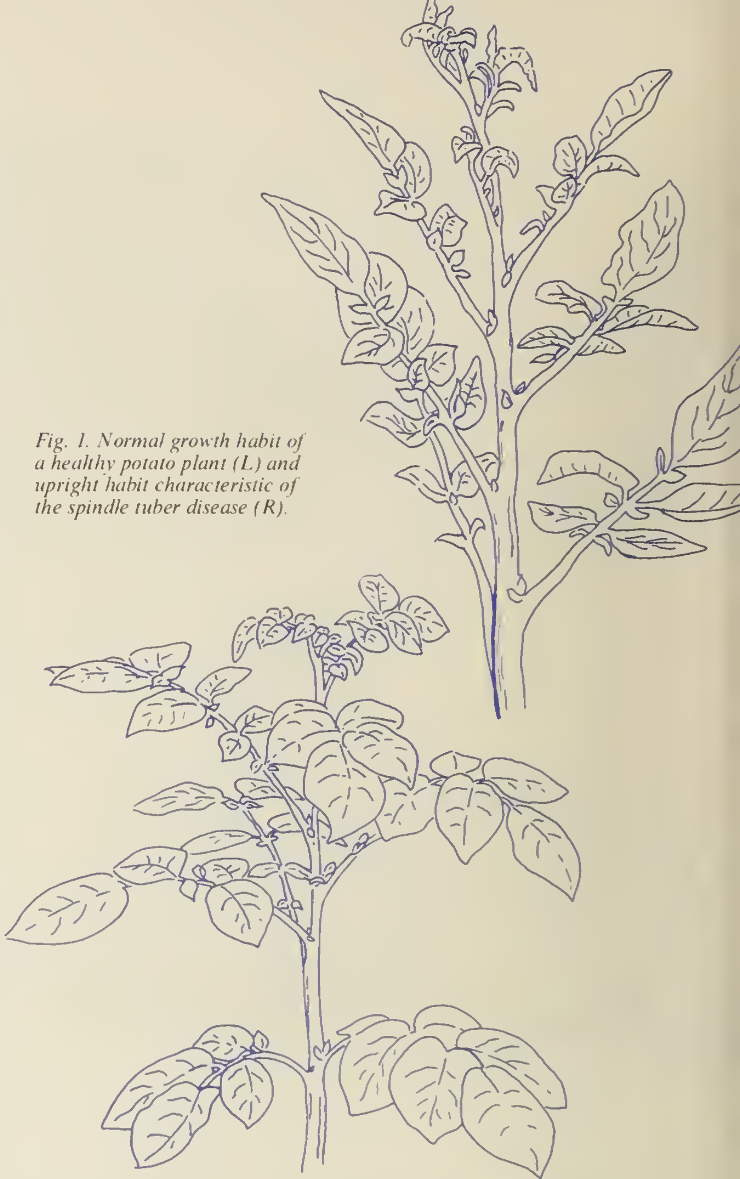


Fig. 1. Normal growth habit of a healthy potato plant (L) and upright habit characteristic of the spindle tuber disease (R).

As a matter of fact, we've decided that he isn't really a virus, and have coined the name "metavirus"—"after" or "beyond" viruses.

Our group at Fredericton, N.B. has been searching for answers to the potato spindle tuber disease problem for the past six years. So little was really known about the causal agent that groundwork was needed, and as noted above, this brought some surprises and

Fig. 2. Healthy tuber (bottom) and typical tubers affected by the spindle tuber disease.

has left us with some intriguing questions. But the prosaic, practical approaches—improved diagnosis and control—were also pressed. Progress has been made in these areas, too.

Long thought to be of virus origin, the most conspicuous characteristics of the disease are elongation or 'spindling' of the tubers. They are often also distorted and cracked. Yield is reduced. The plants often develop a stark, upright habit of growth. The causal agent is carried over from year to year in the tubers and can be transmitted by contact—crushing of foliage, rubbing of tubers, by cutting knives and machinery.

At least two distinct strains of the agent exist, "mild" and "severe". Oddly, the severe strain is easier to deal with.

DIFFICULT TO ERADICATE

Recent surveys in Eastern Canada revealed approximately four percent diseased plants in uncertified "table-stock" potato fields. The mild strain predominated by a ratio of almost 10:1. Apparently plants infected with the mild strain are less readily found in the process of field "roguing". The disease is, in fact, so difficult to eradicate from seed stocks that its presence, even in a small percentage, significantly reduces the value.

It has been found best to concentrate on selection and maintenance of completely disease-free seed stocks. In the normal seed certification program, field and bin inspections are carried out on a regular basis. A grower may also determine the health of his stock by submitting a sample of tubers to be planted during the winter months in Florida.

VIRUS-FREE NUCLEUS STOCK

A new approach to the control of potato diseases is now being tried. A source of virus-free stock is established which serves as a nucleus for multiplication at an isolated seed farm. The crop derived from this is subsequently entered into the Elite Seed Program. Each tuber of the nucleus stock is tested not only for the spindle tuber agent, but also a number of other virus diseases. There are at least half a dozen viruses that commonly infect potatoes. (Seed-borne fungus diseases and bacterial ring rot are considered, too).

A single eye is scooped out of each tuber and a plant is grown from it in a greenhouse during the winter. This potato plant can be observed for virus symptoms, but, since some viruses are carried almost symptomlessly in potatoes, sap will be crushed from a leaf and rubbed on an indicator host. The indicator is a plant of another species which develops distinctive symptoms when infected with one or more of the potato viruses. Tomato plants respond to the severe strain of the spindle tuber agent with characteristic stunting, distortion, and necrotic lesions. Unfortunately, tomato does not show the mild strain well.

Several new differential hosts for the spindle tuber agent are being tried at Fredericton. One of the more promising is *Scopolia sinensis* which develops small necrotic spots when the spindle tuber agent is rubbed over its leaves. *Scopolia* has usually been successful in detecting the mild strain, but occasionally it has failed to do so. We have not yet determined whether this was due to a low concentration of the agent or some inhibiting substance in the sap.

Other means of diagnosis and improvements in the present ones are being considered. For example, it is known that at least one host protein becomes abnormally abundant in tomato plants when they are infected with the severe strain of the agent. Also increased amounts of manganese in the growth medium have enhanced the value of tomatoes as diagnostic hosts.

There has also been a search for genetic resistance. Some potato varieties are less susceptible than others, but no extremely resistant ones have been found. Several wild tuber-bearing *Solanum* species appear to possess some resistance, but these have not yet been critically tested. Nevertheless, in time, this approach to the problem may yield a solution. ■

Fig. 1 (Left to right). Fine surface detail of seeds arranged in increasing order of fungicide adhesion: buckwheat; wheat; flax; and rape x 200. Generally the rougher the seed coat the more adhesion of fungicide but in the smooth-coated flax there is more adhesion than on the rough-coated buckwheat because of a greater surface area per bushel.

SEED TREATMENT update '73

J. T. MILLS and J. J. NIELSEN

Il ne faut traiter les semences que lorsque cette opération est nécessaire et qu'elle peut être efficace. Le meilleur traitement est celui qui agit le mieux contre une maladie donnée, qui n'est pas toxique et qui adhère aux graines. Les auteurs comparent des fongicides appliqués à diverses semences en vue d'en améliorer l'adhérence.

Seed- and soil-borne diseases are a continuing problem in the production of cereals and other crops in Canada. Most of these diseases were controlled by mercurial seed treatments which are being discontinued because of their toxicity. New types of seed treatment are now available which are more versatile, but are also more costly than the mercurials. Cost of treatment, although a minor factor in relation to other costs, has to be considered in the overall cost of production.

In addition to these recent changes in seed treatment, there has been an increasing public awareness of the dangers of environmental pollution. We should therefore (a) set guidelines as to whether or not to treat and when to treat, and (b) evaluate new formulations of seed treatment chemicals for their effectiveness in controlling diseases and (c) try to find ways to improve their efficacy.

WHEN IS TREATMENT NECESSARY?

In the past, seed treatment was often looked upon as insurance against possible losses by diseases. However, any insurance, no matter what kind and how low its cost, is sensible only if there is a risk. Obviously then, seed treatment would be wasteful unless there is a risk of disease causing a loss (in quantity or quality) which would exceed the cost of treatment. That risk has to be assessed for each crop, disease and area.

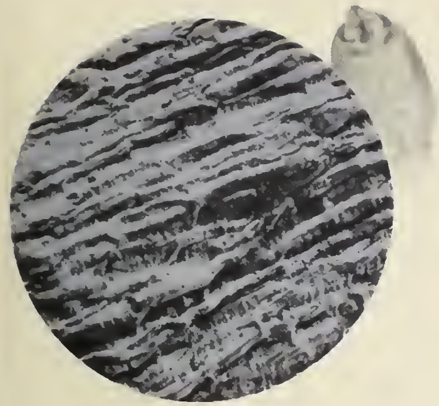
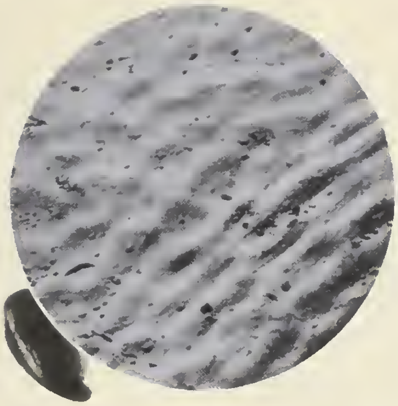
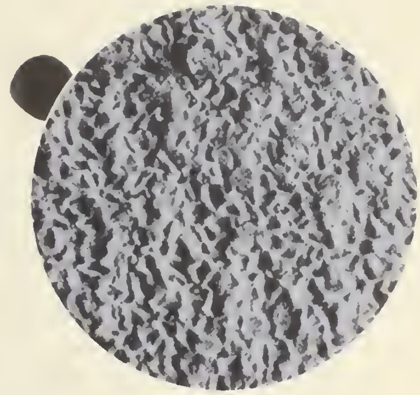
Let us consider the cereals as an example. Historically, seed treatment by chemicals evolved from century-old attempts to control bunt and other smuts. The control of smut diseases is still one of the main reasons for applying treatments today—but they should be applied only when necessary. Certainly, seed of a variety that is resistant to smut does not require treatment. Nor does seed of a susceptible variety that comes from a field free of smut need treatment; pedigreed seed will nearly always meet this condition.

Farmers who grow their own seed should check the field for smut just after heading. If no smut is found, the seed for next year's planting will not require treatment. If the farmer is not sure about the presence or absence of smut, the seed should be treated every few years, according to the relative susceptibility of the variety. The recommended interval between treatments should be stated in the annual recommendations of varieties published by the provincial departments of agriculture.

Besides control of smuts other treatments may be required. Wireworms are a pest of cereals in certain areas of Saskatchewan and Alberta; their damage can be minimized by insecticide or dual-purpose insecticide-fungicide treatments. Seedling blight of barley, caused by the fungus *Helminthosporium sativum*, is often severe in Eastern Canada. Seed rot of flax and soil-borne diseases of sugar beet are problems that require seed treatment. The trend towards precision seeding of sugar beet to save thinning costs can be achieved only by high emergence ensured by an effective seed treatment.

These examples illustrate that modern agriculture seeking high and stable yields cannot do without chemical seed treatment. Through various provincial and federal advisory committees pathologists give the farmer recommendations for seed treatment for particular pests and diseases. The agricultural chemical industry and the Research, and Production and

Drs. Mills and Nielsen are plant pathologists at C.D.A.'s Winnipeg Research Station, Manitoba.

Marketing Branches of CDA give farmers the means to do so by producing and licensing effective chemicals.

The objective of our program at Winnipeg over the years has been to evaluate the chemicals that may be used to control smut diseases of cereals and seed rot of flax on the Prairies. This program provides essential data for the registration of compounds that have to replace the mercurials and other discontinued products. However, most of these new compounds are more costly, so that more emphasis has been placed on the cost of treatment. If a treatment is required, its cost and its possible hazards of use must be considered. This calls for a treatment with the minimum amount of chemical necessary to effectively control the pest or disease.

The main factors affecting the possible use of a seed treatment formulation are its a) physical properties, b) action on biotic components, and c) cost.

A. Physical properties—Dust formulations generally consist of inert carriers, stickers, and active ingredient(s); liquid formulations contain, in addition, wetting agents, emulsifiers, stabilizers and other compounds. The most important properties of the active ingredient(s) are solubility, volatility and persistence in soil.

B. Action—Main considerations are phytotoxicity, increased vigor of, and systemic residues in the plant, and effectiveness against seed- and soil-borne fungi. An important limiting factor is mammalian toxicity.

C. Cost—High costs of formulating a product can preclude its use, but costly, safe and effective chemicals may be acceptable if more efficient application techniques can be found.

Experience has shown that some formulations adhere poorly to some crops resulting in the use of more than is necessary to control the disease. Overtreatment leads to increased cost through wastage, increased hazard to the operator, increased possibility of pollution, and possible clogging and corrosion of machinery. Thus, by determining the amount of each formulation that can adhere to seed of each crop, more accurate dosage rates could be set for each combination of crop and formulation.

A recent study at the Winnipeg Station has compared the amounts of five fungicide formulations that adhered to seed of sunflower, barley, wheat, buckwheat, crambe, flax, and rape (Fig. 1). It was found that the formulations adhered differently to each seed. The order of increasing adhesion was Panogen Px, Vitaflo Drillbox, Arasan 75, Manzate D and Benlate T and the order was the same for each crop. Manzate D and Benlate T had much greater adhesion and smaller particles than the other formulations; however, these compounds are not presently registered for seed treatment. Since the effectiveness of Panogen Px depends in part on its volatility, adhesion and the occurrence of larger aggregated particles are less important.

The study also found that adhesion is related to the gross seed surface area per bushel, to fine surface features of the seed, to the nature of the seed treatment material, but not to the number of seeds per bushel. Generally, the rougher the seed surface (Fig. 2) and the larger the gross seed surface area per bushel the greater the adhesion of a formulation. Adhesion of Manzate D and Benlate T was however more directly related to the gross seed surface area of the crops, and not so much to the nature of the seed surface. This suggests that too much sticker in the formulations prevented them from dispersing readily.

By comparing the adhesion of fungicide formulations to seeds of various crops we can suggest to the manufacturer changes in the proportions of the ingredients. The best formulation will be one that sticks on the seeds—not in small lumps to itself or machinery. The final goal is to arrive at dosage rates that are based on tests on adhesion, phytotoxicity, and effectiveness of control of seed- and soil-borne pathogens, so that whenever seed treatment is necessary, it will be done efficiently. ■

S. FREYMAN, M. D. MacDONALD, and J. B. BOLE

CORN IN ALBERTA

Grâce à de nouvelles méthodes de culture, la production du maïs connaît une faveur renouvelée chez les producteurs albertains. On prévoit que la superficie cultivée en maïs grain passera bientôt à environ 60,000 acres, et celle de maïs à ensilage à 100,000.

In recent years there has been renewed interest in field corn production in southern Alberta.

The word renewed is appropriate because corn has been grown in Alberta for over 60 years. Varieties have been tested at the Dominion Experimental Station at Lethbridge nearly every year since 1908. As early as 1912, W. H. Fairfield, the first superintendent of the Station, recommended corn as a feed for dairy cattle. In his annual report he wrote, "The farmer who is keeping milch cows will find a few acres of corn to be a great aid in keeping up the milk supply during August and the early part of September, when the pastures are dry. By having the corn grow conveniently near his barn, he can cut some each day to feed at night without a great deal of extra labour and he will be certain to be more than pleased by the increased flow of milk."

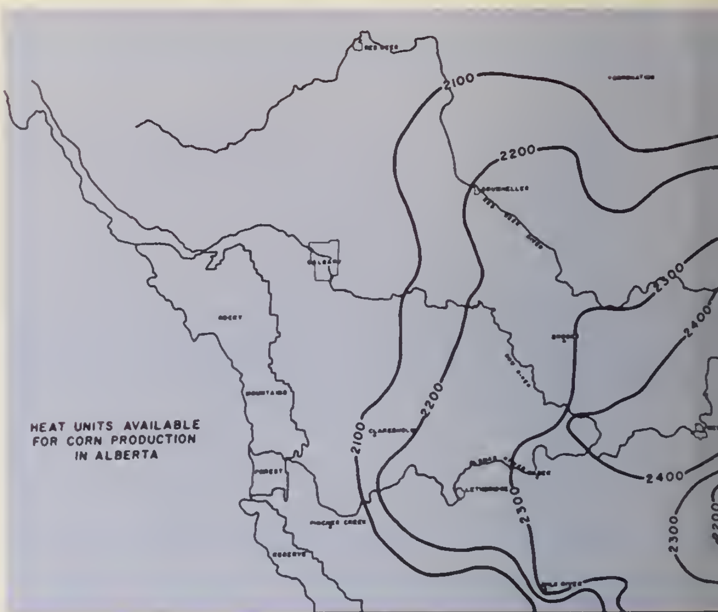
Some of the open pollinated varieties of corn grown in Alberta early this century were 'Angel of Midnight', 'Compton's Early', 'Eureka', and 'Longfellow'. Although these varieties were capable of yielding over 20 tons of green material per acre they all matured too late to be grown for grain.

ALBERTA FLINT

In 1915, Dean Howes of the College of Agriculture in Edmonton selected an extremely early variety of corn that was capable of maturing and forming grain as far north as Fort Vermilion. In 1919 this variety was named Howes' Alberta Flint. Soon after a bulletin was printed describing its adaptability in these words: "It must be apparent that this variety of corn possesses extreme earliness. It has ripened corn every year at Edmonton during each of the last nine years. It has also succeeded in ripening its grain under a wide range of conditions in the province of Alberta."

In 1924 James Murray, the District Agriculturist in Medicine Hat, published a bulletin entitled, "Corn Growing in Southern Alberta," in which he described cultural practices best suited to local conditions. In this bulletin he wrote, "Sufficient corn has been grown in the past five years in southeastern Alberta to demonstrate beyond reasonable doubt that corn is going to have an important place in a system of permanent agriculture for this region."

Dr. Freyman is a crop physiologist, Dr. MacDonald is a cytogeneticist, and Dr. Bole is a plant nutritionist at the CDA Research Station, Lethbridge, Alta.



Grain corn production is profitable and an attractive addition to cash crops enterprises in the irrigated areas of Alberta.

Yields of 8 tons of dry matter per acre have been attained on a field scale in certain areas of Alberta.

During these early years corn was harvested in a variety of ways. As mentioned the crop was often cut green and fed directly to "milch" cows. It was also stooked and fed as dry fodder during the winter. These stooks were often stacked with straw, which absorbed the surplus moisture from the corn stalks. In this way the straw was 'flavored' with corn and was "readily eaten by stock." Trench silos were fairly common in the province and they were filled after first putting the corn through a "cutting box." A few farmers ensiled corn without cutting and removed the crop with the aid of a "hay knife."

The ears on many of the early flint corns, such as 'Howes' Alberta Flint', 'Squaw', 'Dakota White Flint', and 'Gehn', were borne too close to the ground to be harvested satisfactorily with a corn binder. Gathering the ears by hand was a slow and tedious job, so these varieties were usually harvested by "hogging-off", "cattling-off", and even "sheeping-off." Varieties such as 'Quebec No. 28' and 'North-Western Dent' had ears at least 18 inches from the ground and were often harvested for grain, that was used locally as feed for livestock or poultry and was not considered a cash crop as it is today.

SEED PRODUCTION

Since only open-pollinated varieties were grown, most of the seed was produced in Alberta. On this subject James Murray wrote: "It is only by saving seed from year to year of desirable types of corn that mature in Alberta that we can hope to secure the strains and varieties best suited to our conditions. Home-grown seed of strong vitality is better than imported seed and commands a higher price."

In the early twenties, corn was very popular in Alberta and by 1924 the first Corn Growers' Association was formed in Milk River. Alice Campbell in her book, "The Milk River Country," wrote the following: "The perseverance of one person can often change the course of general opinion. No one thought that corn could be grown successfully in the Milk River district until Charlie Oeder proved it. He was convinced that soil and climate were right for it. He grew corn successfully. He urged his neighbours to grow corn. Then the Association outgrew Milk River and the Milk River Corn Show became the nucleus of the Southern Alberta Winter Seed Fair. Through Mr. Oeder's efforts a lasting benefit was brought to the district."

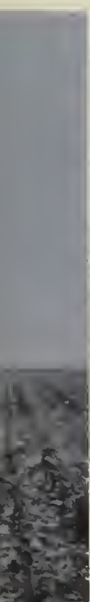
In 1911 there were 700 acres of corn grown in Alberta. The acreage increased each year, with spectacular jumps in the early twenties; in 1920 there were 7,000 acres, in 1921–15,650, in 1922–54,000, in 1923–67,500, and in 1924 the acreage reached a high of 73,700. After that, the acreage devoted to the crop began to decline and by 1940 less than 2,000 acres were grown in the province. Reasons for this decline are not known.

RENEWED INTEREST

The recent revitalization of interest in corn in Alberta is due to a number of factors:

- The instability of overseas wheat markets.
- The existence of an excellent grain corn market in western Canada. This makes corn a valuable addition to the cash crops (sugar beets, potatoes, vegetables) grown on a limited acreage in the irrigable areas of southern Alberta.
- The demonstration, through an economic study, that grain corn production is profitable.
- The availability of suitable hybrids for silage and grain production in certain areas of Alberta.

In 1924, 73,700 acres of corn were grown in Alberta.



Grain corn receiving and drying stations have been established at two locations in Alberta.

- The ability of corn, as an irrigated silage crop, to yield considerably more dry matter per acre than small grains.
- The intensification of the beef industry in southern Alberta and the introduction of a new beef grading system.
- The increase in the price of feed grains.
- The availability of information on corn hybrids and cultural practices suited to the unique conditions of southern Alberta.
- The availability of harvesting equipment and the establishment of a central receiving and drying station.

The CDA Research Station at Lethbridge, the Alberta Corn Committee, the Plant Industry and Extension Divisions of the Alberta Department of Agriculture, and commercial enterprises have played an active role in this renewed interest in corn.

RESEARCH PROGRAM

Conditions in southern Alberta are unlike those found in other corn growing areas of the world. Consequently, a vigorous research program to establish commercial production at a profitable level is underway at the Lethbridge Research Station.

In 1970 the Alberta Corn Committee published a corn heat unit map of Alberta that delineates areas suitable for grain and silage production in the province. With the hybrids now available, corn can be successfully grown for grain in areas with 2300 heat units or more per season. In the 2300 heat unit area, there are approximately 250,000 acres of irrigated land, about one-third of which is available for corn production.

Since 1970, a list of hybrids recommended for the various heat unit areas has been prepared annually by the Alberta Corn Committee on the basis of hybrid trials conducted by the Lethbridge Research Station at four locations in southern Alberta.

Other phases of corn research conducted by the Lethbridge Station include physiology, culture, weed control, and breeding.

PHYSIOLOGY AND CULTURE

Studies underway are aimed at providing information on time and depths of planting, planting patterns and densities, fertilizer requirements, water use under various planting densities and irrigation systems, tillage methods for various crop rotations, and chemical stimulants to hasten germination and seedling growth.

The main concern at Lethbridge has been with the control of annual weeds in corn using chemicals that have limited or no residual effects and allow production of a wide range of crops on irrigated land.

BREEDING

The main emphasis in breeding grain corn at Lethbridge is to develop an early maturing corn for irrigated land in the 2200-2300 heat-unit area. Selections are being made for good growth at low soil temperatures in the spring, good stalk strength, maturity by September 1, high bushel weight, and high individual plant yields. Selections also are being made for tillering-type silage corn and corn for dryland in the 2200-2300 heat-unit area. Dr. L. S. Donovan at Ottawa and J. Giesbrecht and Morden have contributed material to this breeding program.

THE ALBERTA CORN COMMITTEE

The Alberta Corn Committee was formed in 1970 and comprises interested persons from the CDA Research Station, the Alberta Department of Agriculture, industry, and the growers. Its purpose is to test corn hybrids and recommend those suited to various areas of Alberta and generally to encourage and promote the corn industry in the province.

In encouraging corn production, the committee has been involved in numerous activities: making available on a rental basis the first cornhead equipped combine in Alberta, arranging for drying equipment, publishing a guide to corn production in Alberta, organizing tours and conventions, acquiring the services of an experienced grower to assist other producers, and submitting briefs to government agencies that identify developmental problems and suggest solutions. As a result of these briefs a central receiving and drying station has already been established at Taber and an incentive grant to grain corn growers will be made available for four years starting in 1973. The grant is intended to defer the costs of putting into production a new crop and the risks involved due to a lack of experience of new growers.

WHAT IS IN STORE FOR THE FUTURE?

A market for Alberta grain corn exists. International Distillers currently building in Lethbridge will have a requirement of 800,000 bushels per year. Distillers in British Columbia use over two million bushels a year; while 250,000 bushels are used in high energy feeds. Consequently, British Columbia imports close to three million bushels annually from the United States. Hopefully, Alberta corn growers will be given the opportunity to supply this market in the not too distant future.

The acreage of silage corn will probably increase more rapidly than that of grain corn. The number of beef cattle in the irrigated areas of southern Alberta is increasing rapidly. Corn has a distinct advantage over other silage crops for beef production.

With the cooperation of researchers, extension personnel, commercial enterprises, and other farmers, growers will gain confidence in the crop and will find it profitable to grow. Consequently, grain corn production should increase to about 60,000 acres while silage corn production should increase to 100,000 acres in the near future. ■

RAY F. MORRIS and
K. G. PROUDFOOT

THE GOLDEN NEMATODE

Le nématode doré, vers minuscule qui attaque et se nourrit des racines de pommes de terre et de tomates, fut trouvé pour la première fois à Terre-Neuve en 1962. Il était présent dans 78 communes, la plupart du temps dans de petits jardins mais rarement dans les fermes commerciales. Il n'a pas été trouvé au Labrador.

Le nématode n'a pas d'influence économique sur la production commerciale des pommes de terre à Terre-Neuve. Le véritable danger est qu'il peut être apporté aux principales régions productrices de pommes de terre ailleurs au Canada. Des quarantaines strictes appliquées par la Division de la protection des végétaux cherchent justement à l'éviter.

Des recherches sont menées afin de mettre au point des variétés résistantes, pour évaluer les variétés des États-Unis et d'Europe, pour évaluer l'effet des rotations sur les peuplements de nématodes et pour la lutte avec des nématocides.

The golden nematode, a tiny wormlike animal that attacks and feeds on the roots of potato and tomato, was first discovered in Canada in Newfoundland in 1962, and on Vancouver Island, British Columbia, in 1965. It was found in Great Britain in 1851 and at Long Island, New York, U.S.A. in 1941. It is prevalent in Europe.

Research Scientists, C.D.A. Research Station, St. John's West, Nfld.

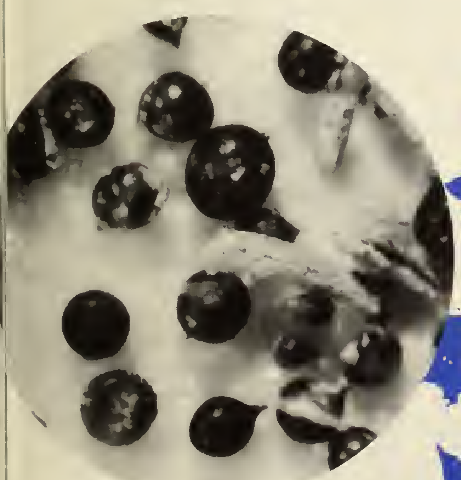


Fig. 1. Cysts of the golden nematode, each containing from 50 to 250 eggs. Cysts may contain viable eggs in nature for periods of up to 15 years.

Surveys show that the golden nematode is now widely distributed in Newfoundland and of the 7505 soil samples examined, 299 contained golden nematode cysts. The soil in 78 communities was infested, but the golden nematode has not been found in either the important potato producing areas of western Newfoundland, or in Labrador.

The golden nematode is of little economic importance in Newfoundland commercial potato production. This favourable situation is due to two factors: (1) It is generally found only in small backyard gardens, and (2) low soil temperature and high moisture conditions limit maximum infestations. Its real economic importance lies in the hazard of its possible accidental transport from Newfoundland to the important potato producing areas of Prince Edward Island and New Brunswick. To prevent this, the C.D.A. Plant Protection Division inspects all cars, trucks and earth moving equipment leaving Newfoundland, and the movement of potatoes, burlap bags, soil, and all plant material with soil-infested roots to other areas of Canada is strictly prohibited. In addition, all cars and trucks leaving Newfoundland via Port aux Basques are thoroughly washed before departure.

LIFE HISTORY

Life history studies of the golden nematode were conducted in a heavily infested area at Cupids, Newfoundland. Invasion of potato rootlets by newly hatched larvae from overwintering eggs within female cysts occurred during the last week of June. At this time the weekly mean maximum soil temperature at 7.6 cm. was 15.2°C. Initial infestation was followed by a gradual build-up, and mass invasions occurred from mid-July to early August. Nematode activity was closely related to soil temperature and moisture, while maximum hatching and movement occurred in soil pores that had just drained of water. The life cycle was completed in 50 to 58 days and there was only one generation per year.

TOLERANCE TESTS

Field tests conducted at Cupids from 1964-1966 to determine the effects of varying concentrations of nematodes, (8.0, 4.0, 2.0, 1.0 and 0.5 cysts per gram of soil) on Arran Victory and Urgenta potatoes showed no significant differences in foliage height and weight or in the root and tuber weight between the infested and the check plants. The number of cysts recovered from plants grown in soil infested with 0.5 and 1.0 cysts per gram of soil increased threefold while the count in plants infested with 2.0 and 4.0 cysts per gram of soil, doubled. In most cases there were no changes in populations infested at the 8-cyst level.

Both the Arran Victory and Urgenta varieties were very tolerant to golden nematode attack. Urgenta was grown each year from 1963 to 1969 without a crop failure, although a total cyst count of up to ten per gram of soil was regularly recorded. It is felt that the tolerance of the Urgenta variety to high nematode populations at Cupids and the external factors of suitable soil temperature and adequate moisture were conducive to sustained yield.

Since potato crops in Newfoundland are only slightly reduced and seldom destroyed by the golden nematode, our research results are difficult to interpret. The fact that after nine years of potato monoculture in rotational studies at Cupids a total yield of 468 bu/acre was obtained indicates the insignificance of this pest in Newfoundland compared with the problem it presents in other countries. The ability of the potato plant to produce under a high density of nematodes also makes the interpretation of chemical control experiments equally difficult (Table 1).

CONTROL

The use of chemicals to control golden nematode has been investigated for many years, mostly with soil fumigants such as DD, which depended for their effectiveness on gaseous diffusion through the soil. Best results were obtained when soil temperatures were above 60°F. and the soil was fairly moist.

More recently, chemicals having insecticidal and nematicidal properties have been tested as possible control agents for golden nematode. One such chemical, DPX 1410, has a broad margin of safety for many crops and because of its systemic activity has been tested as soil, foliar and seed treatments.

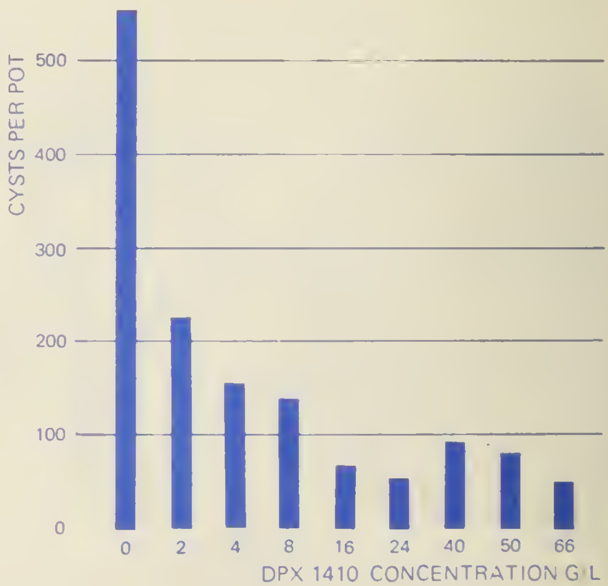


Fig. 2. Effects of dipping potato tubers in DPX 1410 on golden nematode cyst production.

TABLE 1. NEMATICIDE TREATMENTS, AVERAGE CYSTS PER GRAM OF SOIL BEFORE PLANTING AND AFTER HARVEST, HEIGHT OF FOLIAGE AND TUBER YIELDS AT CUPIDS, 1971.

		Ave. cysts gm/soil			Ave. foliage Hgt.''	Ave. Yield Lbs. 30' row		
Treatment	Rate	Spring	Fall	% increase	30-8-71	Large	Total	% Large
DPX 1410 E.C.	2 lb. Seed piece dip ½ lb. ai/gal.	12.2	19.0	56	38.0	18.8	45.2	41.5
DPX 1410 10G.	1 lb. ai/A.	10.0	11.5	15	35.9	22.2	47.6	46.5
DPX 1410 10G.	3 lb. ai/A.	11.0	13.9	27	36.0	17.8	46.0	38.8
DPX 1410 10G.	6 lb. ai/A.	11.2	13.4	20	37.3	22.0	48.5	45.2
Mocap 10G.	3 lb. ai/A.	11.0	16.9	54	37.1	19.9	46.6	42.2
Mocap 10G.	6 lb. ai/A.	10.2	15.3	50	38.6	18.8	47.2	38.5
Lannate 90 W.P.	6 lb. ai/A. (Spray 16 July)	9.6	16.7	74	38.3	21.0	45.4	46.2
Control		10.0	15.1	51	35.5	16.9	41.8	40.2

Fig. 3. The authors examining a potato seedling for nematode cyst formation in a greenhouse control experiment.

TABLE 2. EFFECTS OF DPX 1410 SEED PIECE DIPPING ON TUBER YIELD AND GOLDEN NEMATODE CYST PRODUCTION.

Treatment	Total cysts recovered/ 100 gms soil	Estimated new cysts formed	Tuber yields gms./plant
Water only	73	52	54
50 a.i.g/litre	27	6	46
100 a.i.g/litre	21	0	0

DPX 1410 as a seed piece treatment at the rate of 100 a.i.g./litre caused phytotoxicity and the seed pieces failed to produce plants (Table 2). At the 50 a.i.g./litre rate no plant phytotoxicity occurred and yields were only slightly less than those of the control. The reduction of new cysts formed was significant and a further experiment was undertaken to investigate other concentrations of DPX 1410.

Dipping tubers in DPX solution produced significantly fewer cysts than the control. With increasing concentration of DPX the number of cysts declined markedly though not uniformly. Differences in tuber yields between treatments were not significant. Liquid treatments for the control of fungal or insect pests are not widely used, but seed piece dusts for the control of fungal diseases (e.g. fusarium seed-piece decay) are now recommended. Investigations into the use of granular DPX 1410 with a fungicide to give combined control of fungal and nematicidal pests have been initiated.

Seven nematicide treatments were field tested at Cupids in 1971 (Table 1). There was an increase in cyst numbers in all treatments at harvest. DPX 10G at 1, 3 and 6 lb. ai/A had the lowest % cyst increase and all treatments suppressed nematode cyst buildup. Mocap 10G at 3 and 6 lb ai/A, Lannate 90 W.P. as a foliar spray and DPX as a seed piece dip treatment were ineffective. Foliage height was slightly greater in all treatments but did not differ significantly from the control. Total and large size tuber yields for all treatments were greater than the control. Total and large size tuber yields for all treatments were greater than the control but were not statistically significant. With two exceptions, the percent large tubers was slightly higher for all treatments.

Present control recommendations include:

1. Plant only certified or Newfoundland approved seed potatoes.
2. Disinfect equipment before moving from infested to clean areas.
3. Practise crop rotation.
4. Plant only a resistant variety such as Wauseon or Peconic in infested areas.
5. Plant early and fertilize well.
6. Report suspected fields to the nearest Plant Protection Officer or Agricultural Fieldman.

FUTURE RESEARCH

The development of potato varieties resistant to the golden nematode is now in progress at St. John's and resistant varieties from Europe and the United States will be evaluated by the Research Station as they become available.

Rotational studies started in 1964 will be continued until 1975 to obtain base line data for use in determining the frequency with which potatoes can be grown in infested areas under Newfoundland soil and climatic conditions.

Nematicidal trials, both greenhouse and field, will be continued using the most promising materials available. In this regard, a close liaison is maintained with the Nematology Section, Research Station, Vineland. ■

Figure 1. A - Near infrared color, B - near infrared black and white and C - black and white (green band) photographs showing the study area, while the distribution of peat landforms, vegetation, organic soils and permafrost is shown on the map.

A

B

APPLICATION OF REMOTE SENSING TECHNIQUES TO RESOURCE INVENTORIES

C. TARNOCAI and G. J. BEKE

S'appuyant sur les données fournies par la photographie aérienne et le satellite d'étude des ressources terrestres (ERTS) lancé dernièrement (qui transmet des données multispectrales sur les caractéristiques de la surface terrestre), l'Inventaire des sols du Canada (pour lequel le ministère de l'Agriculture fournit du personnel et d'autres ressources) effectue actuellement une étude afin de déterminer si la rapidité des techniques de télédétection est suffisante pour l'inventaire des ressources essentielles, c'est-à-dire le sol, la végétation et le terrain.

The growing population and rising standard of living are increasing the demands on our natural resources. This requires more effective management and more accurate resource inventories.

Until 15 or 20 years ago, such inventories were carried out almost entirely on the ground. More recently aerial photographs have improved the accuracy and efficiency of taking resource inventories. A new technique of remote sensing is carried out simultaneously in several wavelength bands of the electromagnetic spectrum. In its broadest sense, this remote sensing ranges through the spectrum, from the very short wavelengths at which gamma rays are emitted, through the intermediate wavelengths of the visible and thermal infrared, to the longer wavelengths at which radar operates. In this way one can collect much more information about an area than can be obtained with conventional photography which is limited to the visible spectral band.

The authors are soil surveyors at Agriculture Canada's Research Station, Winnipeg, Man.

The Manitoba-Agriculture Canada Soil Survey has carried out studies in the past two years to determine the potential of this new technique for conducting resource inventories, specifically in its application to soil, vegetation, and terrain. Multispectral remote sensing data in the visible, near infrared and thermal infrared were obtained by use of low-, medium- and high-flying aircraft at several locations in Manitoba. The results of these studies, with examples, are very briefly discussed to illustrate the potential of this new technique.

Panchromatic black and white aerial photography is widely used in soil surveys to provide good stereoscopic images and good patterns related to drainage and vegetation boundaries. Remote sensing data obtained from the near infrared and the thermal infrared regions, however, provides additional or new soil information to that discernable on the visible band. Thus a trained image analyst can separate certain land, soil and vegetation features with greater confidence by use of the multispectral data.

This was demonstrated by a study carried out in central Manitoba where near infrared imagery provided a great deal of new information about vegetation and was especially useful in vegetation type rec-

C

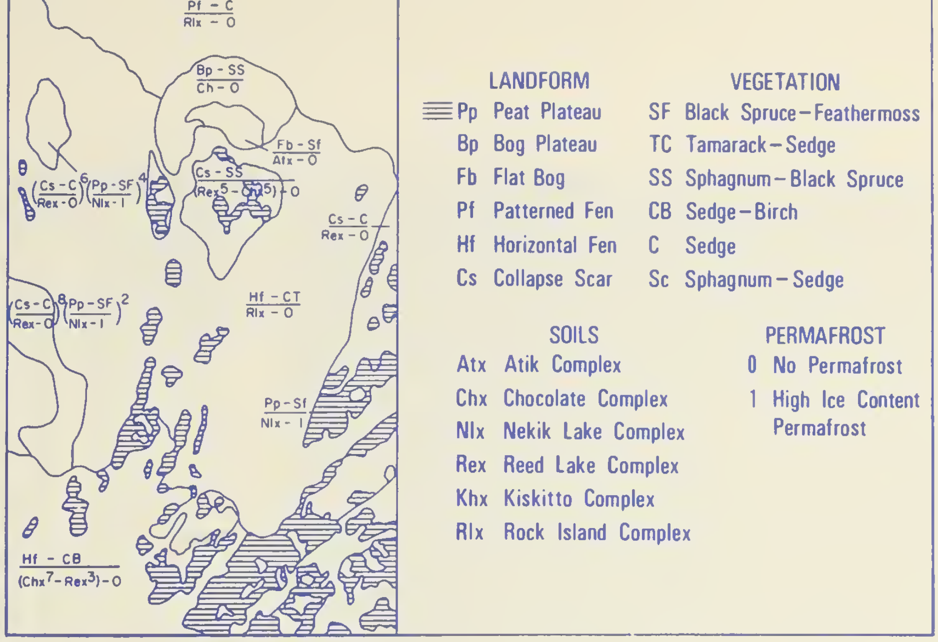
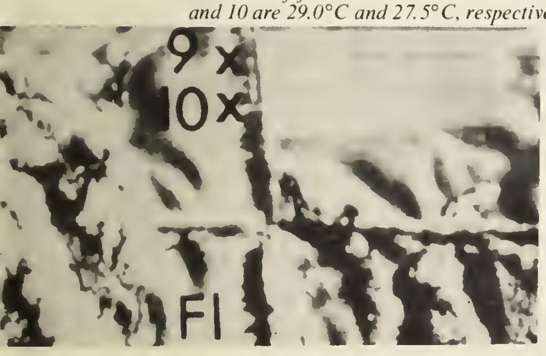


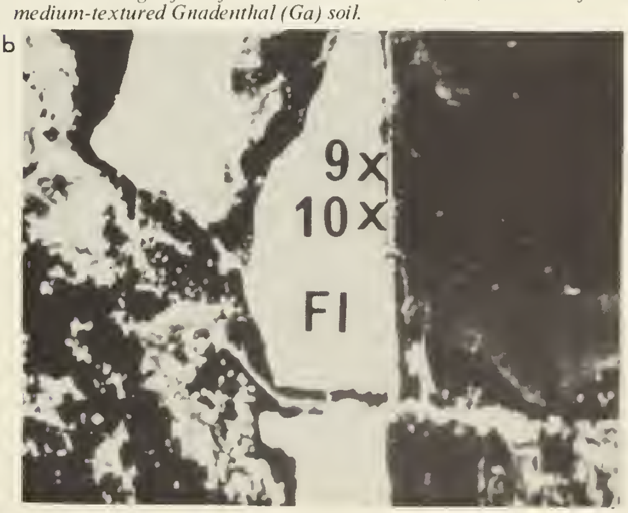
Figure 2. (Top) Thermal infrared imagery (3.0-5.0 μ) showing the effect of relief as substantiated by ground truth data obtained from Site 9 (south aspect) and Site 10 (north aspect). In Figure 2a (AM flight), where the relief features are distinct, Sites 9 and 10 have soil temperatures of 10.0°C and 7.0°C. In the PM imagery (Figure 2b), where relief features are "washed out", soil temperatures for sites 9 and 10 are 29.0°C and 27.5°C, respectively.

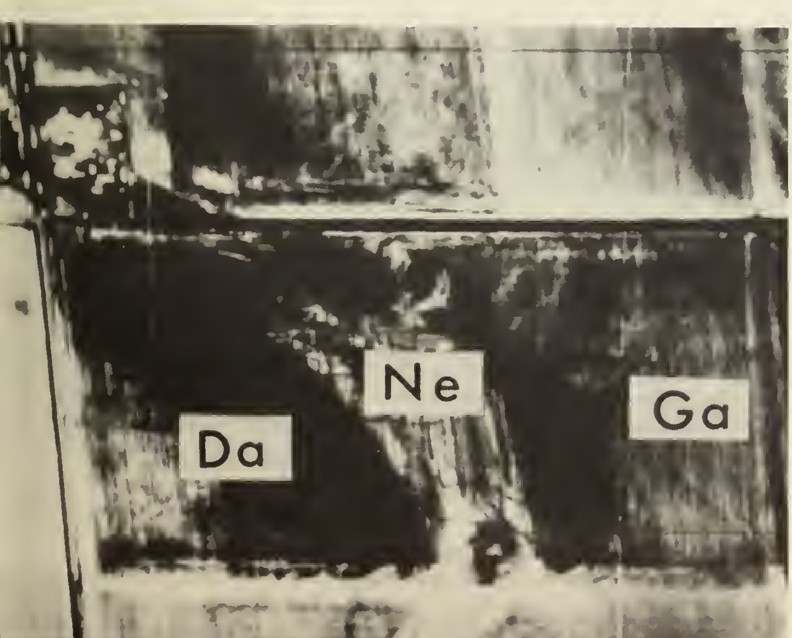
Figure 3. (Bottom) The stratification of geological materials in the Neuhorst (Ne) soil is evident on Figure 3a; i.e. the thermal infrared imagery (3.0-5.0 μ); but is indistinct on the panchromatic black and white imagery (Figure 3b). There appears to be no distinction between the image of the fine-textured Deadhorse (Da) and that of the medium-textured Gnadenthal (Ga) soil.



2a

2b





3a

3b

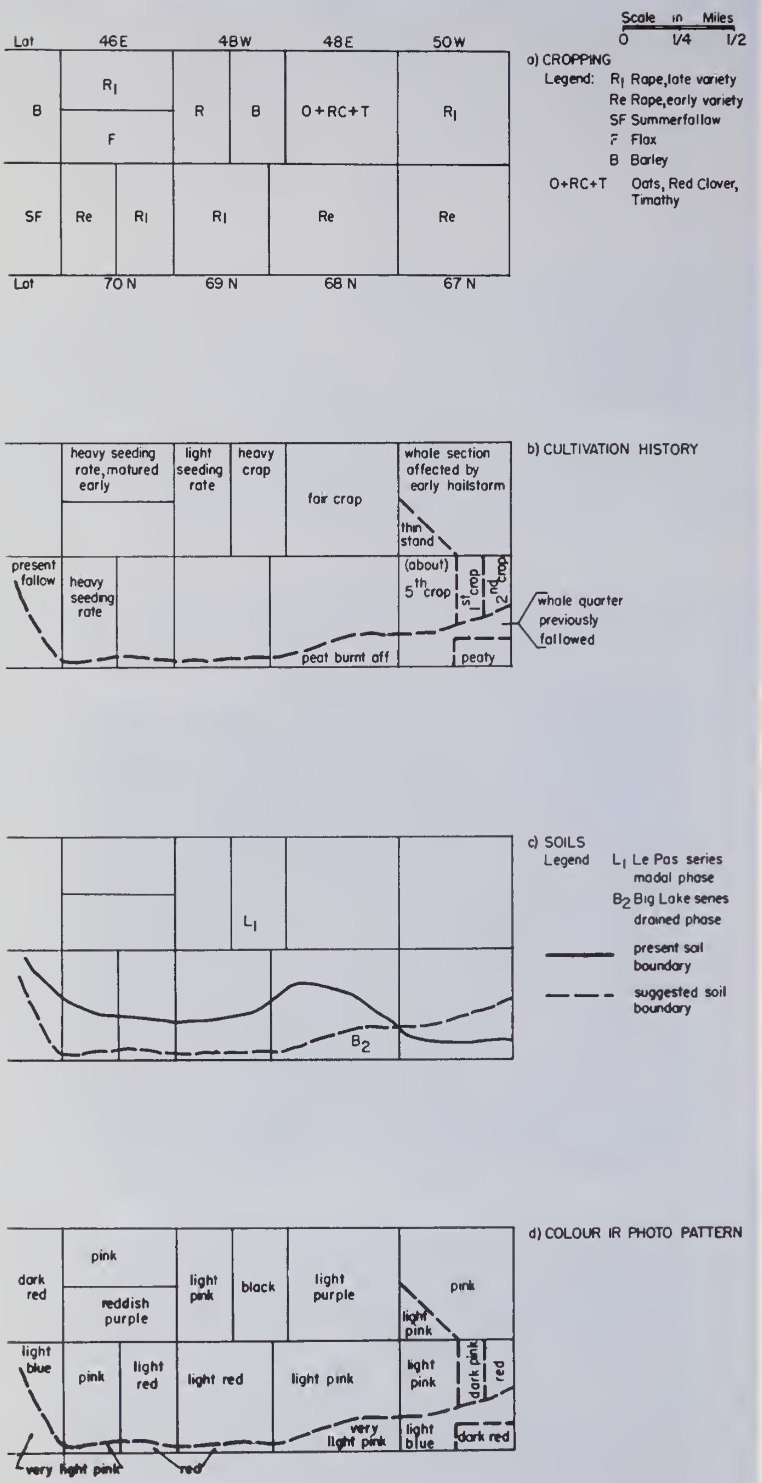


Fig. 4. Color IR photo-pattern and ground truth data of a selected area in the Pasquia Land Settlement Project.

ognition. This species recognition is very important in the identification of different soils because of the close relationship between soil and vegetation. The results of this study are shown in Figure 1 where all the data obtained by use of multispectral photography were combined into a final map.

Soil information can be interpreted more directly from remotely sensed data when dealing with bare soil, than when land is covered by vegetation. All the forms of photographic imagery provide information of sorts on soil distribution, as seen from landform and drainage patterns. Thermal infrared scanning is, however, more specific to land surface and soil conditions than the photographic sensing methods. Hence, microrelief characteristics and certain soil features such as material stratification and salinity, may become evident, provided the imagery was obtained at the proper time. The effect of relief on thermal infrared imagery is illustrated in Figure 2[1]. Such signatures may be due also to a drastic change in soil texture. Evidently, soil conditions at flying time were not satisfactory to differentiate between the (Figure 3) particle size composition of Deadhorse (fine textured) and Gnadenthal (medium textured) soils. Figure 3 does illustrate a noticeable difference in response of the soil with the thin, moderately fine textured lacustrine deposit underlain by sandy sediments, as compared to the dominantly medium textured soil to the east or the fine textured soil to the west[2].

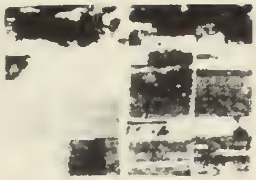
Remotely sensed data not only provide information on the present status of the natural resources, they also reflect land use and management practices. A case in point is the delineation of land areas under fallow. This was most effectively identified by the near-infrared black and white photography. Color infrared photography, on the other hand, provided more useful information on how the fallow land was being managed. Variations in the characteristic blue image of fallow fields having similar soil textures and drainage, tended to reflect the time lapse since the last cultivation. In other words, the more recent the cultivation of a field, the darker blue the image on the false color photograph.

The vegetation signatures on aerocolor and color infrared imagery also contained information with respect to present and past management practices. Thus, a fertilizer experiment conducted for remote sensing purposes by the Department of Soil Science, University of Manitoba, showed that a fertilizer application of 90 lbs N + 40 lbs P_2O_5 per acre gave a darker green image on aerocolor photography than an application of 90 lbs N per acre, or of 40 lbs P_2O_5 per acre, or no application of fertilizer. Within a soil mapping unit, cropping after fallowing provided a darker hue of green on the aerocolor or red on the

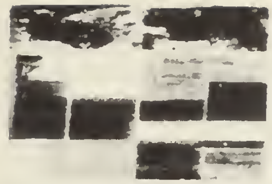
[1]G. F. Mills, Manitoba Soil Survey, personal communication.

[2]W. Michalyna, Canada-Manitoba Soil Survey, personal communication.

Figure 5. Digitized multispectral scanning data showing the five most useful bands for automated crop identification. The final classification is shown on this computer printout where: O indicates oats; C, corn; W, winter wheat; F, forest; P, pasture; H, hay; S, soybeans; and X and I indicate fallow land and bare soil, respectively.



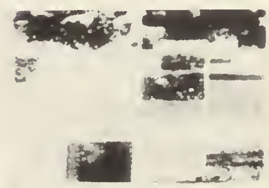
0.52 - 0.57 μ



2.00 - 2.60 μ

1.00 - 1.40 μ

9.30 - 11.70 μ



0.61 - 0.71 μ

color infrared imagery, than successive cropping. On the other hand, cropping after green manuring produced a darker color hue than when cropping succeeded fallowing. Also, the signature of an annual crop became progressively lighter in color with increase in the length of time of continuous cropping. Variation in seeding date of a particular crop within a field resulted in a lighter image for the more recently seeded crop. Variations in color hue within a field in the areas under study were also attributable to weed infestation, to soil drought, and to spring flooding. Certain of these management and environmental influences are illustrated in Figure 4.

All of the above remote sensing data was interpreted by trained image analysts with their knowledge of the spectral response of each wavelength band. Studies indicate, however, that remote sensing data can be interpreted by high speed computers utilizing multispectral data. In short, this entails that the data are stored on magnetic tape in digital form. The computer statistically analyzes these data by what is known as the pattern recognition technique, which is based on the premise that similar crops, soils or other objects, have similar spectral signatures. In the course of the pattern recognition process the computer statistically analyzes and classifies these signatures and then provides a print-out (Figure 5).

It is necessary to remember that remote sensing is still in the adolescence stage. New sensors, platforms and interpretation techniques are being developed daily. The recent launch of the Earth Resource and Technology Satellite (ERTS) represents a big advance. This unmanned satellite covers every area on the earth's surface once every 18 days and transmits multispectral information obtained back to receiving stations on earth. This introduces a new dimension in remote sensing—namely, time. One can now observe such things as change of crops due to maturing, leafing of trees in the spring, soil moisture patterns due to rain and changes in management practices. All of this information is extremely useful to the study of the earth's natural resources. This rapid data gathering will result in more accurate and up-to-date inventories for land managers and thus, more effective management of our natural resources. ■

WHEAT SPINDLE STREAK MOSAIC

J. T. SLYKHUIS and D. J. S. BARR

La mosaïque-bigarrure fuselée du blé est causée par un virus transmis par le sol et qui se développe dans les champs fréquemment semés en blé d'hiver. Bien que la maladie passe généralement inaperçue, elle abaisse le rendement total en blé des principaux comtés producteurs de 3 à 5%.

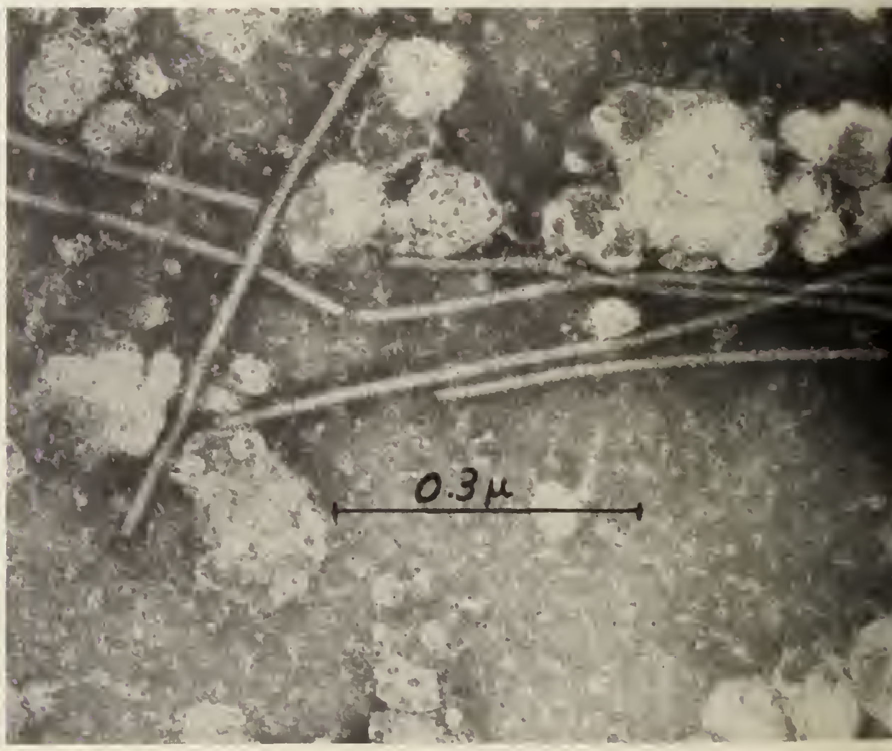
Spindle streak mosaic of wheat, caused by a virus harbored in the soil is under investigation at the Ottawa Research Station. This disease builds up in the soil where wheat is grown frequently. It suppresses yield on much of the best wheat land in ontario. We must learn to control it if we are to achieve maximum yields of wheat in Ontario.

SYMPTOMS

Wheat spindle streak mosaic is first evident on winter wheat when plants resume growth in the spring. Affected fields develop yellowish brown patches in early May. Excess moisture in the soil or lack of nitrogen in cool soils can cause yellowing of wheat in the spring, but the disease is distinguishable because the yellowing results from a mosaic pattern of short yellowish streaks with tapered ends. As the yellow streaks increase, the areas of green on the

Dr. Slykhuis is a virologist at the CDA Ottawa Research Station, and Dr. Barr is a mycologist at the CDA Plant Research Institute, Ottawa.

Fig. 1. Two healthy and two diseased plants with wheat spindle streak mosaic, three months from seeding, were grown in the same pot of infectious soil in a growth cabinet at 50°F. Note the reduced growth of the main shoot, lack of development of secondary tillers, the chlorosis and drying out of all except the youngest two leaves of the diseased plants.



leaves diminish, and older leaves die. However, if the weather warms up quickly in May and early June, the new growth appears greener and the plants seem to recover. Only light green to faint yellow dashes develop in the newer leaves. Despite the apparent recovery, the yields of affected plants are reduced.

DISCOVERY IN ONTARIO

Although recognized only in 1957, the disease must have been present throughout southern Ontario for many years. At first it was believed to be caused by a strain of the soil-borne wheat mosaic known in Illinois, and some other parts of the U.S.A. since 1919. The virus was found to be quite different, however.

Since its discovery, the disease has been most prevalcnt in the major wheat producing counties of Essex, Kent, Elgin, Lambton, Middlesex, Huron and Simcoe. In 1961 and 1967, nearly 2/3 of all the wheat surveyed in southern Ontario had mosaic symptoms.

Fig. 2. (Right) Pairs of the four youngest leaves from two diseased wheat plants. Note that one of the youngest leaves (left) is symptomless, the other has light green, spindle-shaped dashes near the tip. The second youngest leaves have spindle-shaped streaks throughout; the third and fourth pairs have light yellow mosaic with dashes, blotches and patchy areas of light-colored dead tissue.

Fig. 3. Wheat spindle streak mosaic virus particles from leaves of diseased wheat, appear like pieces of thread when photographed by the electron microscope. The unbroken particles are about 1/9000th of an inch long.

In some fields, all the plants have been diseased. It has not been found in areas where winter wheat is grown only occasionally, or in fields where wheat is not grown more than once in eight years.

The same disease is now known to occur in the neighboring states of Michigan and New York. Possibly it may also occur undetected in some other areas.

THE CAUSE

The wheat spindle streak virus is one of the few plant viruses known to be harbored in the soil. Under the electron microscope the particles appear thread-like. Almost 3000 nanometers in length, they are among the longest particles known as a plant virus. It would require more than 9,000 of them, lined end to end, to measure one inch.

We do not know exactly how the virus is harbored in the soil or how it gets into the roots of plants, but there are strong indications that it is carried by a soil fungus. We believe that the virus occurs in the cytoplasm within the resting spore of the fungus. When the fungus spore germinates it releases zoospores that appear much like sperm. They swim in the films of water surrounding the soil particles, carrying the virus with them. They attach themselves to the roots of a wheat plant, then penetrate the plant cell either by producing root-like structures, or by extruding their cytoplasm into the plant cell. We are studying four such zoosporic fungi which frequently occur on winter wheat in Ontario. Two of these have previously been reported as vectors of other plant viruses.

An unusual characteristic of this virus is its low-temperature requirement—the lowest for any known plant virus. It infects the roots of plants in October when the soil temperatures are 45° to 60°F. In experiments in temperature-regulated growth cabinets, some infection has occurred at 64°F, but not at 68°F. Symptoms do not appear in the fall, and because temperatures are too low, there is no development of the disease in the field from November to April. As temperatures rise from 45° to 60°F in late April and early May, and wheat growth resumes, infected plants may develop the yellow mosaic pattern. A long period with temperatures at 45° to 60°F favors the disease. However, if temperatures rise quickly above 60°F, symptoms may not develop. Even if the mosaic becomes very pronounced in early May, the plants will appear to recover in early June if the weather becomes very warm. Development of this disease can vary greatly depending on the temperature in the springtime.

MODIFIED CLIMATE

The disease develops most consistently in fields along the north shore of Lake Erie where the water influences temperature, providing long periods in the fall and spring between 45° and 60°F. Even though plants become infected in October, mosaic symptoms do not develop in most locations in years when a spring thaw is followed by a rapid rise in daily mean temperatures above 60°F.

EFFECT ON YIELD

In addition to the discoloration of leaves, and moderate stunting of plants, wheat spindle streak mosaic causes a reduction in the number of heading tillers and in the number and plumpness of kernels.

Actual losses have been difficult to measure. Yield comparisons of diseased and apparently healthy areas in fields have indicated losses in yield ranging from 5% to 41%. Yield of some fields with severe mosaic has sometimes been 25% to 50% lower than expected for a healthy crop on the same land.

Dr. L. F. Gates of the Research Station, Canada Department of Agriculture, Harrow, Ontario, found that wheat spindle streak mosaic was present on an average of 49.6% of the plants in winter wheat fields surveyed in Essex and Kent Countries in 1967 and 1968. The average loss in grain yield for the two years was estimated at 5%.

In 1969 and 1970, years of mild incidence, Dr. W. C. James, Crop Loss Section, Ottawa Research Station, estimated yield losses in wheat at 3% for Ontario.

The above estimates are probably conservative. Certain tests have shown that significant yield losses also occur in wheat that becomes infected, even if it does not develop symptoms in the spring.

CONTROL

This disease would probably disappear if wheat was not grown more than once in eight or more years in any field. However, this rotation is much longer than desirable in intensive wheat-producing districts.

Most common cultivars of wheat are susceptible. Some unnamed lines and new cultivars possess a high degree of tolerance. These include the unlicensed cultivar Blue Boy from the U.S.A., and the new cultivar Fredrick which originated at the Ottawa Research Station.

Heavy rates of nitrogen fertilizer including poultry manure, applied before seeding, delay and sometimes prevent infection. The fertilizer apparently suppresses the action of the virus carrier temporarily. However, the rates required are so high they reduce the yield as much as the disease.

Certain chemicals, including fungicides, some fumigants and heat treatments, can be used to disinfect soil. At present these are too expensive and difficult for practical application.

There is hope that special uses of crop residues or systemic fungicides used as seed treatments may be found to prevent infection of seedlings during the critical period after seeding in the fall.

Progress is slow, but we have learned much about this disease which was undetected a few years ago. There is still much to be learned, but learn we must if we wish maximum yields of wheat in Ontario. ■

QUAND FAUT-IL SEMER LA LUZERNE?

The following two articles show the results on yield and population of early seeding and rate of seeding for two varieties of Alfalfa, Vernal and Alfa, in Quebec soil and weather conditions.

L. BELZILE, R. RIOUX

A la Ferme expérimentale de La Pocatière nous tentons de déterminer la période la plus propice à l'établissement d'un semis de luzerne dans la région. Le rendement de l'exploitation agricole tout entière augmente d'autant plus que l'on lutte contre l'emploi inefficace des ressources. Il importe donc de semer au taux le plus bas possible et au moment le plus propice. Le rendement d'un champ de luzerne traité aux herbicides et semé sur préparation d'automne pendant la première année et celui des années suivantes a été l'objet de nos travaux. Les travaux de la ferme sont parfois pressants, parfois moins exigeants, aussi nous avons étudié également la possibilité d'effectuer les semis de luzerne en fin d'été comme au printemps.

Pour cet essai nous avons semé trois variétés de luzerne pure (deux seulement servent à illustrer les résultats) Alfa, Vernal et Narragansett en rangs, sans plante-abri sur un sol argileux (Kamouraska) préparé à l'automne de l'année précédente. De l'Eptan a été incorporé au sol avant chaque semis pour combattre les mauvaises herbes. Les semis ont été effectués à 15 jours d'intervalle dès que le sol a été suffisamment ferme pour supporter la machinerie et au mois d'août dès le 1er jour. Les taux de semis furent de 6 lb/a, 12 lb/a et 18 lb/a (6,7 kg/ha, 13,4 kg/ha et 20,1 kg/ha).

Les résultats indiquent que ce sont les semis de printemps aux environs du 10 mai qui donnent les

MM. Belzile et Rioux sont des agronomes à la ferme expérimentale de La Pocatière (Québec). M. Belzile est un spécialiste en culture fourragère tandis que M. Rioux se spécialise dans le contrôle des mauvaises herbes.

TABLEAU I. EFFET DU TAUX ET DE LA DATE DE SEMIS SUR LE RENDEMENT (2 COUPES) DE LA LUZERNE L'ANNÉE DE L'IMPLANTATION

	Semis printemps 1971 année sèche			Semis printemps 1972 année humide		
Variété	Date	Taux lb/a	Rendement lb/a	Date	Taux lb/a	Rendement lb/a
		6	4161		6	5047
	28 avril	12	4039	8 mai	12	5489
		18	3760		18	5497
		6	4692		6	4702
Alfa	12 mai	12	4753	18 mai	12	4573
		18	4569		18	4330
		6	3366		6	4913
	28 mai	12	3208	31 mai	12	4159
		18	3323		18	4343
		6	3476		6	4655
	28 avril	12	3840	8 mai	12	5038
		18	4286		18	5455
		6	3969		6	3831
Vernal	12 mai	12	3867	18 mai	12	3917
		18	4042		18	3807
		6	2180		6	4069
	28 mai	12	2705	31 mai	12	3847
		18	2925		18	3481

meilleurs rendements l'année de l'implantation et cela quelle que soit la température. Les semis du 12 mai 1971 année sèche et ceux du 8 mai 1972 année humide ont été les meilleurs (tableau 1). L'année suivante il existe peu de différence entre les dates; cependant l'effet positif de la meilleure date se fait encore légèrement sentir au mois d'août. La première date de semis donne la meilleure production (figures 1 et 2).

Seul le rendement de l'année du semis est quelque peu influencé par le taux de semis mais cet avantage est négligeable les années suivantes. Les taux de 6 et 12 lb/a semblent suffisants comme l'indiquent les figures 1 et 2.

La comparaison des résultats des meilleurs rendements obtenus des semis de printemps et des meilleurs de l'été indiquent que les premiers donnent en moyenne environ 1150 lb/a de matière sèche de plus que les derniers lors de la récolte de l'année suivante. ■

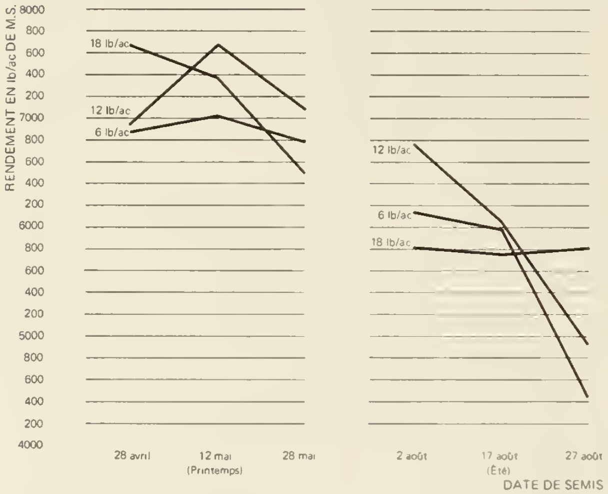


Fig. 1. Influence de la date et du taux de semis sur le rendement de la luzerne Alfa.

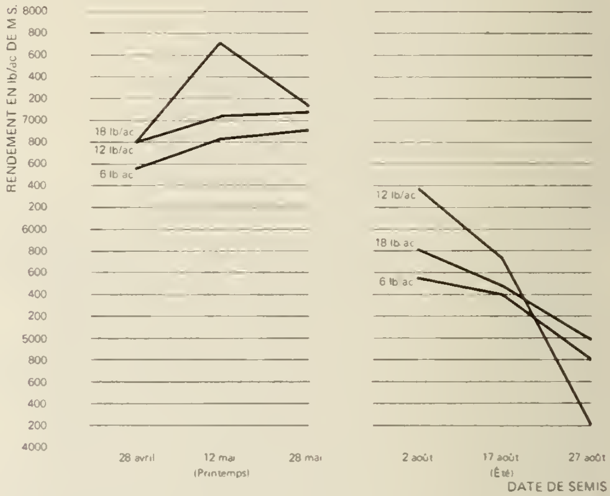


Fig. 2. Influence de la date et du taux de semis sur le rendement de la luzerne Vernal.

QUI VEUT ÉCONOMISER $581 DE LUZERNE?

M. JEAN GENEST

A la Station de recherche d'Agriculture Canada à Lennoxville nous avons compilé les résultats d'essais menés dans plusieurs fermes expérimentales du Québec.

Ces essais portaient sur le taux de semis de la luzerne. Nos essais sont concluants, les anciennes pratiques qui datent des années 50 ne sont plus valables avec la machinerie moderne et l'usage des herbicides. Un coup d'œil à la figure 1 montre bien que plus de 10 à 12 lb/a n'améliorent guère le rendement final en matière sèche.

Pour un champ de 50 acres semé au taux de 10 lb/a (au lieu de 24 lb/a) avec de la graine à 83 cents la livre c'est une économie de $581.00. Êtes-vous intéressé? Lisez bien!

Une livre de semence contient environ 227 000 graines. Étendue sur le terrain cela fait 5 graines/pied carré. D'autre part le meilleur rendement est obtenu avec 15 plants/pi^2 la première année et 6 à 8 plants/pi^2 les années suivantes. Il faut donc théoriquement 3 lb de luzerne par acre. Toutefois toutes les graines ne germent pas. Les conditions du sol, la température, les mauvaises herbes et même la plante-abri réduisent le rendement. Il faut donc pratiquement de 10 à 12 lb/acre de semences. Que l'on sème 10, 15, 20 ou même 100 lb/acre la densité ne

M. Jean Genest est un agronome spécialiste en culture fourragère à la Station de recherches de Lennoxville (Québec).

variera guère. Seul le nombre de plants en début de saison varie mais les rendements ne varient guère en fin de saison.

On peut faire de bons établissements de luzerne, de la mi-avril à la mi-août, toutefois le meilleur temps dépend de la région et du mode de semis. Là où les sécheresses estivales sont fréquentes, il ne faut pas semer après la mi-juin. Dans des cas spéciaux on pourra semer à la fin de la première semaine d'août. Les semailles d'été et d'automne se font sans plante-abri. Celles avec plante-abri se feront en mai.

Il est faux de parler de plante-abri puisqu'elle n'abrite guère mais surtout fait la lutte pour la lumière, l'eau et les éléments nutritifs avec la luzerne. Toutefois il faut dire que la céréale-abri ne fera que retarder la première récolte de luzerne et que souvent, la luzerne bien vivace sera de la même hauteur que la céréale au moment de la maturité du grain ce qui évidemment interdit la récolte de grain.

Le seul avantage de la plante-abri est de lutter contre les mauvaises herbes du début de saison.

Ceux-ci peuvent se faire en luzerne pure ou en mélange. Il est rare que les mauvaises herbes mettent en échec la luzerne mais il est quand même préférable de semer sur un terrain propre comme un retour de maïs pour obtenir de meilleurs rendements d'ensilage dès la première année. Le semoir à grain est fréquemment utilisé, mais pour de grandes superficies le semoir à graines fourragères à rouleaux plombeurs s'impose surtout si l'on pense qu'il permet de faire une autre économie de 40% sur le taux de semis. En effet son action facilite la germination et moins de graines sont nécessaires.

Un semis de luzerne pure est la meilleure façon d'établir une luzernière là ou la luzerne prend bien, puisque la régie en est plus facile tout comme la lutte contre les mauvaises herbes.

Pour un semis en luzerne pure il faut de 10 à 12 lb de semences à l'acre mais guère plus. La figure 2 indique suffisamment que l'augmentation du taux de semis n'améliore guère la densité et qu'il n'est pas économique de viser au plus haut.

Le semis en mélange est le plus courant bien qu'il rende plus difficile la lutte contre les mauvaises herbes en début de saison mais c'est aussi la meilleure façon d'établir pour la première fois une luzernière. L'autre espèce fourragère employée couvrira les endroits où la luzerne n'a pas pris, évitant ainsi le développement des mauvaises herbes. En mélange, le taux de semis de luzerne doit être ramené à 6.8 lb/acre, taux bien suffisant si les conditions sont bonnes.

Voici quelques mélanges: Luzerne 8 lb/brome 10 lb; Luzerne 8 lb/fléole 6 lb; Luzerne 6 lb/trèfle rouge 2 lb/fléole 6 lb.

Ce troisième mélange est préférable lorsqu'on sème la luzerne pour la première fois.

Si le champ doit être pâturé il faudra ajouter une livre de ladino aux deux premiers mélanges. ■

	Champ de 50 acres		Économie réalisée sans perte de rendement
	24 lb/a	10 lb/a	
Variété Vernal 83¢/lb	$996.00	$415.00	$581.00
Variété Alfa 93¢/lb	$1116.00	$465.00	$651.00

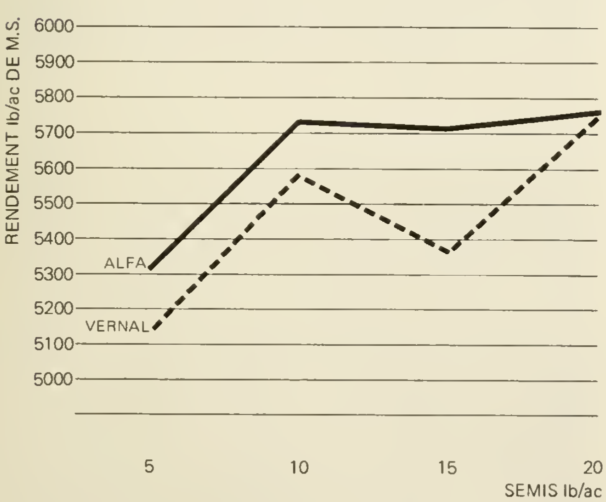


Fig. 1. Influence du taux de semis sur le rendement des luzernes Alfa et Vernal.

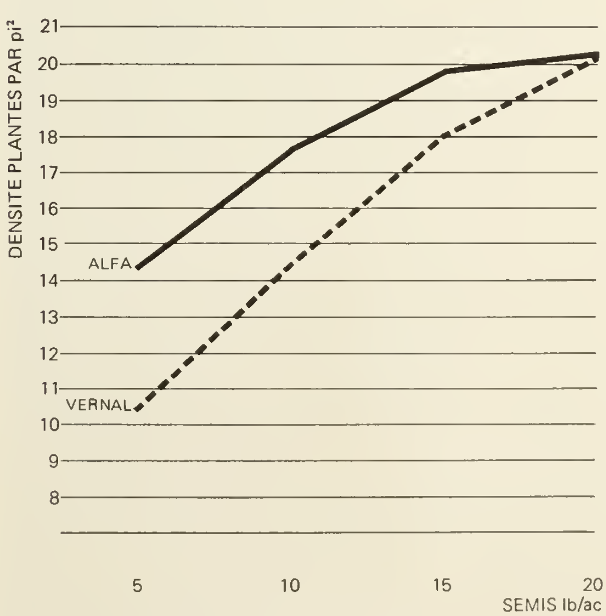


Fig. 2. Influence du taux de semis sur la densité des luzernes Alfa et Vernal.

PLANT GROWTH—TWO TEMPERATURE REGIMES

C. E. OUELLET

Les plantes sont des organismes croissant sous deux régimes de température en même temps. Il est important de connaître ces deux régimes et leur différences. Maintes implications agricoles peuvent en découler.

Living in soil and air, plants have the distinction of growing in two environments at the same time. Soil and air, of course, differ in physical, chemical and biological properties. In particular, the temperature regimes of the two environments show several differences, as well as some similarities. Here, the purpose is to illustrate these differences and to point out some agricultural implications.

The mean monthly temperatures for nine weather stations representative of agricultural regions in Canada have been plotted in Figure 1. There are three curves for each station: the soil temperature at the 4 and 40 inch depths (TS4 and TS40), and the air temperature (TA). The stations are numbered in order of decreasing soil temperature at the 4-inch depth. The curves are based on 10-year average data (1961-70).

SEASONAL SOIL TEMPERATURE

The main similarity between soil and air temperatures is demonstrated by the S-shaped curves plotting the warm and cold periods of each throughout the year. The curves are generally similar because soil and air are dependent on the same source of energy—solar radiation. The main difference is the milder temperature in the soil compared to the air. For instance, at Charlottetown the mean annual soil temperature at the 4-inch depth is 4.4 F higher than the air temperature (Table 1).

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Also, the annual amplitudes (differences between the warmest and coldest months) are smaller in the soil. At Fort Vermilion the amplitude was 72.6 F for air temperature compared to 43.6 F for soil temperature at the 4-inch depth (Table 1).

The length of the period above 32.0 F is much longer in the soil than in the air (Fig. 1). At Ottawa, the air temperature stays above freezing for 287 days whereas the soil temperature at the 4-inch depth stays above freezing for 328 days. These values are based on the mean monthly temperatures and not on the exclusive occurrence of the early and late frosts in the fall and spring.

SEASONAL DIFFERENCES

In winter, the curves indicate that temperatures are much higher in the soil than in the air. See January temperatures at Fort Simpson in Fig. 1. These differences are mainly due to the snow cover insulating the soil against the colder air above and also to

TABLE 1. ANNUAL SOIL AND AIR TEMPERATURE (°F) AT NINE STATIONS

Stations	Mean			Amplitude		
	TA	TS4	TS40	TA	TS4	TS40
Vancouver	49.7	53.2	52.9	25.2	28.9	17.5
Harrow	48.1	51.1	50.8	48.8	40.3	29.3
Ottawa	42.4	47.7	46.4	56.8	37.6	25.5
Charlottetown	41.8	46.2	45.5	48.1	31.6	21.6
La Pocatière	39.4	44.7	44.5	53.4	36.7	23.4
Normandin	33.5	42.7	42.2	63.0	30.4	22.5
Calgary	38.4	42.3	43.0	47.8	39.2	23.9
Fort Vermilion	29.8	40.8	40.7	72.6	43.6	25.9
Fort Simpson	24.6	35.6	33.6	82.1	44.3	13.4

the heat released by the freezing of soil water. Several varieties of forage plants can survive due to this condition. It may be assumed that well established trees with deep roots can overwinter more easily than newly planted trees with relatively shallow roots because the temperature is higher in lower than upper soil layers.

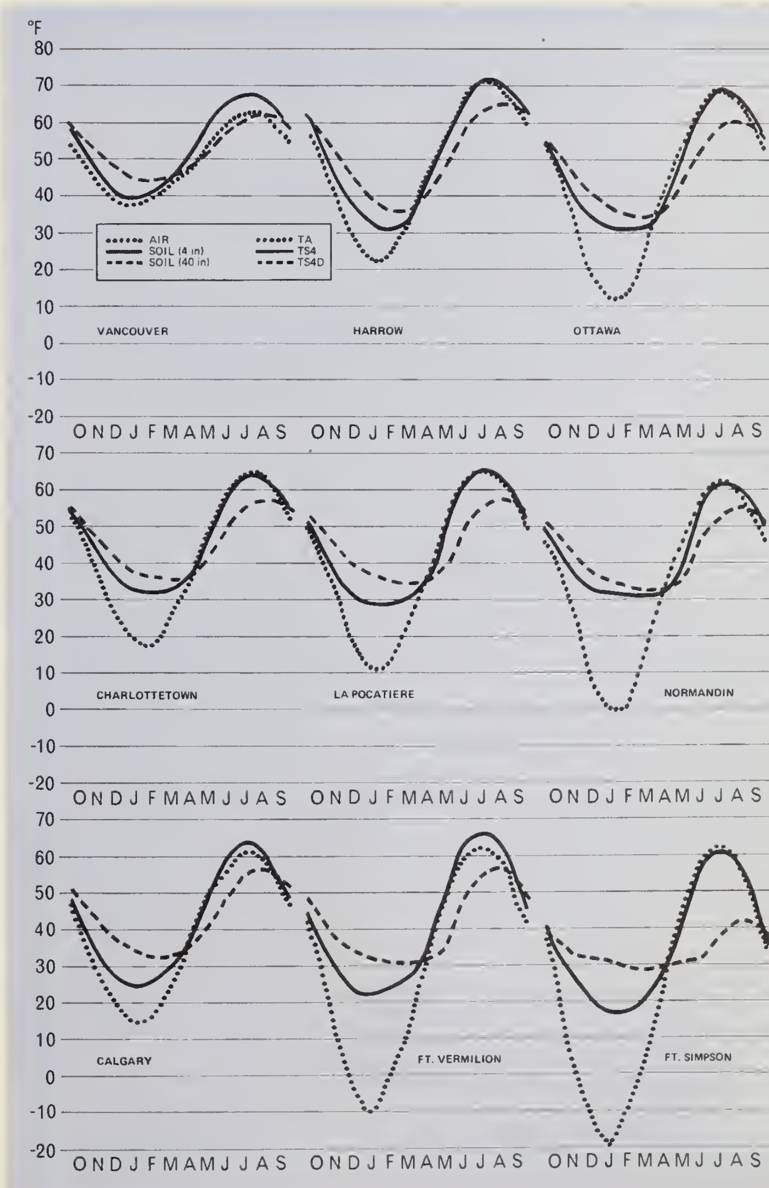
The increase of solar radiation in the spring produces a corresponding increase of temperature. Air temperature increases most rapidly, followed by shallow, and deep soil temperatures. Usually, the curves of TS4 and TS40 cross around mid-April, when TS4 moves higher than TS40. The curves for Vancouver, Calgary and Fort Simpson show that this reversal of TS occurs about March 6, April 12 and April 21, respectively. The plants take advantage of this progressive warming of the soil from the surface downwards. Seeds and young plants of annuals may develop readily in the warmer soil surface layer, while the elongation of their roots matches the progressive warming in depth.

In summer, the curves of TA and TS4 are generally close to each other, reflecting the strong interdependence of the air and soil surface temperatures. The most important feature at this time is the great difference of temperature through the soil profile, commonly called the soil temperature gradient. In July, as indicated by the curves, mean differences between TS4 and TS40 amount to 7.5 F for Vancouver, 10.9 F for Ottawa, 9.0 F for Calgary, and 24.7 F for Fort Simpson. This is explained by the strong solar radiation reaching the surface in summer and the relatively low thermal diffusivity of the soil. The latter is an index of the facility with which temperature is changing through the soil profile. This exposure of the plant roots to decreasing temperatures in depth may be a factor to consider in the selection of varieties and management practices.

Reduction of solar radiation in fall causes a parallel decrease of temperature. However, the rate of the decrease is higher in the air than in the soil. A second and inverse reversal of the temperature curves occurs. In the fall, soil at lower depths cools more slowly than soil at the surface, and soil at the surface cools more slowly than the air. Figure 1 shows that at Harrow, on the average, the temperature of the air and of the soil at the 4- and 40-inch level stays above 42.0 F until November 9, November 27 and December 27, respectively. At Normandin, where temperatures are generally lower, the corresponding dates are October 12, October 26, and November 15. The higher soil temperature lengthens the period for the root growth in lawns and trees planted in fall.

In conclusion, both soil and air temperatures should be considered for the growing of plants. The knowledge of air temperature alone cannot provide adequate information on soil temperature. Unfortunately, only 58 stations are currently observing soil temperatures in Canada as compared to nearly 1900 stations for air temperature. More information on soil temperature might benefit the successful introduction of new varieties, management practices, and the control of insects. Because of the lack of soil temperature data, the development of a climatic model is underway at the Agrometeorology Section, Plant Research institute, in order to estimate soil temperatures from standard climatic data and subsequently prepare soil temperature maps for Canada. ■

Fig. 1. Soil and air temperature (°F) at nine Canadian stations. Curves based on 10-year average data (1961-70). Calgary soil temperature data were normals (1941-70) estimated by equations recently developed by Agrometeoriological Section, Ottawa.



INCREASED PRODUCTION OF LAMB BY CROSSBREEDING

J. A. VESELY

L'auteur compare les effets de la reproduction en race pure et de deux systèmes de croisement entre 4 races (Romnelet, Columbia, Suffolk et North Country Cheviot) sur le poids au sevrage et le poids de marché des agneaux, de même que le poids des agneaux au sevrage ou par brebis.

There are two ways in which a breeder can use genetics to improve production traits. First, he can carefully select the individuals to be used as parents, and second, he can control the way in which the parents are mated, that is, by crossbreeding.

At the Manyberries Substation of the CDA Lethbridge Research Station we conducted an experiment designed to determine the extent to which lamb production is improved by crossbreeding. We used four breeds: Romnelet, Columbia, Suffolk, and North Country Cheviot. The test extended over a 4-year period beginning in 1967. During that time we gathered data on the contemporary performance of lambs and ewes. Each year lambs of the four pure breeds, 12 two-breed crosses, and 24 three-breed crosses were raised. The lambs were born between April 15 and May 20. They grazed with their mothers on range until the first week of August and were then weaned at an average age of 110 days. Immediately after that they were put on a 75-day feedlot test. The ration fed consisted of 50% chopped alfalfa hay, 40% barley, and 10% dried molasses beet pulp. Each year all replacement females were bred as ewe lambs.

Dr. J. A. Vesely is sheep breeding specialist at CDA Research Station, Lethbridge, Alta.

EFFECT ON OFFSPRING

Growth performance in terms of weaning and market weights of lambs of the four breeds and 36 two-breed and three-breed crosses was compared. Purebred lambs averaged 52.9 pounds at weaning and 90.9 pounds at marketing, two-breed cross lambs averaged 55.2 pounds and 97.4 pounds, and three-breed cross lambs 60.3 and 101.1 pounds. The average weaning and market weights of the two-breed crosses were higher than those of the purebred lambs mainly because of their hybrid vigor. The increased growth performance in the three-breed cross lambs was due to the hybrid vigor in the lambs as well as their mothers. Crossbred lambs also exhibited better survival ability to marketing. Seventy-five purebred lambs, 83 two-breed cross lambs, and 86 three-breed cross lambs survived out of 100 lambs born in each group.

PROLIFICACY AND MOTHERING

Increased growth performance of the lambs is not the only benefit to be gained from crossbreeding. The final outcome of lamb production is determined

TABLE 1. AVERAGE WEANING AND MARKET WEIGHT OF LAMBS, POUNDS OF LAMB AT WEANING, AND AT MARKET PER EWE LAMBING OR PER EWE BRED PRODUCED BY PURE BREEDING OR TWO SYSTEMS OF CROSSBREEDING

	Average weights of lambs, lb		Pounds of lamb per ewe lambing		Pounds of lamb per ewe bred	
Mating system	At weaning	At marketing	At weaning	At marketing	At weaning	At marketing
Pure breed ewe to ram of same breed	52.9	90.9	71.9	114.4	49.8	79.6
Pure breed ewe to ram of another breed	55.2	97.4	80.1	129.8	58.1	92.8
Two-breed cross ewe to ram of a third breed	60.3	101.1	90.0	141.0	67.7	105.5

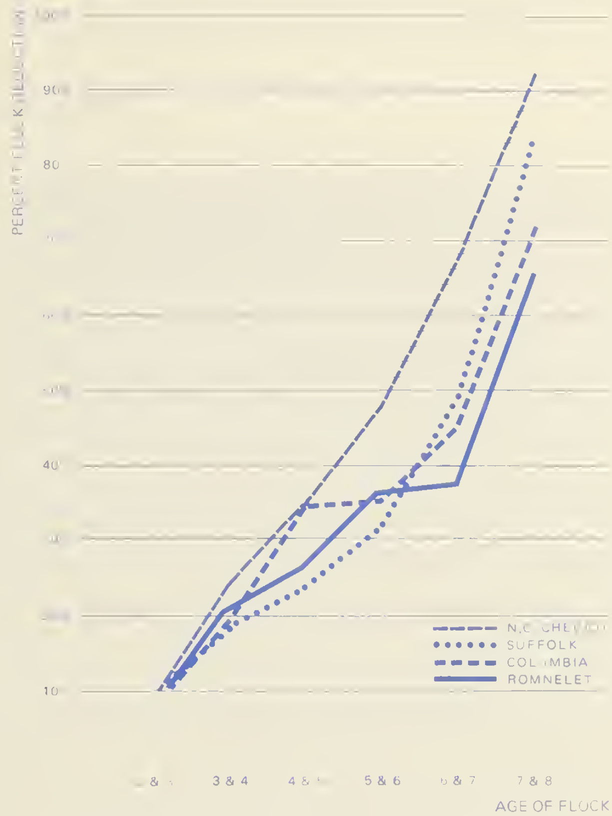


Fig. 3. Cumulative annual reduction in flocks.

by other factors, such as the prolificacy (twinning) and lamb-raising ability of the ewes. Fertility, expressed as the number of ewes conceiving per 100 ewes bred, apparently was not affected by crossbreeding. Eighty-one percent of purebred ewes conceived when mated to rams of the same breed and 78% when mated to rams of another breed. Eighty-three percent of two-breed cross ewes conceived when mated to rams of a third breed. These conception rates were low because replacement females were bred as ewe lambs. Twinning is another benefit to be gained from crossbreeding. The purebred ewes increased their numbers at lambing by 38% and the two-breed or three-breed cross ewes increased theirs by 43%. The crossbred ewes raised also 15% more lambs than the purebred ewes.

LAMB PER EWE BRED

The overall analysis of our crossbreeding experiment is summarized in Table 1. It shows that crossbreeding among the four breeds increased the production through faster growth of lambs from birth to weaning, on the average, by 4.3% or 14.0%, and to marketing by 7.2% or 11.2%, depending on which of the two mating systems was used in cross breeding. The growth of lambs, however, is only one factor in the process of attaining a gain in production by crossbreeding. When the factors of prolificacy in ewes and survival in lambs are considered the advantage gained by crossbreeding is accentuated. For example, the number of pounds of lamb produced at marketing per ewe bred was increased, on the average, by 16.6% or 32.5% if two-breed or three-breed crosses were produced, respectively.

Fig. 1. (Far left) Purebred Suffolk ewes.

Fig. 2. (Left) Crossbred ewes (N.C. Cheviot X Suffolk)—If crossbreeding is well planned, uniformity in type of ewes (and lambs) also can be achieved.

LONGEVITY OF EWES

Crossbred ewes are believed to have a longer productive life than purebreds. Up to now we have not maintained the crossbred ewes long enough to be able to substantiate this belief. However, we can show that differences in longevity exist between pure breeds. The four pure foundation flocks were each established with equal numbers of yearlings and 2-year-olds. The cumulative annual reduction in each flock (Fig. 3) shows that at the average age of 7½ years the Romnelet flock was reduced by 65% and the Columbia, Suffolk, and N.C. Cheviot flocks were reduced by 72, 84, and 92%, respectively. We hope to obtain and report further information on crossbreds.

Crossbreeding cannot be practised without purebred animals. Therefore, pure breeding and crossbreeding have an equally important place in animal production. The decision to practise either pure breeding or cross-breeding rests with the producer. ■

ECHOES
FROM THE FIELD AND LAB


Certified seed grower starts right—by vacuuming the seed drill.

AVOID MISADVENTURE WITH SEED Seed is subject to many haps, and mishaps, from the time it is selected as foundation, till it is increased and distributed. It passes through many hands and machines in the process. It comes in close contact with seed of other varieties, and can be contaminated by weeds.

Seed production needs careful control and regulation if buyers are to get the quality and standard they want. This is largely accomplished under the Canada Seeds Act, and the close co-operation of the CDA Plant Products Division, the seed trade and the Canadian Seed Growers' Association.

The story of Certified Seed is told in a series of 35 mm color transparencies prepared by the Canadian Seed Growers' Association with the assistance of CDA Information Division and the provincial departments of agriculture. It traces the development of a new variety, showing how it is selected and increased to guarantee its genetic purity and performance. The set demonstrates the research, field inspection, seed analysis, certification and record keeping required to produce Certified Seed.

Provincial departments of agriculture plan to project the slides, with commentary, at farm meetings to promote better understanding of Certified Seed.

In the accompanying photo, which is one of the set, an operator vacuums the seed drill to remove impurities before filling up with Certified Seed. He is avoiding a misadventure with seed mixtures.

NEW LIGHT ON AN OLD CONCEPT Organic matter has been known to have a profound influence on the physical well-being and production potential of the soil for a long time. It has been known to improve the structure and water-holding capacity of soils. It is a nutrient reservoir, allowing the gradual release of nutrients for plant growth.

Some forms of soil organic matter may even take part in the biochemical process involved in the uptake of nutrients by the plant, which in turn effects the development and yield of that plant. Recent investigations at the CDA Research Station, Lethbridge, Alta. support this idea. Researchers have evidence that plants can take in small organic molecules through their roots.

"Plant responses to fertilizers have differed from one soil zone to another", says Dr. J. F. Dormaar, research scientist in soil chemistry at Lethbridge. "In the past, these various responses have been attributed to the difference in soil type, climate and cultivation methods. But, in the light of trial findings, it would appear that the presence and kind of organic matter may also be influencing the uptake of nutrients by plants.

HORSE LOVERS—TAKE NOTE A new publication for amateur horsemen is now available from the Information Division, Canada Department of Agriculture, Ottawa.

The Saddle Horse, publication no. 1462, has been written specially for owners of one or two horses. Sections deal with a variety of important aspects of the care and handling of horses: stable construction, feed requirements, desirable characteristics, health problems and hoof care. A number of safety precautions, tips and handy references are also included.

Those who may have only a casual interest in horses will find this informative booklet easy to read and understand. The clever use of diagrams and illustrations lends support to definitions and descriptions.

It is available on request in French or English, and is free of charge.

QUE LES CHEVAUX SE RÉJOUISSENT! Leurs propriétaires sauront maintenant comment les bien traiter. La Division de l'information d'Agriculture Canada vient de publier un recueil destiné aux nombreux propriétaires d'un ou deux chevaux de selle, qui bien qu'armés jusqu'aux dents de bonne volonté, donnent trop souvent à leur monture des raisons pour s'inscrire à l'U.I.E.M. (Union internationale des équidés mécontents).

Cette publication qui en plus du titre de "Le cheval de selle" porte le numéro 1462 traite allègrement de la plupart des problèmes nouveaux et déroutants avec lesquels les "cavaliers du dimanche" sont souvent confrontés. Que ce soit le gîte ou le coucher, la couvert ou la table, la clinique préventive ou la protection contre les méchants, cette très modeste petite encyclopédie du cheval

ECHOS
DES LABOS ET D'AILLEURS

de selle vous en parlera sans ambages. De nombreuses illustrations éclaircissent le texte et de plus elle est . . . gratuite.

HERITABLE PERFORMANCE To the uninitiated, one hog may look the same as another. As a matter of fact there is considerable uniformity among hogs, particularly within a breed. But there are differences nevertheless. Some hogs grow faster than others. Some tend to produce fat. Others eat more to gain market weight. However slight the differences, such factors are important to the hog breeder.

The Record of Performance (ROP) program is designed to measure heritable factors to improve the genetic merits of Canadian swine. It provides the same base, or standard of measurement for all provinces.

There are two distinct programs. The ROP home herd test is carried out on the farm. The breeder weighs his gilts and boars to establish their rate of growth, and probes for backfat thickness. He selects only the best performers for breeding.

The station test is more demanding. Representative sires and progeny from different herds are tested under controlled conditions at a central station. Progeny groups are slaughtered and a cut-out is performed to obtain a predicted lean meat yield as an indication of a sire's potential. Performance tested boars are measured ultrasonically, feed efficiency tabulated, and rigid standards met before boars are allowed to return to the breeder or entered in the test boar sale.

In this competitive age, such sophisticated measurements are necessary to select superior animals for breeding. It is performance that counts, not just appearance.

CIGAR SMOKERS MAY BENEFIT Cigar tobacco breeder, Mr. V. Kozumplik of the CDA Experimental Farm, L'Assomption, P.Q., is striving to improve the yield and quality of cigar tobacco varieties. Established plant breeding methods of crossing and backcrossing of two or more varieties and selection of lines are being used to upgrade the more desirable characteristics of the tobacco plant and the finished product.

The most promising tobacco lines undergo field trials to evaluate yield potential, time of flowering and disease resistance. Laboratory analyses are performed to determine chemical composition and quality. In addition, and of most significance to the consumer, smoking tests enable the researcher to compare the aroma and flavor produced by each tobacco variety.

Research is also being directed at management factors including planting date and plant spacing. An early planting date may allow earlier harvesting and better curing of leaves.

The breeding work on cigar tobacco initiated 10 years ago is being continued and hopefully will lead to the development of varieties that have definite advantages over those currently being grown.

COMPARING IRRIGATION METHODS Proper irrigation can lead to a vast improvement in the total agricultural economic capability of an area. A number of irrigation systems are available and farmers in irrigation areas are faced with the decision of choosing one suited to their needs.

Publication 1488, *Irrigation on the Prairies,* is now available from the information Division, Canada Department of Agriculture. It describes several methods of surface and sprinkler irrigation with the help of pictures and diagrams. Particular consideration is given to water supply, topography and soil type.

Comparative cost data are summarized in table form. The publication is designed to help answer questions relating to irrigation practices under prairie conditions.

RE-SCRAMBLED EGGS Frozen egg melange is used on a large scale by the food industry. Usually the frozen egg was available only in bulk packages of about forty pounds. The large mass took about a day and a half to thaw out, and once it thawed, the food formulator was committed to use it all up.

An Agriculture Canada team relieved this problem somewhat by developing equipment and refining the process to quick-freeze egg in the form of free-flowing granules, about the size of peas. The frozen granules can be packaged and poured easily, and measured in volumes required by the user.

The process was developed by Dr. Gordon Timbers and Dr. M. M. Gref. It won an international award, accepted on behalf of the Department by Dr. Paul Sims, Director of CDA Food Research Institute at the 5th International Food Products Exhibition in Paris.

GOVERNMENT CAR WASH Visitors to Newfoundland, or those who import a used car or a piece of farm machinery are soon made aware of the Federal Government program to control pests. The program is directed at preventing a broader range of pests from entering Canada. Cars and other vehicles being ferried from Newfoundland to the mainland are carefully inspected and washed to prevent movement of two soil-borne potato devastators—golden nematode and potato wart disease.

Soil adhering to cars and other vehicles is capable of carrying organisms that, once established in Canada, could have adverse economic implications.

Here an inspector from Agriculture Canada's Plant Protection Divison takes a soil sample from an imported car.

A NEW FORAGE CROP CICER MILKVETCH

S. SMOLIAK and A. JOHNSTON

L'astragale pois chiche Oxley est une nouvelle légumineuse fourragère vivace créée à Lethbridge, Alberta et dont la vente est autorisée au Canada. Elle est surtout prévue comme plante de pâturage, bien qu'elle puisse aussi être utilisée pour la production de foin. De plus, elle est adaptée à un grand nombre de textures du sol de l'Ouest canadien. Les stocks de semences, qui seront limités jusqu'en 1974, seront multipliés dans le cadre du Programme des semences fourragères du Canada.

The search for new crops is a continuing process. Thousands of plant introductions have been tested at various research stations in Canada. They are evaluated for adaptation, production, and persistence. The most promising plants are further tested and records are kept of such important features as seedling vigor, outstanding vegetative quality, freedom from diseases and insects, ground cover value, drought and winter hardiness, and yield of forage and seed.

One such introduction that has shown great promise is Oxley cicer milkvetch, *Astragalus cicer.* This new perennial legume forage crop was developed by the CDA Research Station, Lethbridge, Alberta, and in 1971 was licensed for sale in Canada.

Cicer milkvetch seed was obtained from the U.S.S.R. in 1931 and sown at the CDA Research Substation, Manyberries, Alberta. In 1945, after years of evaluation, plots of cicer milkvetch were established at the Lethbridge Research Station. In 1950, plots were seeded at the Stavely Research Substation, in the foothills of the Rockies. Here, the plants performed exceptionally well and spread onto adjacent land. Because the cicer milkvetch readily encroached on timothy stands and showed great persistence and competitive ability, we began an intensive study of this crop in 1964. The study led to the registration and release of Oxley as a variety.

PASTURE PLANT

We expect cicer milkvetch to be grown mainly for pasture, but it has potential as a hay crop. It is adapted to a wide range of soil textures in western Canada. It can be grown in the Dark Brown and Black soil zones and in the moister parts of the Brown soil zone in mixtures with grasses. It performs well on rather poor, infertile soils and is useful in preventing them from eroding. The foothills of southwestern Alberta appear to be the most promising area for growing cicer milkvetch. There the seed can be broadcast into existing stands of timothy to improve quality and to increase quantity of forage.

Cicer milkvetch is long-lived and its growth habit ranges from prostrate to upright. The leaves resemble those of native vetches and have from 16 to 20 leaflets. The flowers range from white to pale yellow in color and flowering continues profusely from June until the first frost. The seeds, which do not shatter, are enclosed in bladder-like seed-pods that are green to greenish-red when immature and leathery black at maturity. The bright-yellow to pale-green seeds have extremely hard shiny coats. There are about 122,000 seeds per pound.

Mr. Smoliak and Mr. Johnston are range ecologists at the CDA Research Station, Lethbridge, Alta.

Reproduction is by seed and rhizomes. The plants spread rapidly and often form a dense rhizomatous mat after two or more years of growth.

Cicer milkvetch begins to grow about three weeks later in the spring than alfalfa but remains green much later. The hay is similar to alfalfa in protein content but is higher in digestibility of dry matter and protein. It does not accumulate high levels of selenium. Cicer milkvetch has not caused bloat in experimental animals, although it does contain 18-S protein, a chemical in alfalfa that has been linked to bloat.

Cicer milkvetch is more difficult to establish than alfalfa or sainfoin. Its slow establishment is related to its slow, early seedling development. Delayed germination and slow root growth at temperatures below 68°F restrict the growth of the seedling during its early stages. Cicer milkvetch seedlings grow and develop best when temperatures are near 80°F.

The black, leathery, bladder-like pods of cicer milkvetch each contain from 3 to 11 seeds.

PALATABLE FORAGE

For grazing, cicer milkvetch is quite palatable to both cattle and sheep from late spring until late fall. In a five-year grazing test at Lethbridge, the percent consumption of cicer milkvetch by sheep was equal to that of alfalfa. However, cicer milkvetch produced only 65 percent as much forage as alfalfa and its regrowth is much slower than that of alfalfa.

When we grew cicer milkvetch mixed with grass we obtained the highest yields when the seed was sown in alternate rows with the grass. Over a four-year period, cicer milkvetch with Russian wildrye or crested wheatgrass yielded about 2.8 tons of hay per acre and about 1.8 tons when grown alone. Alfalfa alone produced 3.2 tons of hay per acre.

Cicer milkvetch and crested wheatgrass produced more forage when grown in alternate rows than when grown in the same row.

At the Stavely Research Substation, established stands of cicer milkvetch have yielded as much as 4.7 tons of hay and 670 pounds of seed per acre. However, average yields of forage are from two to three tons per acre. Occasionally, cicer milkvetch has outyielded alfalfa, especially when the alfalfa suffered some pocket gopher damage.

Germination of cicer milkvetch is often poor because of a high hardseed content. It is therefore necessary to scarify the seed to increase germination. Scarification scratches or weakens the hard seed coat and permits air and moisture penetration. The seed also must be treated with an *Astragalus* bacterial inoculant.

Seed of Oxley cicer milkvetch has been released to the Canadian Forage Seed Project for increase and distribution. Some foundation seed will be available in 1973, but amounts are limited. Seed supplies of Oxley should be more readily available by 1974.

We shall continue to conduct evaluation trials with cicer milkvetch. As the newest legume for pasture and hay production in western Canada it has much to offer. ■

W. H. FOOTT

PICNIC BEETLES

PESTS OF PROCESSING-TOMATOES IN SOUTHWESTERN ONTARIO

Un petit nitudule, le *Glischrochilus quadrisignatus*, de couleur foncée, envahit des tomates éclatées, entre la cueillette au champ et la livraison à l'établissement de transformation. Les méthodes de lutte culturale chimique et de piégeage mises à l'essai à la Station de recherche d'Agriculture Canada de Harrow, en Ontario, ont eu des résultats limités. Le problème pourrait être résolu en expédiant les tomates en citernes et en créant des variétés de tomate résistantes à l'éclatement.

Most entomologists study insect pests of fruits and vegetables in order to protect a growing crop, and to increase yield. However, at the CDA Research Station, Harrow, Ont., we are investigating the biology and control of an insect that attacks its host only after harvest. The pest involved is *Glischrochilus quadrisignatus,* a small, dark beetle about a quarter-of-an-inch long, with two yellow spots on each wing cover. The beetle has no officially accepted common name but is usually referred to as a "sap beetle," although some authors have called it the "picnic beetle" or the "four-spotted sap beetle".

A major pest of processing-tomatoes, the beetle invades cracked fruit between picking and delivery to the factory. By the time whole tomatoes are canned, the insects have often burrowed so deeply inside the fruit they cannot be detected by workers on the inspection and canning lines. Angry complaints result when upset housewives discover insect-infested tomatoes.

At Harrow Research Station, we have found that the adult beetles overwinter in grassy and weedy waste areas along the edges of woods, fields and creeks, usually within the top inch of soil. They become active on warm days in April, and start breeding in early May. The only breeding sites of importance are ears of corn that remain in the field after harvest and are subsequently plowed into the soil.

Beetles lay their eggs on or near the ears of corn, and larvae feed within the rotting kernels. New adults emerge over a period of several weeks, starting in early July. Throughout the summer and fall they can be found in or under almost all types of over-ripe and rotting fruits and vegetables. Beetles also feed in corn kernels damaged by birds and insects, in tunnels excavated by the European corn borer, and in large smut balls that commonly form on tiller ears of corn. The beetles can be a nuisance around roadside fruit and vegetable stands and in picnic areas. Several dozen beetles have been known to land on a table during the course of a family picnic—hence the name "picnic beetle," favoured by some entomologists.

There is no proof of a second beetle generation in one season in southern Ontario.

FUTILE MEASURES

Control measures suitable for other insects do not work against the sap beetle. It would be futile to spray tomato fields, because the beetle does not feed on foliage or on growing, undamaged tomatoes; in addition, many of the beetles that invade hampers of picked fruit are attracted from outside the tomato field. No parasites have been observed in the pests, and predators are of minor importance to the beetle. Early burial of ears of corn to prevent reproduction of the species, is pointless. Beetles infested the ears in our test plots, whether we buried the corn in the fall or in spring, at soil depths of three or of six inches. If hogs were turned loose in the fields in the fall they would consume most of the unharvested ears of corn, but an absence of fences around most fields prevents this form of biological control.

The three methods of sap beetle control examined so far are: cultural, trapping, and chemical.

Dr. Foott is an entomologist at the CDA Research Station, Harrow, Ont.

CULTURAL

It was evident early in our investigation, that a number of changes in cultural practices would help reduce beetle infestation:

First, many growers had not left roadways at suitable intervals in their fields. The fruits that were squashed by farm vehicles attracted and retained beetles in the field. On our recommendation, many growers now leave roadways.

Second, pickers are now being cautioned to minimize fruit cracking during harvest, and to avoid excessive jolting of the hampers.

Third, the longer damaged tomatoes remain in the field the more attractive is their odor to beetles. Growers who deliver tomatoes to the factory within 24 hours of harvest seldom have a beetle problem.

Fourth, we found that wagon loads of tomatoes left in fields exposed to the wind, are less severely infested than loads left in sheltered areas around buildings and trees.

Recommendations on these cultural control methods are now included in the *Ontario Vegetable Production Recommendations* (Ontario Ministry of Agriculture and Food Publication 363).

TRAPPING

Baited traps are being tested in a cooperative program with one of the processing companies. Two traps per acre are placed at the edges of tomato fields from early spring to late fall. Sliced bananas are used to attract the beetle. Bananas, sprinkled with an insecticide and placed in 100-ounce cans with a little water, will attract and kill beetles for at least a week. The number of beetles captured per trap varies greatly with location, time of year, and weather. The average number of beetles captured per trap during an entire season has ranged from approximately 21,000 to 28,000 in four fields. This would be almost 500,000 beetles per 10-acre field when two traps per acre are used. Of added significance is the fact that each destroyed female could have laid several dozen to several hundred eggs. Although the results are encouraging, a trapping program to reduce beetle populations can only be effective if the majority of growers in an area of severe infestation cooperate.

CHEMICAL

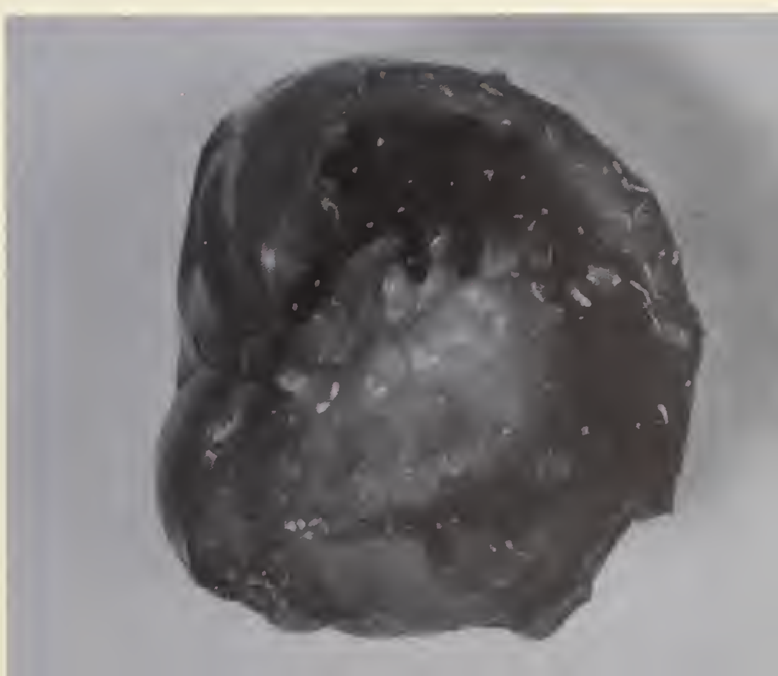
Spraying of hampers with an insecticide immediately after they are filled with tomatoes might greatly reduce beetle infestations, but this would be impractical for most growers, and could result in illegal insecticide residues. In tests at Harrow, we concentrated on the treatment of empty hampers by spraying or dipping them in insecticides for from one to several days before use. Dipping would be the most practical method, since a grower could treat an armful of hampers at a time, in a suitable dip tank. Beetle mortality varied greatly in our tests, not only between insecticides, but with the same insecticide on different days. Although further data are required, the two most important factors appear to be wind speed, and the location of the damaged tomatoes with the hamper.

Under calm conditions beetles can hover over a hamper and drop down to the tomatoes without touching the treated surfaces of the hamper, but on windy days they land near the hamper and crawl in. If there are damaged tomatoes, or tomato exudate, on the floor of the hamper, many beetles stay there and are killed by contact with the treated wood. Conversely, if the damaged tomatoes are restricted to the middle of the hamper, many beetles have only brief contact with the treated wood before moving upwards, and are not killed.

Other control possibilities include the gradual conversion from hampers to bulk tanks for delivery of harvested tomatoes. When hampers are stacked five high on trucks and wagons, many tomatoes are squashed. Under the bulk system, hampers are dumped directly into tanks in the field and the tomatoes must be delivered within a few hours. Tomato varieties with greater crack-resistance would further reduce the problem. The development of a tomato variety suitable both for mechanical harvesting and for the whole-pack system, would almost eliminate the sap beetle problem. ■

Fig. 1. Adult of Glischrochilus quadrisignatus.

Fig. 2. A ripe, damaged tomato cut open to illustrate typical beetle infestation.



THE SEARCH FOR NEW FARM CROPS

CHARLES WALKOF

La Direction de la recherche du ministère de l'Agriculture du Canada est à la recherche de nouvelles plantes cultivées afin d'en déterminer le potentiel économique pour le Canada. Les nouvelles plantes cultivées, provenant du monde entier, sont d'abord mises à l'essai à Morden, Manitoba. En 1972, les espèces et les souches mises à l'essai comprenaient des plantes cultivées pour leurs graines oléagineuses, leurs huiles aromatiques, leurs protéines et leurs sucres. Les délégations internationales qui visitent les parcelles d'essai de Morden sont très optimistes sur les possibilités qu'offrent beaucoup de ces plantes sur les marchés d'outremer.

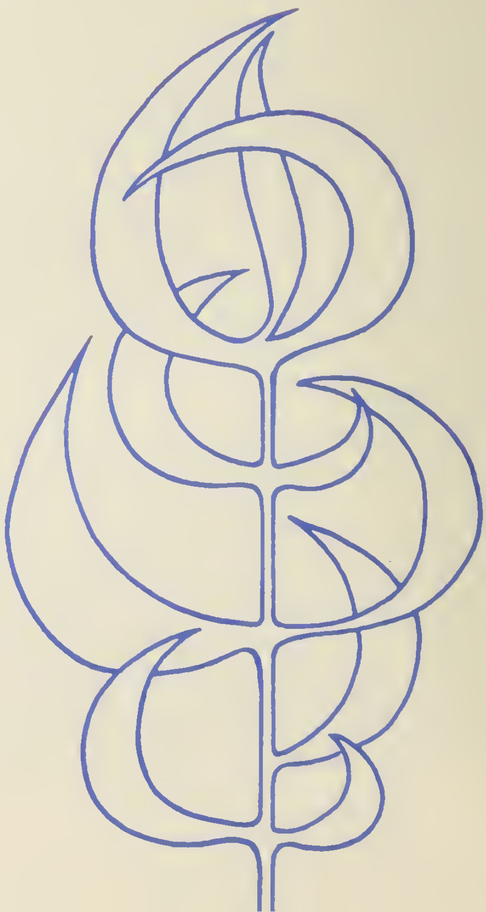
Morden 39 mung beans produce up to 1000 pounds of seed per acre at the Morden Research Station.

Who would have predicted in 1804, when soybeans were first introduced as a novelty in North America from China, that they would eventually become a major edible oil crop? Now, more than 20 million acres planted annually in the United States yield a farm value of more than $1 billion.

In Canada, rapeseed production, unknown 20 years ago, was grown on 5.3 million acres in 1971, and generated an estimated crop value of $245 million. Thus soybeans and rapeseed have been valuable alternatives to wheat, oats and barley in the farm economy, particularly during periods of price depression in cereal crops.

An important objective of the CDA Research Branch now is to locate other new crops and determine their potential for production in Canada, and their possible advantage to the farm economy.

Dr. Walkof, former head, Vegetable Crops Unit, CDA Research Station, Morden, Man., retired recently.



Heavy crop of seed pods on brown mustard at Morden.

New crops are obtained from world sources and tested initially at the CDA Research Station, Morden, Man. We evaluated more than 80 species and strains in 1972. Their adaptability to Canadian farm production, potential yield, and usefulness to industry are being checked closely. The most promising crop entries are offered to other research stations in Canada for testing on a regional basis. In addition, we maintain close contact with farm industries and provincial extension personnel to keep them informed of possible new crops.

FIVE GROUPS

At Morden we have classified potential new crops into five groups, according to their primary products. One group involves species grown for their seed oils, such as crambe, camelina, mustard, pumpkin and coriander. A second group produces essential or aromatic oils and includes dill, several mint species, monarda, sage, fennel and basil. Third, is a protein-producing group that primarily includes legumes and ranges through many kinds of beans to lentils, sweet lupins and chick peas. A fourth group is examined for carbohydrates such as starch from cow cockle, and fructose sugar from tubers of chicory and Jerusalem artichoke. As in most projects involving a wide range of material, there are miscellaneous crops that defy classification. Into this fifth group go such plants as hot peppers, horseradish and caraway.

Sunflowers, dry peas, field corn and buckwheat may be new to many western farmers who are now increasing their acreage of these crops, but at Morden we do not consider them new. Each of them is being improved by an intensive breeding program. New varieties resulting from our research will undoubtedly encourage further acreage increases.

PROTEIN SOURCES

Lentils are among the more promising new crops tested at Morden. They are grown largely for export to Europe and the Middle East, but the market has been unstable, probably due to the uncertainty of world lentil production. In Canada, satisfactory yields vary from 700 to 1,700 pounds an acre—enough to encourage continuing farmer interest. Morden research tests have obtained excellent yields from all types of lentils. The dark-green-and-tan colored seed variations are popular in Europe and most

Horsebeans are a valuable protein crop.

Mediterranean countries. Red lentils, popular in Turkey, produced high yields, but a satisfactory herbicide is needed to control weeds. Lentils do well in warm, dry growing conditions.

Most bean species are sensitive to high temperatures and dry weather when the plants are in flower. In particular, horsebeans or fababeans, a good new crop, grow and produce best in cool, moist conditions. For this reason we suggest they be grown in the Park Belt areas of Canada. Plot yields of 2,000 pounds of seed an acre are typical for horsebeans at Morden. The seed contains up to 28 percent protein, which is useful for providing protein feed supplements needed in many countries.

There is a big export market for pinto beans. Morden tests have shown that high yields of more than 2,000 pounds an acre are possible. Pinto beans are used in culinary preparations. Also, excellent results have been obtained from adzuki beans, *Phaseolus angularis*, a species different from *P. vulgaris* to which navy beans and garden beans belong. At Morden, adzuki beans have yielded up to 1,700 pounds an acre. There is a big demand for this crop in Japan where the beans are milled and used for baking and confections. Another species that has performed remarkably well at Morden is the mung bean, *Vigna radiata*. It has consistently produced 1,000 pounds of seed an acre, and has a large home and export market. Mung beans produce bean sprouts, an ingredient of Chinese foods prepared in Canada; in Japan the seed is milled to make noodles of a special kind.

Sweet lupins have a three-fold use: the seed is excellent as a protein feed supplement; when used as green forage, the plants produce up to 280 pounds of protein an acre; also, they can be ploughed down as green manure for soil improvement. The Morden tests show that lupins are best adapted to acid soils or those below pH 7.2 Lupins do not thrive on soils that are high in lime. The *Lupinus albus* species is best adapted to Canadian conditions.

SUGAR, AROMATIC CROPS

Chicory and Jerusalem artichoke are rich in fructose sugar. This is an expensive sugar that is two-and-a-half times sweeter than sucrose. Interest in fructose has increased since cyclamates were banned as sweeteners. Sweetening agents are in great demand by the $500 million diet food industry. Our tests at Morden indicate potential yields of more than eight tons an acre of chicory roots and more than 35 tons an acre of Jerusalem artichoke tubers. The quality of fructose from these crops has been excellent.

Coriander is an aromatic seed crop used by the flavor industry to produce flavoring agents for baked foods and liquors. This crop is well adapted to farm production in Canada. Our tests show that seed yields of up to 2,000 pounds an acre are possible. The usual farm equipment can be used to produce this crop and Treflan herbicide is excellent for weed control.

An interesting group of new plants, rich in aromatic oils, include dill and several species of mints. To extract oil, the plants are cut when they first begin to flower, placed in stainless steel tubs, and steamed. Plants grown at Morden yielded from 60 to 80 pounds of oil an acre, from dill, fennel, basil and peppermint. Market prices vary from $4 to $8 a pound. The quality of oil at Morden was as good as, or better than, the comparable commercial product. A mint native to the prairies, *Agastache fœniculum*, produced a fine, daintily perfumed oil. Its main constituent, trans anisole, was of a high standard in our tests.

At Morden, where newly introduced plants are first examined as potential new crops, the test plots may be small, but one never knows where the information they produce may lead. During the summer of 1972 an unusual number of people from research, industry and farming examined the plots with an evident desire to help diversify crop production on Canadian farms. Delegations from Japan, Germany and India were pleased with the variety in our plots and discussed viable markets for many of the crops overseas.

We are doing the research. It is up to Canadian exporters to establish market contacts, and to Canadian farmers to produce the new crops effectively. ■

PHYSIOLOGICAL ASPECTS OF REPRODUCTIVE EFFICIENCY IN SWINE

G. W. DYCK

L'auteur traite de deux aspects de la production porcine, envisagés sous l'angle de l'efficacité de la reproduction. L'apparition d'un premier œstrus ou de la puberté chez les jeunes truies est variable et ne peut être contrôlée, tandis que l'apparition d'un œstrus après le sevrage peut en général être facilement contrôlée. Les conditions d'hivernage n'ont aucun effet sur la taille des portées. Toutefois, l'œstrus d'après-sevrage au cours duquel a lieu la saillie, et la quantité d'aliments consommés influent sur la taille des portées.

Steadily increasing costs demand greater efficiency of livestock production. For swine, new techniques of confined housing, more intensive methods, improved nutrition and rapid animal growth all require better management if the cost of production is to be reduced.

One way of improving efficiency is to increase the number of pigs farrowed per sow per year. To do this, one has to have a good knowledge of the reproductive process and factors limiting reproduction. Two of the major factors limiting reproductive efficiency are the occurrence of estrus for breeding and the size of the litter farrowed. Research on these aspects of production efficiency has been in progress at the CDA Research Station, Brandon since the fall of

Dr. Dyck is an animal physiologist at CDA Research Station, Brandon, Man.

1966. Our research program is centered on the gilt, and the sow after weaning her first litter. The Yorkshire and Lacombe breeds are used in the program.

ESTRUS

We have observed that puberty or first estrus occurs at an average age of 197.5 days. However, there is considerable variation as shown in *Figure 1*. Studies on the growth of the reproductive tract from birth to puberty suggest that prepubertal development is completed by 150 days of age. Our attempts to induce estrus at 160 days of age, however, have not been successful.

After weaning, sows generally show estrus within a few days. In our studies, 90 per cent of the Yorkshire sows and 48 per cent of the Lacombe sows were in estrus seven days after weaning from a 42-day lactation period. By the end of four weeks after weaning, 99 per cent of the Yorkshire and 80 per cent of the Lacombe sows were observed in estrus. Delayed estrus after weaning in some sows appears to be due to a failure of gonadotropic hormone secretions from the pituitary. Estrus was detected in 12 of 14 Lacombe sows within five days of weaning after a single injection of 1500 IU of PMSG (Pregnant Mare's Serum Gonadotropin) on the day after weaning. All sows ovulated, as determined by post-mortem observation. A corresponding group of 14 control Lacombe sows averaged 14 days to estrus after weaning (range 4 to 41 days). This postweaning anestrus condition is not confined to the Lacombe breed, but has been observed by producers in most breeds of swine.

The length of the estrous cycle in pigs, while averaging approximately 21 days, also shows considerable variation. *Figure 2* shows the percent distribution of estrous cycle lengths for 418 cycles observed in 284 gilts and sows. Long estrous cycles were observed to be more common from the first to second estrus after puberty or weaning. Also, the length of the estrous cycle in any one pig showed remarkable consistency. In 75 per cent of the sows, estrous cycle length varied by only one day from the mean for the sow.

LITTER SIZE

In swine, litter size is a function of ovulation rate and embryonic death during pregnancy. The extent of death losses during pregnancy are shown in *Figure*

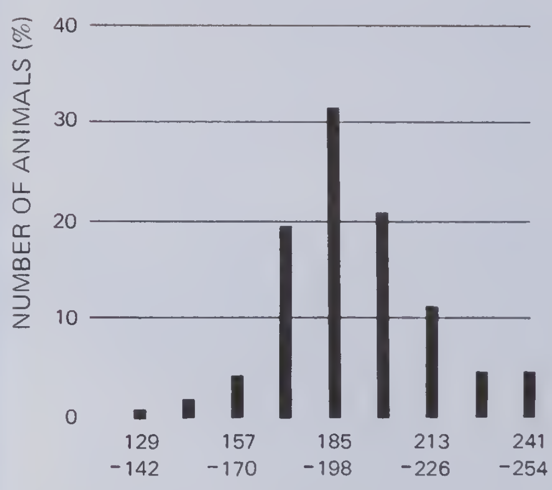


Fig. 1. Age-distribution of gilts at puberty.

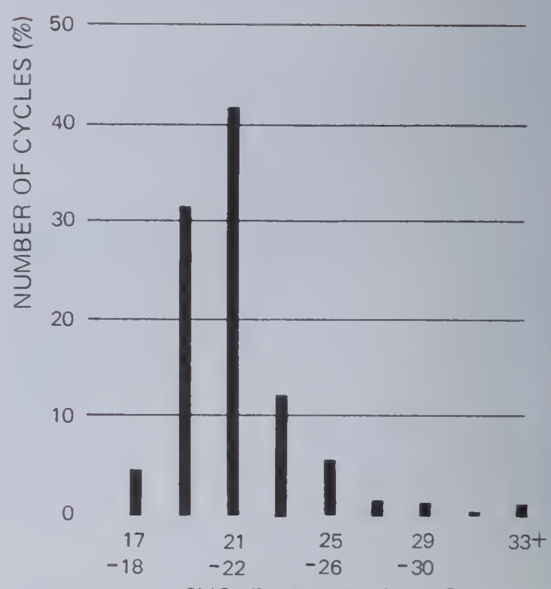


Fig. 2. Estrous cycle length distribution of gilts and sows.

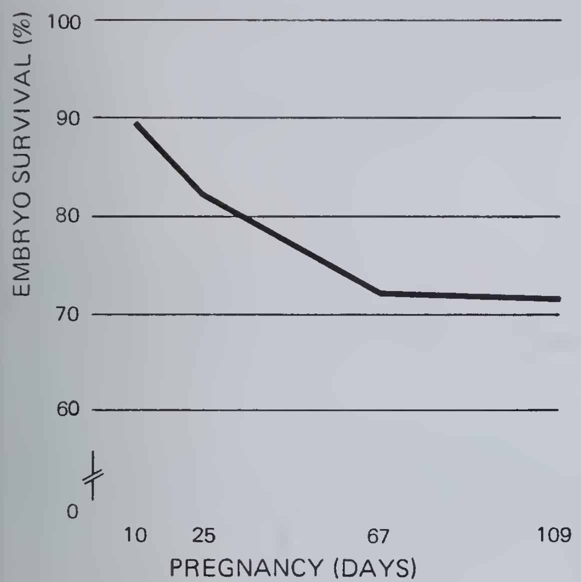


Fig. 3. Embryo survival at four stages of pregnancy.

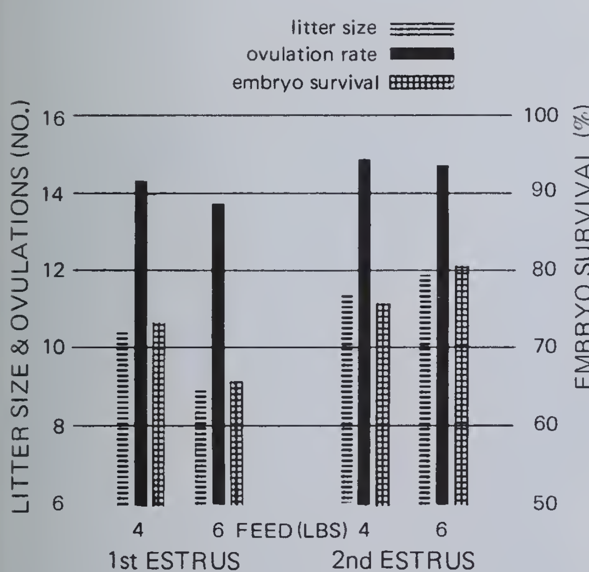


Fig. 4. Effect of level of feeding and breeding at first or second post-weaning estrus on litter size, ovulation rate and embryo survival at 67 days of pregnancy.

3. This graph shows that the majority of embryonic deaths occur during the first 25 days and that very few deaths occur after 67 days of pregnancy. The reduction of embryonic death losses is of primary importance to the producer. Management can play a significant role in reducing embryonic death losses and increasing litter size.

Where good management is maintained, housing conditions appear to have no effect on litter size. In a project designed to study the effect of environment temperature on litter size, gilts were housed individually either in a heated barn or in outside pens with boarded cabins for shelter during December, January, February and March. The gilts were bred during December and January, and killed after 66 days of pregnancy. Litter size at slaughter was the same for both groups of animals In a concomitant study, gilts housed inside showed no increase in body weight when fed 3.3 pounds per day, compared to a moderate gain on 6.6 pounds per day. Gilts housed outside had their daily feed consumption adjusted to provide similar average daily gains. This required approximately two more pounds of feed per day. Litter size was similar for both treatment groups. However, the ovulation rate was greater for the animals fed at the higher level indicating that embryonic death losses were greater.

In this study, 31 of 48 animals on the low level of feeding and 40 of 48 animals on the high level of feeding were pregnant at the time of slaughter. This indicates that the conception rate was reduced with the low level of feeding. There was both a failure of gilts to cycle (anestrus) and a failure to become pregnant when bred. Outside housing had no effect on conception rate. In other studies at the Brandon Research Station, it was observed that conception rate was greater for gilts bred at a mean daily temperature of −13°F, compared with breeding at above 10°F. Litter size also was improved by breeding on two consecutive days during estrus as opposed to one mating.

Breeding sows at the second estrus after weaning their first litter (six week lactation), rather than at the first estrus, resulted in a 2-pig increase in litter size at 67 days of pregnancy. This increase in litter size (shown in *Figure 4*) is a result of an increase in both ovulation rate and embryonic survival. In this study the sows were fed either four or six pounds of feed once daily. Feeding at a rate of six pounds per day resulted in a slight increase in litter size as compared to four pounds per day when breeding at the second estrus *(Figure 4).* However, when sows were bred at the first estrus after weaning, the higher level of feed consumption reduced litter size. The reduction in litter size is largely due to a decrease in embryo survival. The reasons for the detrimental effect of the higher level of feeding on litter size of sows bred at the first postweaning estrus is not clear from the results of this experiment. ■

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