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CANADA AGRICULTURE

A scanning electron microscope is giving scientists another perspective, such as this image of the labium and stylets of a six-spotted leafhopper. See story page 11.

Le microscope électronique à balayage donne aux chercheurs des perspectives nouvelles comme on peut en juger par cette photo du labium et des stylets d'une cicadelle à six points. (Voir page 11)

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Agriculture Canada

THE TRICKLE IRRIGATION SYSTEM

FACT OR FICTION...

D. S. STEVENSON

L'irrigation goutte à goutte sur le plan pratique convient, en principe du moins, aux vergers, aux vignobles, aux petits fruits et peut-être à plusieurs cultures sarclées. La pratique permet de réduire le coût de la main-d'oeuvre et les arrosages comparativement à toutes les méthodes traditionnelles d'irrigation. Il se peut que cette technique augmente le rendement et la qualité des cultures qui sont sensibles aux fluctuations de la teneur en eau du sol, mais il faut comparer avec soin le rendement avec les méthodes d'irrigation traditionnelles. Dans l'ensemble, l'irrigation goutte à goutte n'est peut-être pas aussi économique que les premiers rapports semblent indiquer.

Rarely has a technological change in farming techniques been written and talked about so much with so little solid experimentation to back it up as has trickle irrigation. This method has burst upon us with great and sometimes wild promises of doubling or tripling yields, of reducing labor, of saving large quantities of water, and all of this at very nominal costs. Evidence to support these promises is at best flimsy and highly optimistic, or sometimes completely lacking.

The purpose of this article is to examine each of these facets briefly and to try to present some realism, probing for the proper place and use of this new irrigation method.

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First, however, for those unfamiliar with the technique, trickle irrigation is a method of applying water for irrigation of crops at numerous dripping points all the time, or at least daily, throughout an entire field or orchard. In short, the quota of water for any field is applied over the whole field all the time. This is a radical departure from our normal practice of applying that same quota of water through a few sprinklers, or a few furrows, at a time and relying on the soil to store water for crop use until the sprinklers can return, anytime from a few days to several weeks hence.

WATER STORAGE

The fundamental difference, then, between conventional irrigation methods and trickle irrigation is that with the former we utilize the ability of soil to store water for long periods, but with the latter we must utilize a soil's capability for transferring water horizontally. Soil water storage is of minor consequence.

Without going into detail, we can describe trickle irrigation as a series of delivery pipes laid in parallel, with drippers, or emitters as they are often called, at intervals along each pipe. Spacing of delivery pipes depends upon the type of crop, kind of emitter and, most important, the spreading distance of water in soil.

Our objective in design is to space drippers so that the spreading circles of water in soil (not necessarily those we see at the surface) merge slightly, not unlike the overlap of circles from sprinklers though not to the same magnitude. For complete coverage of all the land the drippers must be spaced on a square, or perhaps offset triangular pattern so that the circles merge in all directions. For rows of close-spaced trees, vines, cane fruits, etc., where complete coverage may not be necessary, the wetted circles should merge along each row but not necessarily between rows. On wide spaced standard plantings of trees, each tree should be considered as the irrigable unit and the drippers spaced around each tree in such a way that they uniformly irrigate its root zone.

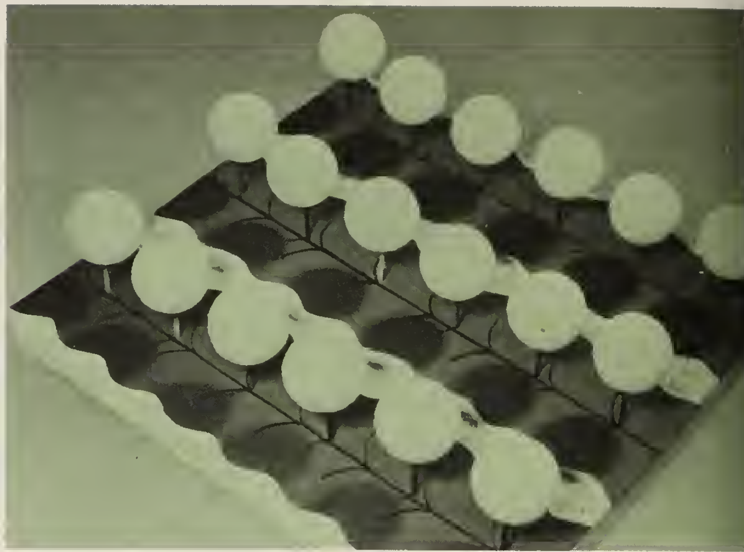
UNIFORM DISTRIBUTION

To achieve the desirable goal of as uniform distribution of water as possible, we should apply water at each dripper point at a rate that will satisfy the daily maximum horizontal transfer of water in a soil, before excessive quantities appear as drainage below the root zone. At the same time the rate must satisfy the daily water withdrawals by the crop over the same area of land surface as defined by the daily lateral transfer. This is the key to trickle irrigation design. We must match the input flow rate to the average daily withdrawal of water over the maximum, or near maximum, area of water spread from a dripper point. We then have the most efficient and economical irrigation that is possible with trickle irrigation.

We should add a little extra to the matched flow rate to avoid salt buildup in the soil, but if we greatly exceed the proper input rate we will overirrigate and waste water. If we fall short of that rate, there will not be enough water to keep up with the demand of the crop.

Our experiments so far have indicated that dripper spacings in the order of 5′ x 5′, 6′ x 6′, or 7′ x 7′ constitute the range of spacings on most soils. Thus, we cannot expect each dripper to irrigate more than 25 to 50 square feet. The differences between soils are not large, but they are important to the design and efficient operation of trickle systems.

The trickle method in its present stage of technology is almost totally unsuitable for pastures, forages, cereals, and other crops that cover the ground and are usually planted and harvested with machinery. An unburied system would be destroyed by harvesting



(Top) The concept of irrigating a strip along each tree row is illustrated in this scale model. Trees are 8 feet apart, drippers on a 6′ x 6′ spacing, rows 15 feet apart. The dark strip is irrigated, the narrow light strip between rows is not irrigated.

(Middle) A 6′ x 6′ spacing of dripper leaves a narrow strip not irrigated between rows 15 feet apart.

(Bottom) A narrow spacing of drippers (5′ x 5′) leaves a relatively wide dry strip between rows that are 15 feet apart.

machines; a buried system would be destroyed by cultivating and planting machines.

The method is probably not suitable for turf. The system would have to be buried, growth would have a tendency to appear as circles, and unless every dripper performed perfectly all the time, either very dry or excessively wet areas would appear. Each dripper, and there must be many of them, would produce a wet spot that would be most undesirable on a lawn that has normal use.

CROP RESPONSE

The potential for increasing yields of crops with trickle irrigation lies with those crops that are particularly sensitive to some degree of rising soil-water stress. Trickle irrigation can maintain low soil-water stress in most if not all the normal root zones of crops all the time. Conventional methods of irrigation usually permit periods of rising soil-water stress although any form of irrigation can be operated so as to prevent this, albeit perhaps not economically. Twofold or threefold increases in yields from trickle irrigation compared with conventional irrigation may or may not be realistic. Some increases may be as much a result of inadequate conventional irrigation as that of any outstanding effect from trickle irrigation. A small vineyard at the Summerland Research Station yielded almost identical tonnage under trickle irrigation in 1972 as it had under sprinklers in 1971. This, however, is not sufficient data from which to draw conclusions.

Once installed and operating properly, continuous flow trickle irrigation can reduce labor to almost zero except for periodic inspection and maintenance. This is not so if the system is designed for intermittent flow, unless it is somehow automated. Solid-set sprinkler systems, not automated, reduce labor to roughly 20% of a portable pipe system and to almost zero if it is automated. Compared with portable pipe sprinkler systems or furrow irrigation, trickle irrigation has great potential for lowering labor inputs.

Reduction in the amount of water applied is a most important facet of trickle irrigation in regions where water supplies are marginal. In orchards, vineyards and probably some small-fruit farms, not all the soil needs to be included in irrigation design. In a high density orchard, for example, we can design for efficient, adequate irrigation of a 12-foot strip along each tree row, if the rows are 15 feet apart, 3 feet mid-row or 20% of the land is not irrigated. This is an immediate application reduction of 20% compared with sprinklers. Wherever a 10-foot strip is adequate with rows 15 feet apart we can realize an application reduction of over 30%.

PEAK DEMAND

In areas like the Okanagan Valley, where farmers generally irrigate at or near the peak requirement steadily with sprinklers, application rates with trickle systems can be reduced below the peak requirement. Sprinkler systems are designed so that the farmer can safely complete one irrigation cycle during a peak demand period for his particular soil. If, for example, for a 5-day peak period we were to apply water through sprinklers at 100% of the peak demand but through tricklers at 80% of the peak demand—same soil, same peak period—we find by simple calculations that five consecutive peak periods are required under tricklers before the soil water content declines as much as it does in part of the orchard in one peak period under sprinklers. This is because the trickle system replaces water throughout the orchard continuously, with the result that the rate of decline of soil water content is only 20% of that in the orchard irrigated with sprinklers. Never do five consecutive peak periods occur; rarely do we experience two consecutive peaks. This feature alone gives the trickle system its greatest potential for reducing water applications.

Published cost estimates of trickle systems often tend to be highly optimistic. Many of the estimates do not account for installation labor, often the farmer's own, nor do they account for existing facilities already in place. We cannot writeoff capital costs of pumps, mainlines, labor that went into original installations and so on, simply because we change from sprinklers to trickle equipment.

We find that a microtube trickle system, which is probably the least expensive at this time, starting at the existing mainline carries a materials' cost up to and exceeding $200 per acre for an adequately designed system. To this we must add labor and a fair share of other fixed capital costs for reasonable comparison with conventional systems. Power costs may come down from those for sprinklers because operating pressures are significantly reduced. Pipe sizes of parts of the system may be reduced because less water is applied than with sprinkler systems and this also will lower costs.

So far, with all our testing the trickle method of irrigating has done an excellent, efficient job of applying water to tree fruits and a vineyard. Trickle systems must be designed to conform to basic principles of uniform distribution of water in the root zones of crops. Flow rates must relate to recommended or permissible acreage flows. The rates must be founded on the average daily water consumption by crops and on the areas of daily water spread that each soil is capable of before excessive quantities of water are lost as drainage below the roots of crops.

The technology of trickle irrigation is still in its infancy. Many refinements of equipment are required, not the least of which is adequate filtration of very large quantities of water. Assuming that technological problems can be solved, we have every reason to be optimistic about this new and somewhat revolutionary way of irrigating many, but not all, of our irrigable crops and croplands ■

FARMING ACID SOILS OF THE WESTERN CANADIAN PLAINS

P. B. HOYT

Dans l'ouest du Canada, la production de milliers d'acres est réduite par l'acidité du sol et la toxicité de l'aluminium. On recommande aux agriculteurs d'utiliser des cultures plus tolérantes et de chauler selon les indications fournies par l'analyse du sol.

Soil acidity was first recognized as a problem in western Canada in the mid-1960's. In Alberta and northeastern British Columbia (Peace River section of B.C.), about one-fifth of the total cultivated land has pH below 6.1. Of this area, approximately 100,000 acres of cultivated soil have pH below 5.1. There are another 1 million acres with pH from 5.1 to 5.5, and 4 million acres with pH 5.5 to 6.0. Also, there are 7 million acres with pH 6.1 to 6.5, some of which will probably fall below 6.1 with continued use of nitrogen fertilizers.

The problem was first recognized by researchers at the Beaverlodge Research Station, Agriculture Canada. This Station is located in the Peace River region of Alberta and B.C. where one-third of the soils have pH below 6.1. Research on these soils has also been conducted by members of staff of the University of Alberta, Edmonton; the Soil Research Institute, Agriculture Canada, Ottawa; and the Lacombe Research Station, Agriculture Canada.

To date, research has shown two main ways to increase agriculture productivity of acid soils. One is to grow crops that have a high tolerance for soil acidity. The other is to raise the soil pH by applying lime.

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GROWING TOLERANT CROPS

All of the major crops of the area have been compared for their growth on strongly acid and very strongly acid soils with and without applications of lime. The most tolerant crop is oats. Good yields of oats can be obtained on very strongly acid soils, providing they receive adequate fertilizer. Barley, on the other hand, is the least tolerant of the cereal and oilseed crops. Wheat and rapeseed were found to be intermediate in tolerance, and generally, responded about half as much to lime as did barley.

Red clover (Altaswede) is somewhat more tolerant than Alsike clover (Aurora), and considerably more tolerant than alfalfa (Ladak). In 28 field trials in Alberta and northeastern British Columbia, red clover yielded 2 tons per acre on soil with pH below 5.1, whereas alfalfa yielded less than 1 ton/acre (Table 1). On soils with pH 5.1 to 6.0, both red clover and alfalfa yielded 2 tons/acre. However, red clover did not respond to lime applications at pH 5.1 to 6.0, whereas alfalfa yields were increased by 1 ton/acre. Thus, in terms of potential yield on acid soils, red clover production is not as good an alternative as alfalfa production on limed soils. Grasses were generally more tolerant of soil acidity than legumes.

LIMING

In experiments conducted throughout Alberta and northeastern British Columbia during the two-year period, 1971-1972, alfalfa showed a surprising response to lime on Black Chernozemic soils (Fig. 1). This soil had a pH of 5.5, and on the average, liming doubled the yield of alfalfa hay on soils with this pH. Most of the lime response by alfalfa is usually due to improved nodulation and nitrogen fixation. The nitrogen-fixing bacterium, *Rhizobium meliloti,* is very

sensitive to soil pH below 6.0. *Rhizobium* survival, growth, and nodule formation were greatly improved by increasing the pH to above 6.0 by liming.

Although the response of alfalfa to lime was closely related to soil pH, responses of barley, rapeseed, and red clover, showed much better correlations with soluble soil aluminum than with soil pH. In strongly acid soils (pH below 5.5) soluble aluminum often reaches levels which are toxic to plants. By analyzing farmer's soil samples for soluble aluminum, the liming requirement for most crops can be predicted.

The amount of soluble aluminum critical for growth of barley is about 2 ppm. Soils with higher quantities of soluble aluminum require lime for barley production. The response of barley to lime on a soil with 30 ppm of soluble aluminum is shown in Figure 2. In soils with less than 2 ppm aluminum, there is also a response to lime because of the release of nitrogen. However, the major damage to crops by soil acidity is aluminum toxicity. Hence, the measurement of aluminum gives the best estimate of long-term expected benefit from liming.

The need for lime on some soils in Alberta and northeastern British Columbia has been established, but the availability of liming materials at economic prices is a problem. Hopefully, the interest of farmers in using lime will create sufficient demand to enable the lime industry to supply their poducts at reasonable prices. Even so, it will take a great amount of lime and considerable expenditure to bring all of the acid soils of this region to the best pH level for crop production. Hence the use of acid tolerant crops is an important part of farming acid soils.

RECOMMENDATIONS

In the fall of 1973, the Alberta Soil Testing Laboratory in Edmonton and the British Columbia Soil Testing Laboratory in Kelowna, began a soil testing program for acid soils of Alberta and the northeastern part of British Columbia.

If a farmer submits soil samples from land on which he intends to grow alfalfa, and if the laboratory tests on these samples show a pH in the range 5.6 to 5.9, then the farmer will be advised to resample the field in more detail. Tests will be made on the new samples, to find the amount of lime needed to bring the soil to pH 6.2.

For soils with pH 5.5 and below, the farmer will be advised to resample the field in more detail. Tests will be made on the new samples to find the amount of lime needed to rid the soil of toxic quantities of aluminum, so that grain crops can be grown. Also, tests will be made to find the amount of lime required to bring the soil to pH 6.2, so that alfalfa or any other crop may be grown.

Thus it is hoped that soil analysis will be the basis for all lime recommendations. These recommendations are aimed at correcting acidity problems where they are most pressing and where there will be a definite and noticeable response to liming. ■

Figure 1 (Top) Response of alfalfa to lime at Wanham, Alta.

Figure 2 (Bottom) Response of barley to lime at Silver Valley, Alta.

TABLE 1 YIELDS OF RED CLOVER AND ALFALFA ON VARIOUS SOILS

		Average yields of hay (tons/ac)			
Crop	Soil pH	No. of sites	Without lime	Limed	Increase from lime
Red clover	5.0 and lower	6	2.0	3.0	1.0
	5.1 to 5.5	13	1.8	1.9	0.1
	5.6 to 6.0	7	2.3	2.4	0.1
Alfalfa	5.0 and lower	6	0.8	3.2	2.4
	5.1 to 5.5	13	1.6	2.7	1.1
	5.6 to 6.0	8	2.2	3.2	1.0

NOTE: The results are based on the results of 28 field experiments.

AUGMENTEZ LE RENDEMENT ET LA VALEUR ALIMENTAIRE DE VOTRE ENSILAGE DE MAÏS

G. PELLETIER et J. GENEST

Research at Lennoxville, Que. indicates that maximum yield of corn silage can be obtained by growing a hybrid rated at 2900 heat units in Zone A (2500 to 2700 heat units); and a hybrid rated at 2800 heat units in Zone B (2300 to 2500 heat units). Hybrids rated at 2700 heat units give maximum yields in Zone C or with less than 2300 heat units.

La production de maïs pour l'ensilage obtient une faveur grandissante dans l'Est du Canada. La création de nouveaux hybribes, la lutte contre les mauvaises herbes, la fertilisation adéquate et le perfectionnement des machines de récolte ont permi l'élargissement des zones propices à cette culture. Dans les régions où la formation complète du grain n'est pas assurée en raison des conditions climatiques, à quel stade doit-on récolter le maïs pour en faire un ensilage de qualité? Quel hybride doit-on utiliser? Que faut-il faire pour récolter tous ces champs de maïs au stade optimum?

Ces trois dernières années, la Station de recherches de Lennoxville a effectué des expériences afin de répondre à ces questions. Dans la région de l'Estrie certains cultivateurs récoltent leur maïs à la fin d'août ou au début de septembre. Les grains sont alors au stade laiteux et la teneur en matière sèche du plant entier n'est guère supérieure à 20%. Cette pratique conduit à une perte variant de 1 à 2 tonnes de fourrage sec par acre en plus de fournir un ensilage de qualité inférieure à celui récolté à la fin de septembre comme en témoigne le tableau 2. En effet les hybrides de 2700 Unités Thermiques (U.T.M.) et de 3000 (U.T.M.) produisent des rendements de fourrage sec de 1 et 2 tonnes (entre 3.5 et 7 tonnes d'ensilage) de plus respectivement s'ils sont récoltés à la fin de septembre plutôt qu'au début de septembre. La teneur en protéine et en fibre diminuent légèrement avec une maturité plus avancée. La consommation d'ensilage est plus forte quand celui ci est récolté à un stade plus avancé, donc quand l'ensilage contient moins d'eau. Alors, pour une consommation d'égal volume, l'animal bénéficie d'une ingestion plus grande de matière sèche avec l'ensilage provenant d'un hybride de 2700(U.T.M.)récolté au stade tardif. Par conséquent, les gains de poids par jour sont plus élevés. L'efficacité alimentaire est améliorée et les gains de poids par acre plus élevés de 300 à 500 lb avec le maïs récolté à un stade plus avancé. Il n'y a aucun doute maintenant que le maïs récolté au stade

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plus avancé fourni les meilleurs rendements d'un fourrage de meilleure qualité.

Dans la zone A, (2500-2700 U.T.M.) on récolte le maïs pour l'ensilage au stade pâteux ou lorsqu'il contient de 30 à 33% de matière sèche. On obtient alors un fourrage de bonne qualité (tableau 1).

L'ensilage récolté à 33% de matière sèche est consommé en plus grande quantité par les vaches laitières et conséquemment la production de lait est augmentée. Toutefois, si la teneur en matière sèche à la récolte est supérieure à 33% la consommation sera moindre et se traduira par une diminution de la production du lait ou de chair.

Les essais de maïs hybrides pour la production d'ensilage effectués dans les diverses zones de la province indiquent que les rendements des hybrides de 2500 U.T.M. sont généralement inférieurs à 4.5 tonnes de matières sèches à l'acre même en zone A tandis que la performance moyenne des hybrides de 2600 U.T.M. se situe aux environ de 5 tonnes de M.S./acre. Les tableaux ci-dessous démontrent qu'en zone A les rendements maxima proviennent d'hybrides de 2900 U.T.M. et qu'en zones B et C ils proviennent d'hybrides de 2800 U.T.M. Si les semis tardent, des hybrides de 2700 U.T.M. seront appropriés (tableau 3).

Comme on peut le voir, la réponse à la question posée au début du texte à savoir "quel hybride doit-on semer?", varie selon les objectifs recherchés. Si l'on veut maximiser la production par unité de surface les hybrides de
2900 U.T.M. dans la zone 2500-2700 U.T.M.
2800 U.T.M. dans la zone 2300-2500 U.T.M.
2700 U.T.M. lorsque moins de 2300 U.T.M.
peuvent être utilisés.

Comment concilier les objectifs visant à maximiser la production fourragère tout en maximisant la production bovine?

La réponse varie sans doute avec les exploitations. Un exploitant devant acheter des aliments hors de la ferme aura sans doute intérêt à augmenter la production à l'acre tandis que celui qui subsiste amplement au besoin de son troupeau pourra sacrifier un peu de rendement à une augmentation de la qualité. Enfin, on peut également diminuer la teneur en humidité de l'ensilage et ainsi en obtenir de meilleures performances alimentaires en le récoltant quelques jours après une gelée à 28°F.

La gelée n'affecte pas la composition chimique de la plante ni n'avance la maturité mais diminue la teneur en eau. La réduction de l'humidité permet une meilleure fermentation dans le silo et en fait tout simplement un aliment mieux accepté par les animaux qui se traduit par une légère augmentation de la consommation et une amélioration de l'efficacité alimentaire (tableau 4). Il ne faut pas trop retarder la coupe

TABLEAU 1 COMPOSITION CHIMIQUE ET CONSOMMATION DU MAÏS RÉCOLTÉ À DIFFÉRENTS STADES DE MATURITÉ 1962-1963

Stade de maturité	Pâteux mou	Pâteux	Pâteux dur
Teneur en matière sèche (%)	25.4	30.3	33.3
Protéine brute	8.3	7.9	8.1
Cellulose brute	26.2	23.1	21.8
Matière sèche d'ensilage consommée par jour lb/100 lb de poids	1.95	2.13	2.31
Production de lait par jour par vache (lb)	39	42	43

après la gelée car les feuilles se dessèchent et ceci occasionne une perte de fourrage et une diminution de la qualité. Toutefois, l'utilisation d'un sas recoupeur diminue ces pertes. Le maïs devrait donc être récolté au stade pâteux ou après une gelée dans les zones où le grain n'atteint pas une formation complète. Comment peut-on alors récolter tout le maïs au stade optimum? Le tout commence par la date du semis. Il est impératif de semer le maïs tôt au printemps mais aussi quand le sol est réchauffé. Le choix de la variété adéquate est aussi d'importance. Les hybrides trop tardifs peuvent donner des rendements élevés d'ensilage mais à des teneurs en humidité excessives. Si le terrain le permet, le producteur qui possède plusieurs champs de maïs devrait commencer à récolter le champ où la maturité du maïs est la plus avancée. La récolte devra attendre que le maïs ait atteint le stade pâteux dur ou que la gelée ait enlevé l'excès d'humidité, (tableau 4).

En résumé, le producteur d'ensilage de maïs qui veut obtenir des rendements maximums utilisera un hybride de 2900 U.T.M. dans la zone 2500-2700 U.T.M.; de 2800 U.T.M. dans la zone 2300-2500 U.T.M.; les hybrides de 2700 U.T.M. dans les zones de moins de 2300 U.T.M., ainsi que pour les semis tardifs. ■

TABLEAU 2 COMPOSITION CHIMIQUE ET VALEUR ALIMENTAIRE DE L'ENSILAGE DE MAÏS PROVENANT DE VARIÉTÉS À MATURATION HÂTIVE 1966-1968

Date de récolte Stade de maturité	Hybride de maturation semi-hâtive 2700 U.T.M.			Hybride de maturation tardive 3000 U.T.M.		
	6 septembre Grain laiteux	26 septembre Grain pâteux	Moyenne	6 septembre Grain laiteux mou	26 septembre Grain laiteux	Moyenne
Rendement de M.S. tonne/acre	5.0	6.0	5.5	4.8	6.9	5.9
Teneur en M.S.	20.9	25.6	23.2	18.1	21.9	20.1
Protéine brute %	9.0	8.2	8.6	10.2	9.4	9.8
Cellulose brute %	27.4	23.5	25.5	30.0	26.3	28.1
Quantité de matière sèche consommée par bouvillon par jour (lb)	7.8	8.8	8.3	7.7	8.1	7.9
Gain de poids par bouvillon et par jour (lb)	0.71	0.93	0.82	0.66	0.77	0.71
M.S. d'ensilage consommée par lb de gain (lb)	11.0	9.5	10.3	11.7	10.5	11.1
Gain de poids calculé par acre de maïs ensilage (lb)	917	1266	1091	832	1317	1075

TABLEAU 3 PERFORMANCE DES HYBRIDES DE MAÏS POUR LA PRODUCTION D'ENSILAGE[1]

Catégorie d'hybrides U.T.M.	Rendements matière sèche tonne/acre	% humidité	Épis %
	Zone 2500 U.T.M.		
2700 U.T.	6.25	70	52
2800 U.T.	6.50	71	51
2900 U.T.	6.90	72	45
3000 U.T.	6.66	74	48
	Zone 2300 U.T.M.		
2600 U.T.	4.93	72	53
2700 U.T.	5.46	74	45
2800 U.T.	5.84	74	46
2900 U.T.	5.70	76	37
3000 U.T.	5.66	76	40

[1]Données extraites des Rapports des essais de maïs (CPVQ) 1968-1972.

TABLEAU 4 COMPOSITION CHIMIQUE ET PERFORMANCES DES BOUVILLONS ALIMENTÉS À L'ENSILAGE DE MAÏS RÉCOLTÉ AU STADE PÂTEUX-MOU ET APRÈS UNE GELÉE. 1971-1972

Date de récolte Stade de maturité	Mi-septembre Grain pâteux mou	Fin-septembre Après une gelée
Matière sèche (%)	23.5	29.5
Protéine brute (%)	8.5	8.6
Cellulose brute (%)	22.3	24.6
Quantité de matière sèche consommé par bouvillon et par jour (lb)	9.5	10.5
Gain de poids par bouvillon et par jour (lb)	0.88	0.95
Matière sèche d'ensilage consommé par lb de gain de poids (lb)	12.0	11.0

Greatly enlarged photograph of a pea aphid with its mouthparts inserted deeply into a plant.

MOUTHPARTS OF SUCKING INSECTS

A. R. FORBES

Les pucerons et les cicadelles sont de bons vecteurs de maladies des plantes car ils ont des mandibules spécialement adaptées pour sucer les sucs des plantes. La connaissance de la structure des mandibules et des organes sensoriels de ces insectes peut contribuer à l'élaboration de méthodes de lutte contre la propagation des maladies.

Sucking insects have greatly modified mouthparts enabling them to feed by sucking fluids from plants or animals. One group, including aphids and leafhoppers, is specialized for piercing plants and sucking up plant juices. Another group, including mosquitoes and bedbugs, is specialized for piercing (biting) animals and sucking up blood.

At the Research Station at Vancouver we are particularly interested in studying the mouthparts of the first group, using both transmission and scanning electron microscopes. We are studying this group of insects because they convey highly destructive diseases from plant to plant during feeding; they are vectors of disease-producing agents. We are concentrating on their mouthparts because it is these structures that pick up the virus or other pathogens from a diseased plant and carry it to a healthy one.

All insects that suck juice from plants have remarkably similar mouthparts, which consist of four needle-like bristles or stylets. These stylets are extreme modifications of the tooth-like mandibles and maxillae of chewing insects such as grasshoppers. They are enclosed in a tube-like structure called a labium. The labium has important sensory structures on it.

STRUCTURE OF STYLETS

In aphids, such as the pea aphid, the stylets are about 500 microns or ½ millimeter long and look like tiny pieces of hair when dissected out. In cross-sections it can be seen that the stylets are in two pairs: the inner pair are the maxillary stylets and the outer pair are the madibular stylets. The maxillary stylets are interlocked to enclose a large canal for sucking food and a smaller salivary canal. When piercing a plant, the madibular stylets work alternately, making a channel for the maxillary stylets. When feeding, the aphid sucks plant sap up the food canal and pumps saliva down the salivary canal. The mandibular stylets each contain a central duct which has two nerves running to the tip. The outer surface of the mandibular stylet near the tip has a series of barb-like ridges. The tip of each mandibular stylet is

Dr. Forbes is an entomologist at the CDA Research Station, Vancouver, B.C.




very sharply pointed, making it ideal for penetrating plant tissue.

Aphids show varying degrees of host specificity. That is, some aphids feed on only one or a very few plants, others feed on a limited range of related plants, while still others feed on a wide range of plants from many different families. It is evident then, that aphids must have sensory mechanisms to distinguish different plants. It seems probable that the nerves in the mandibular stylets are important for identifying plants, perhaps by detecting specific chemical substances in them.

The labium also has sensory structures on it, including 16 sensory cones at the tip. When an aphid first settles on a leaf, it taps the surface with the tip of the labium to find cell walls and a suitable place for probing. The sensory cones apparently detect the correct spots to pierce and may also help in identifying the plant.

LEAFHOPPER STYLETS

The stylets of leafhoppers are longer and sturdier than those of aphids. In the six-spotted leafhopper, both the mandibular stylets and the maxillary stylets have nerves. There are three nerves in the mandibular stylets and five in the maxillary stylets. The mandibular stylets in leafhoppers are conspicuously barbed, producing a saw-like structure capable of rapid penetration of plant tissue. The labium of leafhoppers has more kinds of sensory structures on it than does the labium of aphids. Sections of the sensory cones at the tip of the labium when studied in the transmission electron microscope show that there are two or three different types of cones. Some apparently detect chemical substances in the plants and others may identify surface features on leaves.

The mouthparts of other insects that transmit plant virus diseases have also been studied here at

(Far left) Greatly enlarged photograph of a six-spotted leafhopper.

(Middle left) The tip of the labium of the green peach aphid as seen with the scanning electron microscope.

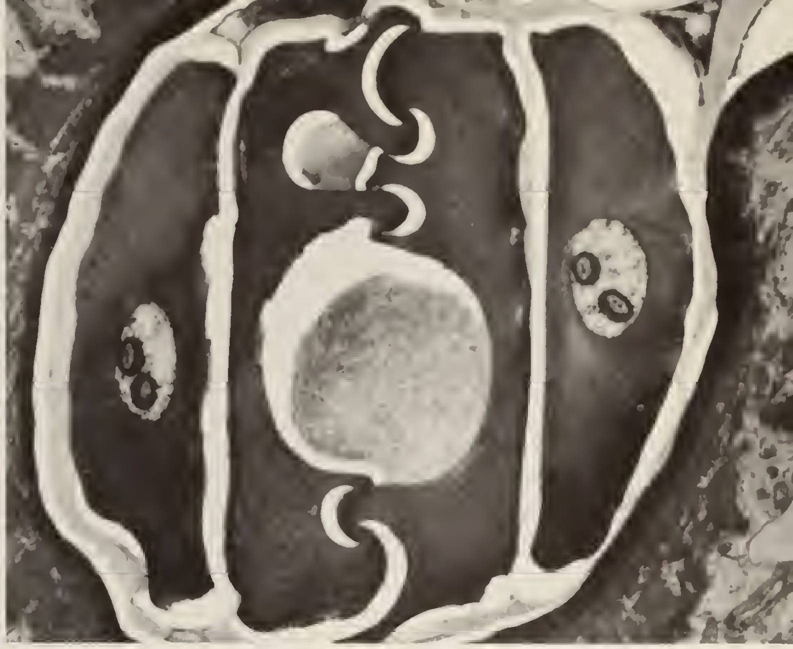
(Bottom left) A cross-section of the stylets of the six-spotted leafhopper.

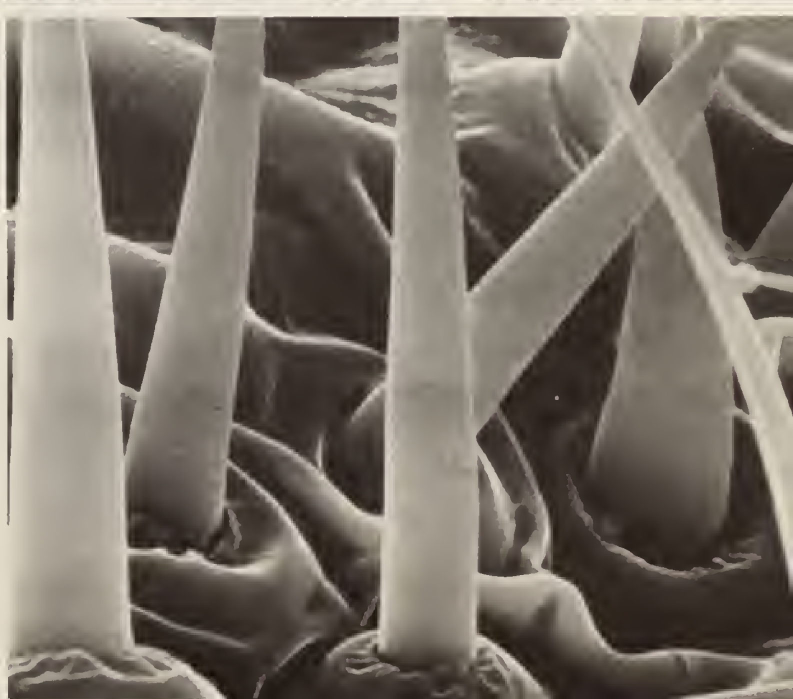
(Left) A general view of the labium of the six-spotted leafhopper. The stylets are protruding from the slit along the labium. The labium is covered with sensory hairs.

(Right) A cross-section of the stylets of the pea aphid as seen with the transmission electron microscope.

(Middle right) A highly magnified view of the tips of the stylets of the six-spotted leafhopper.

(Bottom right) A highly magnified view of the sensory cones on the tip of the labium of the six-spotted leafhopper.





Vancouver. The mouthparts of the greenhouse whitefly and the pear psylla are remarkably like those of their relatives, the aphids.

VIRUS TRANSMISSION

Knowing the structure of the stylets of vector insects and how they function tells a great deal about how disease-causing agents, such as viruses or mycoplasmas, are acquired from diseased plants and transmitted to healthy ones. Some aphid-transmitted viruses, the so-called stylet-borne viruses, are picked up as contaminants on the aphid's mouthparts when they probe the epidermis of a diseased plant and are inoculated into the epidermis of other plants which the aphid probes soon after leaving the diseased plant. The virus particles may be carried behind the barb-like ridges that occur on the mandibular stylets. Other aphid-transmitted viruses, the so-called circulative viruses, are picked up from the phloem along with the plant sap by way of the food canal. The virus particles pass through the gut wall, enter the salivary glands, and are injected with the saliva into the phloem of another plant when the aphid feeds again. The leafhopper-borne viruses and mycoplasmas are acquired and transmitted in a manner similar to that described for the circulative aphid-borne viruses.

Knowing about the sensory structures on the mouthparts gives us clues on how these insects find their host plants and feeding sites. We may be able to determine what particular chemical substance or surface features of a plant induce feeding by the insects. Plant breeders may then be able to modify crop plants so as to make them unacceptable to vectors of disease-causing agents.

The ultimate objective of these and other basic studies is, of course, to devise ways to stop or slow the spread of plant diseases. ■

PEST MANAGEMENT IN ONTARIO APPLE ORCHARDS

E. A. C. HAGLEY

Lorsqu'un programme de lutte contre le Tétranique rouge du pommier aura été mis au point, et que les progrès dans la lutte contre les maladies permettront de modifier les calendriers de traitements par pulvérisation, un programme global de lutte contre les ravageurs sera disponible pour les vergers à pommes de l'Ontario. L'application de ce programme global permettra la lutte contre les principaux ravageurs de la pomme avec le minimum de produits chimiques.

The major insect pests of apples in Ontario are the codling moth and the apple maggot. The plum curculio, some fruitworms, and leafrollers and aphids also cause economic damage in some localities or in individual orchards. Recommendations made to growers for control of these insects usually embody one "calyx" and six to seven "cover" sprays applied at 7-10 day intervals throughout the growing season. In addition, a grower might apply six or seven other sprays to control specific pests not controlled by the "calyx" and "cover" sprays.

A modified spray program has been developed that has given good control of the major pest species using the following four sprays as a minimum:

(i) at "calyx", primarily against fruitworms, redbanded leaf-roller, plum curculio, and some species of plant bug;

(ii) at about the time the second "cover" spray is usually applied, or a few days later, to coincide with maximum codling moth emergence. Depending on the insecticide used, this spray can also give some control of the green apple aphid which sometimes causes severe damage on young trees:

(iii) 8-10 days after the commencement of apple maggot emergence. This is generally about mid-July but the spray can be delayed or advanced, depending on the interval between maximum hatch of codling moth eggs and the appearance of the first maggot;

(iv) during the second or third week in August to control late first or second generation codling moth larvae, as well as the apple maggot.

At least two additional sprays will probably be needed in some years, due to the occurrence of pests not controlled under the above program. As an annual oil spray is not recommended because of its adverse effects on certain insect predators, as well as its phytotoxicity, scales, rosy aphid, and some other early season pests may cause economic damage in some areas. Under such circumstances, a dormant oil spray may be applied to reduce their numbers to levels that can be maintained under the general program. It has also become evident that the oblique banded leafroller and the green apple budworm are becoming increasingly important pests in Ontario orchards. These species, fruitworms and other lepidoptera and, perhaps, some plant bugs, will have to be controlled by a prebloom insecticide spray applied at "½ green" to "tight cluster" as indicated by their occurrence in individual orchards.

SPECIFIC PESTS

Further, some pests will be more abundant in certain orchards than in others, and individual

Dr. Hagley is an entomologist in the fruit protection section, CDA Research Station, Vineland, Ont.

orchards will have specific pest problems. Hence, control measures must be taken in individual orchards as these pests occur.

The modified program using the insecticides guthion and imidan at 12-15 oz and 2-3 lb per acre, respectively, has been used effectively in two orchards during 1971-73. In both orchards control of early season caterpillars was achieved by using about 4-6 oz guthion per acre.

On young, non-bearing trees pest populations were managed with 2-3 sprays, usually a prebloom guthion spray, a "calyx" spray and one application of an aphicide. The latter spray reduced populations of the green apple aphid to noneconomic levels that were maintained by its parasites and predators. In some cases a special spray may be needed for control of leafhoppers.

Codling moth fruit injury.

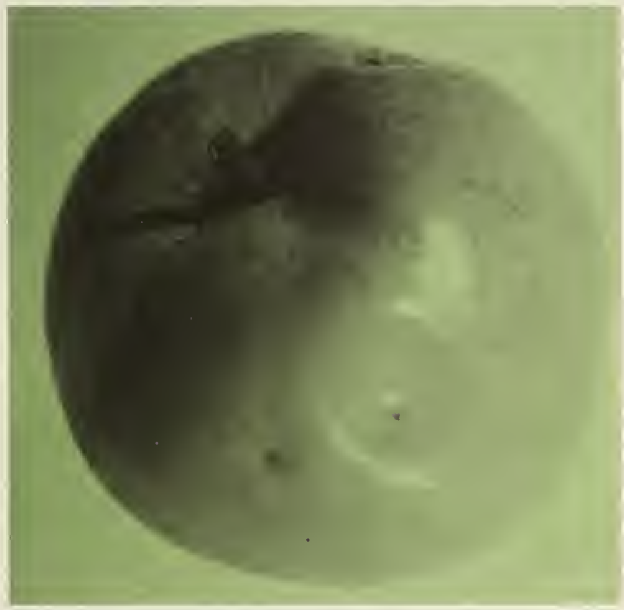
PEST MONITORING

Sprays must be properly timed for maximum effect on the target organisms and minimum adverse effects on parasites and predators. Insect populations are therefore monitored in the orchard with sex attractant and other traps, and frequent visual inspections of trees to determine pest occurrence and abundance. Sprays timed to maximize their effect against the target organism are then applied only if the pest is present in a developmental stage that is likely to cause economic injury.

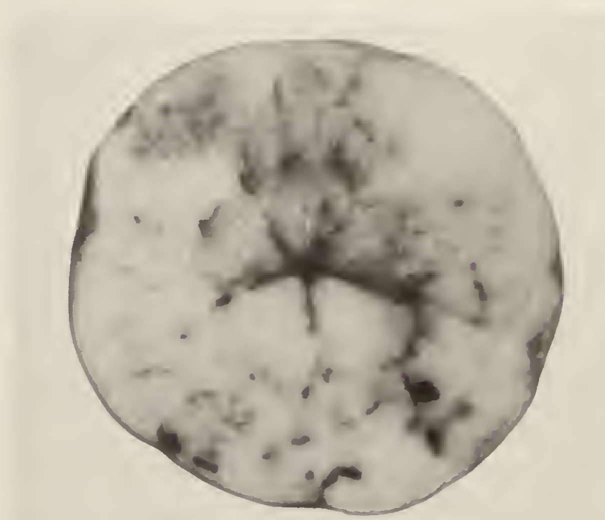
As populations of the major pests are not generally regulated by specific parasites or predators, sprays must also be timed to preserve as many as possible of the total beneficial fauna present in the orchard. Indeed, the future timing of sprays will probably be influenced to a greater degree than at present by the occurrence of predator species or groups as their relative importance in the ecosystem becomes established.

Refinements in timing will also result from increased ecological knowledge of the pest species, advances in monitoring techniques, development of bioclimatic indices and the establishment of economic thresholds. The additional information will enable a pest warning system to be developed and form the basis for the implementation of other control methods employing sex attractants, hormones, genetic manipulation and artificial sterilization.

Finally, when a program for controlling European red mite with one summer spray has been developed and advances in control of diseases (especially apple scab) enable a modification of spray schedules, a total pest management system will be available. Implementation of such a management system will ensure control of the major apple pests with a minimum use of pesticides. It will maximize the effect of beneficial species on pest populations, minimize adverse environmental effects, and save time and money for the grower. ■



Apple maggot oviposition punctures.



Apple maggot fruit injury.

ECHOES
FROM THE FIELD AND LAB

A group of processors taste testing new varieties of green and wax beans at the recent display of processed vegetable varieties held at the Research Station, Kentville.

PROCESSOR-GOVERNMENT EXCHANGE Representatives from seven Maritime vegetable processing firms were at the Kentville Research Station recently to view processed vegetables. Frozen and canned samples of 125 vegetable varieties produced at the Research Station were on display. These consisted of snap, lima, broad and shell beans, brussels sprouts, carrots, corn (on cob), peas and squash. All the products were processed fresh from the Research Station Trial Plots during the growing season, just as they would be handled commercially. From this annual review, processors were able to select varieties adaptable to the Maritimes and to their own particular requirements.

Representatives from three government departments: Agriculture Canada, Department of National Health and Welfare (Food and Drug Inspectorate), and the Department of Consumer and Corporate Affairs made presentations. These departments are all responsible for formulating and administering a multiplicity of regulations governing the labelling and identity standards of foodstuffs.

Very often the processor looking for a new label design or introducing a new product finds himself involved in a profusion of regulations. This was an opportunity for processors to hear exactly what segments of the regulations each department is responsible for, and also to question the representatives on specific problems which arise from time to time.

SAVING MONEY AND EFFORT In spite of less insecticide use, the Nova Scotia apple crop in 1973 was exceptionally free of insect damage. A preharvest survey of 68 orchards has shown that 98 percent of the fruit was free of insect damage from a wide range of individual species of pests, CDA Research Station, Kentville, N.S. reports.

The efficient use of pheromone traps by many growers in monitoring codling moth populations resulted in more timely and fewer applications, frequently at lower dosages, of pesticides normally recommended against this potentially damaging pest. The smaller use of pesticides allowed natural enemies to be more common and possibly more efficient in reducing numbers of secondary pests and subsequent damage to fruit.

AGRICULTURE CANADA REORGANIZATION After the establishment of the new Biosystematics Research Institute from the amalgamation of the Entomology Research Institute and the Plant Research Institute, a Committee under the chairmanship of the Director was established in order to reorganize the Taxonomy and Economic Botany Section. As a result this section has been divided into two new sections: the Cultivated Crop Section and the noxious and Native Plant Section.

The Cultivated Crop Section is working on the taxonomy of cereal crops, forage crops, vegetable crops, grasses, and ornamental plants. The main task is to find the relationships between the cultivated crop species and their wild allies, so as to enable research in the tapping of useful genes from the wild, and transferring them to the cultivated plants.

The role of these activities is of fundamental importance in the Research Branch for ongoing breeding problems, collection of gene pools, seed analysis and conservation. Also as a result of these activities and the resulting expertise, an identification service will be made available to this Department, to other government agencies, and to the public.

GROUND SPRAYING During infestations of bertha armyworm in the Lethbridge area, some rapeseed growers suffered losses because they had to wait several days before the arrival of sprayer aircraft. Tests carried out by Dr. W. A. Charnetski, CDA Research Station, Lethbridge Alta. indicate that they could have sprayed immediately with wheeled vehicles.

Equipment used in the tests to measure losses due to crushing included two types of self-propelled swathers, a small tractor mounted with sprayers and a commercial, self-propelled sprayer.

The key factor measured in the experiments was the total wheel track, computed by multiplying the number of wheels on the vehicle by the tire width. The implements were driven through the fields at intervals of 50 feet and it was found that losses were acceptable when total wheel track was less than 24 inches.

A major loss—about 11 per cent—occurred with one of the swathers that had six wheels, each seven and one-half inches wide, for a total wheel track of 45 inches.

Generally, it is concluded that ground spraying of rapeseed may be an acceptable alternative when aerial application is uneconomical or impractical.

BROADENING OF WMO AGROMETEOROLOGY PROGRAM Expertise and methodology developed in agricultural meteorology should be applied more extensively to the study of forest meteorology problems. This is one of the several recommendations made by the U.N. Interagency Group on Agricultural Biometeorology at its recent 6th Session in Rome.

Wolfgang Baier, of CDA Chemistry and Biology Research Institute, in his capacity as President of the WMO Commission for Agricultural Meteorology, attended this meeting. The Group reviewed a special report "Research needs in forest meteorology" prepared by Prof. William E. Reifsnyder, School of Forestry and Environmental Studies, Yale University. The Commission was requested to use the WMO machinery for preparing a manual or reference book that would bring together existing knowledge

ECHOS
DES LABOS ET D'AILLEURS

about the application of meteorology to environmental forest problems. Attention should be paid to the use of this knowledge in forestry planning and operations, effects of shelter belts on areal climate, basic exchange processes in forests, and forest fires in relation to atmospheric conditions.

Other items discussed at the meeting included the agroclimatological surveys in Latin America and South-East Asia, the Sahelian drought program and agrometeorological activities by WMO, Unesco and FAO, especially the world food appraisal and security programmes. The Group recognized the potential value of supplementing the existing FAO early crop-warning system by quantitative crop-yield assessments through the use of climatological techniques similar to those developed and now in operation in Canada.

CONTAMINATED POLLEN A NEW PROBLEM FOR BEEKEEPERS In order to prevent the spread of infectious bee diseases, provincial and federal regulations control shipment and sale of used combs and the use of honey for feeding bees. A new problem has arisen from the increasing production of bee-collected pollen for sale to other beekeepers who need supplemental food for their colonies. Recently, Tom Gochnauer, Ottawa Research Station, and John Corner, British Columbia Department of Agriculture, detected and identified bee disease bacteria in a sample of commercial pollen collected in B.C. The pollen caused an outbreak of American foulbrood disease when fed to a healthy colony. A pure culture of the disease organism, *Bacillus larvae,* was obtained from the pollen. The bacteria are not harmful when the pollen is eaten by humans but contaminated pollen is a threat to the honey industry in Canada which contributes substantially to the agricultural economy.

CONTROL DIFFICULT The $4 to $5 million cherry industry in the Okanagan Valley is seriously threatened by a new outbreak of little cherry disease, CDA Production and Marketing officials observe.

This is the same disease that wrought havoc with the cherry industry in the Kootenays during the period 1933-50, and prospects of the same thing occurring in the Okanagan are serious unless the disease is eradicated now. Dr. O'Reilly, provincial plant pathologist, says the removal of all trees known or suspected of having little cherry disease is the only practical method of preventing further spread. No method has been devised whereby the disease can be cured by sprays or other means.

An extensive survey of Okanagan Valley cherry trees was conducted by the B.C. Department of Agriculture following the initial discovery of little cherry in the Penticton area in the summer of 1969. No new cases were found until last summer, when a total of 108 positively diseased or suspicious trees were discovered during the annual survey. The B.C. department has been making every effort to explore unknown areas that may help in combating the spread of little cherry disease. Growers are being urged to report suspicious trees to their district horticulturist. The future of B.C.'s cherry industry now depends upon this cooperation.

ALBERTA DROUGHT A summary of the 1973 weather records from the Lethbridge Research Station shows that precipitation was below normal in every month except November. The total for the year was only 9.60 inches and is the third lowest in 72 years of records. It was also the sixth consecutive year with below-normal precipitation, which ties the previous long-term low precipitation period (1917-1922). Drought was not nearly as severe or as prolonged at Lethbridge in the infamous 1930's as in either the 1920 or the present period. The current drought was general throughout the southwest corner of the province and was even more severe at several recording stations than at Lethbridge.

Although hay and pasture crops suffered badly, cereal yields on fallow were remarkably good and there were few instances of serious soil erosion. This indicates that soil tillage, erosion control, and other production methods have improved substantially since "the dirty thirties" and that farmers' practices in 1973 were generally effective in preventing serious difficulties and in obtaining reasonable production in spite of adverse weather.

PHEASANT FOR FOOD, FUN AND FANCIERS A new publication, entitled "Pheasants", published by Agriculture Canada, clearly outlines production practices and uses of pheasants raised on a commercial scale. Written by men in the business, A. and D. Streih and Sons of Uplands Pheasantry, Alymer, Ontario, and D. A. Fletcher, Production and Marketing Branch, Agriculture Canada, Ottawa, the book opens with a description of breeds and breeding, then continues through rearing, housing, feeding and sanitation to processing and merchandising.

Color photographs 'worth a thousand words' describe the beauty of pheasantry, while other photos and many diagrams illustrate the technical aspects of management.

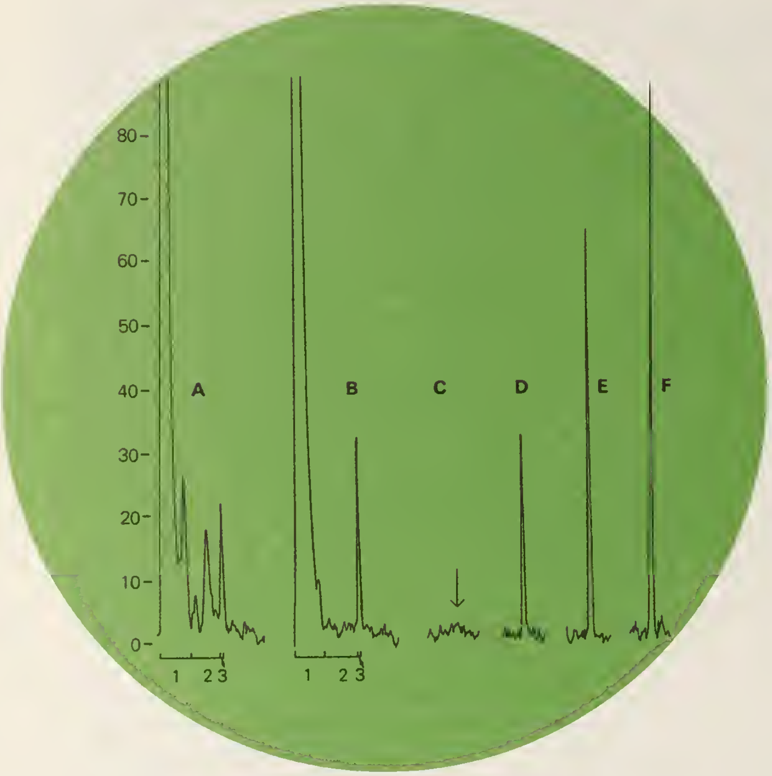
In the section on the byproducts of the industry, game bird farming commands the most attention. Brief pointers are mentioned for the successful establishment and management of such farms.

Although the book is oriented towards large scale operations, fanciers can benefit from the tips on breeds, feeds, sanitation and diseases. And for those who like the edible end product, gourmet recipes are included.

To obtain this thorough review of pheasantry, request Publication 1514, 1973, from: Information Division, Agriculture Canada, Ottawa, K1A 0C7.

The English Ringneck is the most popular pheasant in Canada. The Ringnecks provide excellent hunting in the wild and are the birds used most extensively on hunting preserves. For more information on pheasants, see Publication 1514, *Pheasants*.

A. Behaviour in a carbon furnace, of 5 microlitres of a swordfish sample solution containing selenium. The absorbance signal is shown as a function of the three stages of heating. During the drying stage (1), water and other volatiles are evolved, while during the ashing stage (2) the signals are caused by smoke and other decomposition products. The intense atomization stage (3) results in volatilization and atomization of the selenium present in the sample to give a sharp selenium response.
B. Response of an identical swordfish sample from which interfering substances have been eliminated resulting in an increased selenium signal.
C,D,E,F. Selenium standards containing 0, one-one billionth, two-one billionths, and three-one billionths of a gram of the element. Only the atomization stages are depicted.



ANALYSIS OF TRACE METALS IN AGRICULTURAL MATERIALS

M. IHNAT

Les oligo-éléments des produits agricoles sont soit essentiels sur le plan nutritif, soit d'origine étrangère ou toxiques. Présents dans les quantités voulues, les éléments essentiels assurent le développement normal de la culture ou de l'animal. Les éléments toxiques nuisent au rendement du produit et peuvent être dangereux pour le bien-être de l'homme dont la subsistance dépend étroitement des produits agricoles. Il est important de connaître les teneurs exactes en oligo-éléments. Cette tâche pose des défis stimulants au chimiste analytique.

The importance of the macro nutrients, hydrogen, carbon, nitrogen, oxygen, sodium, magnesium, phosphorus, sulfur, chlorine, potassium and calcium in maintaining plant and animal life is well known. A second group of elements comprising boron, fluorine, silicon, vanadium, chromium, manganese, iron, cobalt, copper, zinc, selenium, molybdenum, tin and iodine found in living organisms only in trace amounts in the part per billion to part per million range has also been established as essential for life processes. These elements function as key components in enzyme, protein and hormone systems.

Deficiencies of one or more of these nutrients can be detrimental to the health status of crops and livestock and can result in economic losses to Canadian agriculture. Examples of elemental deficiencies are copper and magnesium in cattle, and selenium in poultry, swine, sheep and cattle. Selenium deficiency is associated with degeneration of cardiac muscle (mulberry heart) and skeletal muscle (white muscle disease), leading to severe impairment of health and death resulting in substantial losses in livestock production. On the other hand, excess concentrations of essential elements can have equally disastrous consequences. An illustration is again provided by selenium; high levels in livestock resulting in fatal ''blind staggers'' and ''alkali disease''.

The occurrence in the environment of a multitude of other elements brings to the foreground the aspect of non-nutrient trace element toxicity. Uptake of toxic elements such as berylium, arsenic, mercury, lead and cadmium by plants can contaminate the food

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An atomic absorption spectrophotometer is an invaluable tool for analysis of metallic elements. Robert Westerby (left) and David Gordon operate one of the instruments in the author's laboratory.

chain and have serious consequences on human health. Recent findings indicate high levels of cadmium and lead in some Canadian sewage sludge used as fertilizer on lands which grow food crops. Together with the occurrence of nutrient elements at high (toxic) levels in certain areas, this problem forms a broad basis for concern. Among the various facets and requirements of trace element research is found analytical chemistry and development of analytical methodology.

In the Chemistry and Biology Research Institute of Agriculture Canada, our laboratory within the environmental chemistry program is involved with the development of methods of analysis for trace metals and other inorganic compounds of interest in materials of agricultural importance. Several current research projects are briefly discussed below.

FLUOROMETRIC DETERMINATION OF SELENIUM

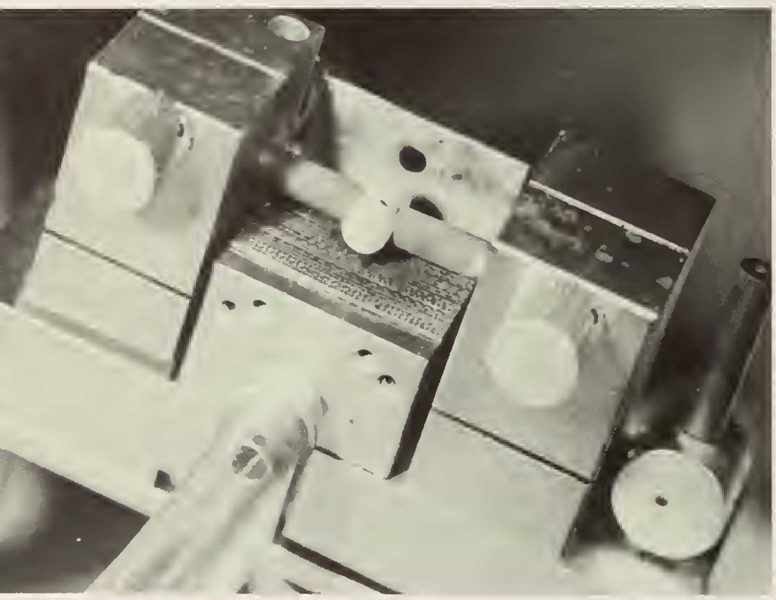
A procedure whereby selenium is detected by the molecular fluorescence of a complex it forms with 2,3-diaminonaphthalene was improved and validated through interlaboratory study for the Association of Official Analytical Chemists (AOAC). Successful validation gives official status to analytical methods so that reliable, tested procedures are available to regulatory agencies. The selenium procedure was recently adopted by the AOAC as official-first action and it, and similar versions are widely applied routinely by laboratories within the department and elsewhere, to plant and animal tissues and fluids, foods, feeds and other materials.

FLAME ATOMIC ABSORPTION—EMISSION SPECTROSCOPY

Atomic absorption spectroscopy is one of the analytical methods of choice in many laboratories and is the cornerstone of our analytical methodology research programs. It is relatively rapid and sensitive, and applicable to the majority of elements. A flame fueled by acetylene and supported by air or nitrous oxide is often utilized as the source of energy for atomization of the element of interest. The absorption by the atoms of light at a characteristic wavelength is translated into a concentration reading.

While many elements are amenable to analysis by the above technique, direct solution aspiration does not provide sufficient sensitivity for the estimation of selenium at the levels occurring in biological tissue.

(Above) Introducing a sample solution into the carbon tube by means of a micropipet.
(Below) Carbon furnace in operation during the ashing sequence.
(Bottom) Furnace at the moment of atomization.



A variant in the procedure is introduced whereby selenium in the sample is reduced to a volatile hydride, released from solution and directed into a hydrogen-argon-entrained air flame. Sensitivity is substantially improved; levels in the part per billion region are detectable.

The atomic spectrophotometer can be easily converted into an emission mode of operation whereby the characteristic emission of an excited atomic vapor in the flame is detected and measured. This technique is useful for elements such as potassium, lithium and aluminium whose analytical sensitivities are greater by emission than atomic absorption.

FLAMELESS ATOMIC ABSORPTION

Recent commercial development of instrumentation for flameless atomic absorption has permitted us to examine the potentials of this technique and its applicability to the problems on hand. The flameless accessory is used in conjunction with the existing atomic spectrometer replacing the flame as the atomizing medium. Basically, the device consists of a carbon rod or furnace connected to an electrical power supply. A droplet of sample solution (on the order of one microlitre) is introduced into the hollow of the furnace which automatically goes through three heating stages ending with a high temperature atomize step during which the transient absorption signal is monitored.

We are currently applying this technique to the estimation of selenium in foods as a possible alternative to fluorometry, which although quite precise and accurate, is fairly time consuming. The results look promising. It is our intention to pursue investigation and evaluation of this technique and extend it to other elements of interest. Two possible advantages of carbon furnace flameless atomization lie in the small volumes of sample solution required (permitting the continuing analysis of blood of small experimental animals without the necessity of sacrificing them) and the extremely small weights of element detectable (down to less than one trillionth of a gram depending on the element).

As increasing attention is being directed towards investigations of lower and lower levels of nutritionally and toxicologically important inorganic elements and compounds, analytical measurements become increasingly more difficult. In addition to the problems inherent in detecting extremely small amounts of substance, the ubiquitous nature of elements and inorganic compounds can pose serious contamination problems in sampling and analysis. The laboratory environment probably contains every element the sample is analyzed for. In fact, at the part per billion and part per trillion levels, the presence of virtually every natural element in the periodic table can be suspected. Precautions and exacting techniques are mandatory for the generation of reliable data. ■

D. W. MacDONALD

Le Québec ne possède pas les sols les plus chauds, ni la plus longue saison de croissance pour l'horticulture, mais néanmoins les maraîchers de cette province se taillent une bonne part du marché grâce aux résultats des recherches agricoles d'Agriculture Canada.

HORTICULTURAL RESOURCE DEVELOPMENT IN QUEBEC

Located on the fringe of commercial fruit and vegetable production on the North American continent, Quebec growers do not have the warmest soils, the longest growing season or the most favorable climate for production. But they do have a great consumer market on their doorstep, including Montreal and other great cities in the northeastern United States. In spite of any geographical limitations, Quebec fruit and vegetable growers have taken advantage of their market opportunities to the extent that they generate millions of dollars in business.

Their production, packaging and storage facilities are such that merchandisers can meet the demand on a wide range of markets whenever the price and situation require it. In apples, onions, carrots, cabbage, rutabagas and lettuce, Quebec growers compete on markets such as New York, Boston Philadelphia and Washington, D.C. They share domestic and export markets in competition with commodities from more temperate or even tropical areas.

A large proportion of the fruits and vegetables produced in Quebec are still grown on the owner-operator type of farm where family labor is a key factor in harvesting. However, large corporation farms are also in the business, with the capital and production resources to merchandise and market commodities on a large scale. In some cases, smaller producers market their produce through the corporate farms, or the giant Coopérative Fédérée, taking advantage of their storage and packaging facilities as well as their specialized sales staff who are in touch with all major markets in Canada and the United States.

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Aerial view of St. Jean Research Station satelite farm at Frelighsburg, Que.

Paul Omer Roy, retired extension pomologist, keeps in touch with the St. Jean Research Station, through Director J. J. Jasmin.

Quebec apples are now being processed into cider and champagne.

Like everything else, production and marketing of horticultural crops has become more specialized in order to remain competitive. Growers can't solve all the problems themselves. They need the support of industry and government, not only to regulate distribution but to find answers to technical problems that are constantly affecting their capacity for quality production.

Federal research in horticulture in Quebec has now been centralized at the Research Station, St. Jean, Quebec. Eighteen research scientists occupy a laboratory-office building in the western part of the city, however, they carry on investigations in crop production and plant protection at three satelite farms offering a range of soil and topographic conditions representative of commercial fruit and vegetable production in the province.

ORCHARD FARM

In 1969, the station acquired 332 acres of orchard land at Frelighsburg, Quebec, giving orchard specialists better facilities for research in tree fruits. This land complements facilities for study and demonstration of vegetable production methods on organic soils on a 65-acre farm at Ste. Clotilde, and facilities for study of small fruits and vegetable production on mineral soils on a 212 acre satelite farm at L'Acadie.

As problems arise, they are viewed by teams of specialists in fruits and vegetables. Priorities are allocated according to the nature of the problem and its importance to the economy and consumer. J. J. Jasmin was appointed Director of the Station in 1972 after many years experience in commercial horticultural production and government research. He succeeded. A. A. Beaulieu who served as Director from 1948-1972.

Major problems receiving attention at St. Jean at this time are:

APPLES
- —breeding for varietal resistance to scab
- —high density planting to reduce labor for pruning and picking
- —hardy varieties and rootstock
- —chemical and biological control of insects

STRAWBERRIES AND RASPBERRIES
- —high yielding varieties for fresh market and processing
- —virus free planting stock
- —winter hardiness of raspberries
- —plant nutrition and management

CORN
- —hybrids resistant to corn borer, cultural practices

ONION
- —control of pests, cultural practices

CARROT
- —insects, diseases and weed control, cultural practices

POTATO
—improved varieties for muck and mineral soils
CABBAGE
—hybrids resistant to club root
LETTUCE
—increase of marketable heads per acre

Research in horticulture was not always centralized as it is today at St. Jean. It has evolved over the years in response to growers needs and as a result of reorganization of various divisions of the department involved in all aspects of production, protection and marketing. Federal research officers meet regularly with provincial extension officers to discuss their findings with a view to communicating them to producers. Hardly a week goes by that one or more committees of federal and provincial specialists do not meet to discuss growers problems. Much of the knowledge gained at St. Jean is finally written into the crop guides and spray calendars issued by the provincial extension service.

The federal role in horticulture probably started in 1887. That year, the Director of the Experimental Farm Branch in Ottawa, William Saunders, established a Division of Horticulture, and delegated an Abbortsford, Que. apple grower Wm. Gibbs, to help introduce hardy apple stocks for Quebec. A Siberian crab from the Royal Botanic Gardens, St. Petersburg, was one of a number of stocks planted at the Central Experimental Farm, Ottawa, that contributed to the breeding of hardy fruits for Quebec.

Early work consisted largely of growing open-pollinated seedlings of varieties like McIntosh, Spy, Wealthy which had been pollinated presumably by hardier Russian varieties. Varieties like Melba, Hume, Lobo, Lawfam and Sandow which were developed from these all had special significance to growers in Quebec because of their quality and hardiness.

PROTECTION SERVICE

By 1911, apple production had reached significant proportions in some areas. Growers were encountering pest problems and members of the Quebec Pomological and Fruit Growing Society requested help from Ottawa. A graduate in entomology, C. E. Petch was appointed as a field investigator and operated out of a small laboratory at Covey Hill, Que. It was the beginning of a long career in plant protection and established the foundation of recommendations to control orchard pests.

Early growers knew very little about the performance of varieties except what they heard from salesmen and neighbours. There was great variability in the rootstocks and varieties. Growers took considerable risk in planting out an orchard because they were not sure of the quality and hardiness. The test came in the winter of 1933-34. All the Fameuse and many McIntosh trees were destroyed by prolonged low temperatures on immature wood. As a result pomologists in Ottawa intensified their efforts to develop hardy rootstocks and stembuilders. The story of building hardier trees through selection, budding and grafting was effectively told to growers in Quebec by Paul Omer Roy, a Bedford, Quebec, orchardist, employed as an extension agent by the Division of Horticulture, Ottawa.

He demonstrated the value of Robusta No. 5 as a hardy rootstock and stembuilder for McIntosh. Propagated in stool beds, Robusta No. 5 provided much needed uniformity in apple stocks, and eliminated weakness in the main trunk or crotches that had destroyed many McIntosh trees. Mr. Roy worked under the Ottawa Research Station until he came under the direction of the enlarged St. Jean Station, in 1967.

Over the years, Quebec has surpassed Nova Scotia, and rivaled British Columbia and Ontario in apple production. In this expansion, biological and chemical control of major orchard pests has been a factor in profitable orchard production. It was found for instance that DDT was not required on a large scale in Quebec orchards, and growers were able to avoid some of the side effects from use of this chemical. And when lime sulphur continued to burn foliage and reduce yield when used to control apple scab, federal plant pathologists led the search for milder materials by testing the alternatives under Quebec conditions. The effect of sprays on the life history and natural control of economic pests has been of special interest to specialists at St. Jean.

At one time, the lighter soils in the vicinity of Montreal were used extensively for vegetable production. Montreal melons were said to have sold for $15 each on the New York market at the height of their fashion in the twenties. But the city overgrew much of the market garden land that produced melons and other fine vegetables. Growers had to look elsewhere. Land south of the city was cold and

Horticultural research on three satelite farms in Quebec is directed from Agriculture Canada's laboratory-office building in St. Jean, Que.

heavy, which limited the choice of vegetable crops. However, a soil survey in 1930 drew attention to 51,000 acres of unused, high grade organic soils within 50 miles of the city. Through the energy and vision of such men as M. B. Davis and Fred Browne of Ottawa, and Phillippe Roy, Quebec Department of Agriculture, a substation of the Horticulture Division was established at Ste. Clotilde, Que., in 1936. This was the beginning of investigations into problems of drainage, land clearing, lime, fertilizer and cultivation for vegetables on organic soils.

Research at Ste. Clotilde demonstrated the usefulness of organic soils for such crops as celery, carrots, onions, lettuce and potatoes. Farms of 50 to 100 acres were cleared for production by the owner-operator type of farmer. Corporations with financial backing and marketing expertise have developed areas on a larger scale.

In 1940, vegetable growers and canning companies requested investigation of problem insects and diseases, and a laboratory was set up at St. Jean under the leadership of J. B. Maltais. Entomology and pathology sections were eventually combined in the two-story research centre that accommodates the headquarters of even broader activities today.

BORER EPIDEMIC

Timely information on the control and management of insects and diseases is more important than ever for the grower because of his more intensive and costly methods of production. In 1973, the rapidly increasing corn acreage in the province was suddenly infested with corn borers in epidemic proportions. Entomologists at St. Jean were quick to observe that temperature and humidity conditions during the egg laying stage of the insect triggered an unusually large hatch. Rapid development of the borer offset the effect of sprays, and the invaders devoured their way through the crop on an unprecedented scale.

Many Quebec farmers had been forced out of corn production earlier in the thirties when the corn borer invaded an expanding acreage. Another generation of Quebec farmers was just getting back into corn production based on earlier maturing hybrids that had more resistance to the borer and vastly improved harvesting and handling equipment. With power to plow down corn stubble, smothering over-wintering borers, and with the use of efficient spray equipment to apply insecticides, the new generation of growers have managed to increase production without undue interference from the borer. Conditions now, however, require a re-evaluation of control methods. At one time DDT provided effective, inexpensive control of the corn borer, but restrictions on its use forced growers to accept more expensive, less effective alternatives.

The search for new chemicals, and more resistant hybrids continues at St. Jean in order to give Quebec growers up-to-date information and the management tools required to keep this pest under control without undue effect on the environment.

Growing horticultural crops anywhere requires a lot of expertise and know how. Growers in Quebec may continue to face crises in the management of their crops but they are now better informed and better equipped as a result of the years of investigation and research into their problems by federal specialists. These activities have now been largely centralized and coordinated under one roof, at the St. Jean Research Station, to give growers a centralized information centre for horticultural resource development. ■

Quebec growers show interest in dwarf apple stock on CDA satelite farm at Frelighsburg, Que.

ALFALFA SICKNESS

E. J. HAWN

Les recherches effectuées sur la maladie appelée ''maladie de la luzerne'' révèlent que celle-ci n'est pas uniquement attribuable à un manque de matières nutritives ni à des conditions climatiques désavantageuses. On tente de découvrir si les nématodes des agents toxiques, provoquerait la maladie. On étudie également les effets du chaulage et de la fertilisation.

Alfalfa sickness is the nondescriptive name given to a serious disease situation that has existed in central and north-central Alberta since 1961 and has drastically reduced the alfalfa acreage.

Farmers found large patches of sickly alfalfa plants on land that had previously produced good alfalfa hay yields. The growth of alfalfa was generally poor with scattered patches of good growth. Even in severely affected areas where most of the plants were short, spindly, and yellowish-green, a few healthy specimens frequently occurred either singly or in clumps. Plants from areas of poor growth had either no nodules or a few large whitish clumps that are indicative of ineffective strains of nitrogen-fixing bacteria.

A survey, initiated by Dr. G. R. Webster of the Soil Science Department, University of Alberta, Edmonton, showed that most of the 'sick'soils were dark gray or gray wooded, acid in reaction (pH 5.8 to 6.0), of sandy loam texture, and deficient in nitrogen, phosphorus, and sulphur.

UNKNOWN TOXIC AGENT

Since 1961 many field and greenhouse experiments have been carried out by the Soil Science Department of the University of Alberta. Their tests indicate that nutrient deficiency is not the sole cause of the disease nor are adverse moisture conditions. Brief periods of steam treatment and partial sterilization of sick soil by chemicals and gamma radiation have frequently corrected the disease indicating that some toxic agent, possibly of biological origin, is responsible.

In 1970 the late Dr. W. R. Orchard discovered that the soil around the roots of sick alfalfa plants contained high numbers of 'pin' nematodes, *Paratylenchus projectus* Jenkins. These 'pin' nematodes are very tiny ectoparasites that attack the roots of some 88 plant species including alfalfa, wheat, barley, red clover, birdsfoot trefoil, brome grass, and timothy. Surveys were then made of affected and suspected areas covering more than half a million acres. The data collected showed that the numbers of nematodes were not related to the soil type, pH, or N.P.K. content and were not consistently related to severity of alfalfa sickness, although there was a trend toward higher numbers of nematodes in the rhizospheres of diseased plants.

ROLE OF PIN NEMATODE

Research at the Canada Department of Agriculture Research Station, Lethbridge, is concerned with establishing whether the pin nematode has a role in the development of alfalfa sickness. Soil collected from treated plots and headlands in experimental plots of the University of Alberta located at Breton is being used in our greenhouse studies. The soil from affected areas has good populations of pin nematodes wheras that from the headland is essentially nematode-free, making it an ideal control. We also have access to records of cropping sequences and fertilizer applications since 1963. We increase the populations of pin nematodes by first planting infested soil to timothy *(Phleum pratense* L.) and then we plant it to alfalfa in our greenhouse tests. Our studies have not yet shown whether the nematode is the causal agent of alfalfa 'sickness'.

The effects of liming, fertilizing, and seed inoculation are also being studied. In addition, a number of bacterial isolates taken from sick soils will be tested alone and in combination with pin nematodes to determine if they contribute to alfalfa sickness.

Research to date indicates that the cause of alfalfa sickness is not simply solved and that a combination or combinations of various factors including the pin nematode may be at the root of the problem. ■

'Healthy'(left) and 'sick' (right) alfalfa from a field at Ryley, Alberta.

Dr. Hawn is a plant pathologist, Plant Pathology Section, CDA Research Station, Lethbridge.

J. N. TINGLE and M. C. J. van ADRICHEM

MEADOW FOXTAIL LENGTHENS THE SPRING PASTURE SEASON

Le vulpin des prés manifeste une croissance hâtive et une bonne réaction aux engrais dans les sols humides d'argile lourde du centre de la Colombie-Britannique.

Meadow foxtail *(Alopecurus pratensis)* is one of the first grasses to show green in the spring and to reach maturity. At the Canada Agriculture Experimental Farm at Prince George we have seen clones of meadow foxtail emerging from a blanket of snow in late April.

Central British Columbia is cattle country with high winter feed requirements and a short pasture season from June 1 to September 15. The fall grazing period can be lengthened to October 30 with good management of hayfield and pasture regrowth. Spring pasture, however, is critical because of diminishing stored feed supplies and the potential damage to forage stands grazed too early.

Meadow foxtail is a native of Europe where it is grown in high-elevation meadows and pastures. It is known for its bunch-type habit, earliness, hardiness and its preference for good moisture and fertility levels.

One problem with meadow foxtail is the light fluffy seed. However, this difficulty can be overcome by mixing the seed with inert material such as cracked grains, or by only partially filling the hoppers of grass seeders. We recommend seeding meadow foxtail at a rate of 10-15 lb. per acre, alone, or in combination with other early grasses such as orchardgrass or crested wheatgrass. A non-aggressive legume such as birdsfoot trefoil will also do well with meadow foxtail. There are no licenced varieties of meadow foxtail in Canada, but commercial seed can be obtained. The Northern Research Group, with headquarters at Beaverlodge, Alberta, is attempting to produce an earlier and more productive variety.

Pure stands of meadow foxtail and timothy grown at eight locations for three years produced an average 2.33 and 2.65 tons of dry matter per acre, respectively (Table 1.). Meadow foxtail reached the 8 to 10 in. pasture stage on May 16, compared to May 24 for timothy. Fertilized meadow foxtail had higher crude protein and digestible dry matter levels than timothy when cut at the early heading stage. Meadow foxtail also has relatively high levels of mineral elements.

Applied nitrogen produces large increases in dry matter production of meadow foxtail (Table 2.). The crude protein level of the forage is directly related to nitrogen treatment prior to each harvest. Crude protein levels in 1971 ranged from 9.5% in the unfertilized material to 22.4% for the spring applied 200 lb. N/acre treatment. Dry matter digestibility is not influenced by nitrogen level.

Meadow foxtail responds to moisture and is well adapted to the heavy clay soils of central B.C., presumably because of their moisture-retaining properties. The low growth habit and the problem of lodging restricts the use of meadow foxtail to pasture.

Meadow foxtail doesn't grow through the snow most years, but it is early and highly nutritious! ■

J. N. Tingle and M. C. S. van Adrichem are agronomists at CDA Experimental Farm, Prince George, B.C.

TABLE 1 THE AVERAGE DATE OF HARVEST, DRY MATTER YIELD AND QUALITY PARAMETERS OF MEADOW FOXTAIL AND TIMOTHY CUT AT THE EARLY HEADING STAGE

Harvest No.	Commercial meadow foxtail		Climax timothy	
	Date of harvest	Dry matter yield tons/acre	Date of harvest	Dry matter yield tons/acre
Cut 1	June 2	1.30	June 28	2.07
Cut 2	July 14	0.76	Sept. 21	0.58
Cut 3	Sept. 23	0.27	—	—
Total seasonal yield		2.33		2.65

Average protein and digestibility levels of first cut forage.

	Commercial meadow foxtail	Climax timothy
Crude protein, %	16.8	12.1
Dry matter disappearance %	66.9	62.4

TABLE 2 RESPONSE OF MEADOW FOXTAIL TO APPLIED NITROGEN

Treatment	Average dry matter yield, 1971-1973 tons/acre
Check	0.69
50 lb. N. Spring	1.71
100 lb. N. Spring	2.30
200 lb. N. Spring	2.87
50 lb. N. Spring and after each of 3 cuts	3.04

FORAGE KALE IN QUEBEC

G. PELLETIER

Ayant une forte production et possédant une haute valeur nutritive comme culture fourragère et de plus, étant bien adapté aux récoltes tardives, le chou fourrager présente certains avantages aux cultivateurs de l'est du Canada.

Forage kale is an important forage crop in England, continental Europe, and New Zealand. It is used mainly for late fall and winter feeding. With the exception of small areas on the Pacific coast, forage kale is not commonly grown in North America and has received little attention from research workers in either the United States or Canada.

Recently, marrow-stem kale (*Brassica oleracea* var. *acephala* D.C.) has been shown to be a very productive crop in Quebec and Ontario and some farmers have started to grow it. Marrow-stem kale has yielded 4-6 tons of dry matter per acre, which is close to the yield of alfalfa and corn. This fodder is characterized by high digestibility values and frost resistance, the latter feature resulting in kale continuing to grow late in the fall.

Numerous types and varieties of forage kale are grown (table 1). Varieties of the marrow-stem type have given the best output in Quebec and their feed value has been studied with interest at Lennoxville.

CHEMICAL COMPOSITION

Kale harvested in mid-September has had a dry matter content of 11%, and up to 13% at the end of October. Its crude protein content has been high (table 2). The leaves are richer than the stems (table 3). With high level of nitrogen fertilization, up to 50% of the nitrogen in the stems and 20% of the nitrogen in the leaves is in a non-protein form. The nitrogen content declines slightly with maturity. The crude fiber content, at 15% is almost twice as low as legumes or corn silage. The fact that 95% of the crude fiber of forage plants is usually in the form of cellulose does not apply to forage kale because its cellulose content is much higher than its crude fiber content. Cell wall neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL) content are also very low (table 4). On the other hand, its soluble cell constituents content, at 75%, is high compared to other forage crops. Fiber content did not increase with maturity (Tables 2 and 4).

Forage kale is rich in minerals, especially when one considers that the mineral content is 11.3%, out of which only 0.47% is silica. Calcium content is high and phosphorus content relatively low due to a high calcium, phosphorus ratio of 6:1. Furthermore, forage kale is rich in chlorine, potassium, sulphur, iron and magnesium.

Mr. Pelletier is a plant scientist at CDA Research Station, Lennoxville, Que.

TABLE 1 DRY MATTER YIELD, CRUDE PROTEIN CONTENT, *IN VITRO* DRY MATTER DIGESTIBILITY AND LEAF: STEM RATIO OF A FEW FORAGE KALE VARIETIES. LENNOXVILLE, 1968

Varieties	Dry matter yield kg/ha	Crude protein (%)			Dry matter digestibility *in vitro* (%)			Leaf: stem ratio
		Leaf	Stem	Whole plant	Leaf	Stem	Whole plant	
Pastour	7412	15.6	15.9	15.7	87.7	70.6	83.7	3.30
Sarbo	9600	22.4	12.5	18.6	85.5	70.0	79.6	1.62
Proteor	9896	20.2	13.3	16.9	85.7	71.1	78.8	1.11
Celtic	11376	18.3	11.6	14.3	87.4	68.3	76.2	0.71
Maris Kestrel	10698	19.2	14.8	16.6	86.0	78.4	81.5	0.69
Giganta	11475	21.4	14.1	16.2	85.1	71.9	75.8	0.42

TABLE 2 CRUDE PROTEIN, GROSS ENERGY, CRUDE FIBER, CALCIUM AND PHOSPHORUS OF FRESH AND DRIED MARROW-STEM KALE HARVESTED ON TWO DATES. PELLETIER AND DONEFER, 1973 (DRY MATTER BASIS)

Forage description	Crude protein %	Gross energy kcal/g	Cellulose %	Crude fiber %	Calcium %	Phosphorous %
Physical form						
Fresh	18.8	3.99	24.8	14.2	2.53	0.39
Dehydrated	19.5	3.95	25.0	14.8	2.51	0.39
Date of harvest						
October 15	20.1	3.98	24.7	14.1	2.70	0.41
October 30	18.3	4.00	25.2	15.0	2.34	0.37
Average	19.2	3.97	24.9	14.5	2.52	0.39

Since forage kale is a leafy plant, one would expect its vitamin content to be high. Effectively, it is high in carotene (equal to alfalfa) and vitamin C (three times more than for an orange).

DIGESTIBILITY AND INTAKE

Digestibility of marrow forage kale is high (table 5). Indeed, digestibility coefficients of dry matter, gross energy, crude protein and cellulose have been respectively 78.3, 81.4, 83.7 and 86.3. Neither harvesting time nor dehydration have notably affected digestibility. Digestible energy content, at 3.28, 3.17, 3.18 and 3.29 kcal/g for fresh and dried forage kale, harvested in mid-October and at the end of October respectively, has been higher than for alfalfa (2.38) or for corn silage (3.04) harvested at 33% of dry matter.

Fed free choice, dry matter intake of forage kale has been higher for dehydrated kale than for fresh kale. Harvesting dates have not markedly affected consumption of forage dry matter or energy intake. Forage kale dry matter intake has been lower than for alfalfa but higher than corn silage. Digestible energy intake of forage kale and a nutritive value index of 65 compares advantageously with a very high quality forage such as alfalfa harvested in the early flowering stage. A diet based exclusively on forage kale would provide enough energy, protein, calcium and phosphorus to meet the needs of a lamb of 45 kg, with a daily gain of 65 g.

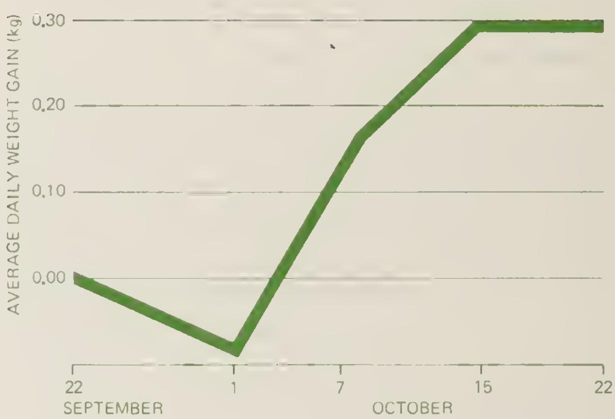

Figure 1 Average daily weight gain of sheep grazing on marrow-stem kale. Normandin, 1969.

FORAGE KALE UTILIZATION

Although forage kale is mostly used in cattle rations, it has been shown that pigs, laying hens, geese, and rabbits can satisfactorily use forage kale.

In Quebec, kale is most often recommended as fall pasture. Controlled grazing with an electric fence minimizes waste and does not require a large investment in money or manpower. If dairy cows are left free in a forage kale field, losses due to trampling can

TABLE 3 CHEMICAL COMPOSITION OF WHOLE PLANT, LEAVES AND STEMS OF MARROW-STEM KALE. S. J. C. JONES, 1958

Chemical components	Leaves %	Stems %	Whole plant %
Water	85.6	88.6	87.7
Crude protein[1]	23.2	13.3	16.9
Fat[1]	3.4	0.8	1.8
Crude fiber[1]	10.5	19.7	16.4
Nitrogen free extract[1]	49.3	56.3	53.7
Ash[1]	13.7	9.9	11.3

[1]Dry matter basis

TABLE 4 NEUTRAL DETERGENT FIBER (NDF), ACID DETERGENT FIBER (ADF) AND ACID DETERGENT LIGNIN (ADL) CONTENT OF FRESH AND DRIED MARROW-STEM KALE HARVESTED ON TWO DATES. PELLETIER AND DONEFER, 1973 (DRY MATTER BASIS)

Forage description	NDF (cell wall)	ADF	ADL
Physical form			
Fresh	25.4	22.0	2.8
Dehydrated	24.6	22.2	2.9
Date of harvest			
October 15	25.3	21.8	2.8
October 30	24.7	22.5	2.9
Average	25.0	22.1	2.9

TABLE 5 COEFFICIENTS OF APPARENT DIGESTIBILITY OF FRESH AND DRIED MARROW-STEM KALE HARVESTED ON TWO DATES. PELLETIER AND DONEFER, 1973

Forage description	Coefficients of digestion (%)						
	Dry matter	Gross energy	Crude protein	Cellulose	Crude fiber	NDF	ADF
Form fed							
Fresh	79.4	82.3	83.9	87.2	73.0	68.4	70.4
Dried	76.9	80.2	83.4	85.2	70.0	67.1	70.8
Date harvested							
October 15	76.9	80.6	83.2	86.3	71.9	69.0	70.3
October 30	79.8	82.3	84.2	86.5	71.6	66.7	70.8
Mean	78.3	81.4	83.7	86.3	71.6	67.8	70.6

reach up to 35%. Losses from trampling are lower with sheep but sheep do not consume the stems until late in the season. Lambs have gained substantially when they were offered a new kale acreage before the stems had been completely grazed down. Cattle can then clean out the stems. Lambs have taken about two weeks to adapt to forage kale grazing, but after that the gains have been high (Figure 1). The animals had free access to hay but ate only 0.25 kg per day per head. Lambs seemed to adapt more rapidly to forage kale when it was fed in the barn. Weight gains during the first two weeks of feeding with forage kale have been higher with whole forage kale, than with chopped kale and grazing. Animals fed whole or chopped kale ate the same quantity of forage, i.e. 0.72 and 0.50 kg/day/head of kale dry matter and hay respectively. Animals fed chopped kale did not leave any waste while those fed whole kale, left 50% of the stems.

It has been shown that forage kale has a beneficial impact on milk production. There may be a slight decrease in milk fat content (0.09%) but an increased total production of butterfat. Forage kale should not be given at milking time, since it can give milk an off flavor.

Forage kale is easy to ensile provided it is well ground. However, high dry matter losses (30%) particularly in crude protein, have been noted by several researchers. Dry matter losses have been lower in small silos (24-25%) than in large ones (32-38%) and no beneficial effect has been found through the addition of hay before the forage kale was put into the silo. Tests performed in Switzerland and in Germany have shown that digestibility of kale silage was just as high as the kale itself before ensilage. A mechanical method is still to be found to minimize losses at harvest of forage kale for ensilage.

PHYSIOLOGICAL DISORDERS

Anemia has been associated with forage kale feeding. It would appear that mineral deficiencies are not the cause. Rather it could be due to a toxic substance such as hydroxylamine produced in the rumen of animals fed forage kale. An important indication of the cause of anemia is that it appears only in ruminants. Furthermore, forage kale dehydrated at high temperatures, and silage, do not produce anemia. Recent tests have shown that forage kale fresh, or dehydrated at low temperature (25 to 30°C), could induce anemia in sheep where it is fed as the sole ration. In order to avoid these physiological disorders, it is recommended to reduce the intake volume to 1.2 kg of dry matter per 100 kg of live weight for dairy cows.

It has long been established that cole crops contain substances with goitrogenic activity. Lambs from ewes fed forage kale in the last two months of pregnancy have been affected. Potassium iodate injections given to pregnant ewes were effective in preventing goitre. ■

(Left) Buds are produced in isolated Foundation Orchard, one-half mile from other Summerland Research Station plantings and two miles from closest commercial orchards.

(Right) Apple fruit symptoms caused by viruses.

(Far right) Budding test trees in the virus-indexing program.

IMPROVED TREES FOR BRITISH COLUMBIA ORCHARDS

M. F. WELSH and S. W. PORRITT

Le programme de certification des greffons de la Columbie-Britannique (B.C. Certified Budwood Program) fournit aux pépiniéristes et aux producteurs de fruit, des greffons qui sont conformes à la variété, indexés pour les maladies à virus et codés pour la couleur. Le programme est administré conjointement par les pépiniéristes, l'Association des producteurs de fruit de la Columbie-Britannique, le ministère provincial de l'Agriculture et le ministère de l'Agriculture du Canada. La distribution annuelle de greffons est passée de 34 000 à 925 000 en 25 ans.

When a fruit grower plants an orchard, he establishes the physical plant that will be his source of income for the next 10 to 50 years. It yields the maximum return only if he chooses his varieties well and plants trees that are healthy and productive. With many varieties, he can profit by using improved strains that provide higher productivity and fruit quality, and have desirable growth characters.

In most regions, before the advent of certification programs, fruit growers found that some of their trees proved to be of varieties they have not ordered, were of undesirable strains, had genetic abnormalities, or were diseased. Frequently these faults did not become evident until the trees bore fruit.

British Columbia nurserymen and growers were among the first in North America to have access to superior sources of tree fruit budwood and scionwood for propagation of their trees. A budwood distribution program, initiated by the Summerland Experimental Farm more than a quarter of a century ago, evolved to become the B.C. Certified Budwood Program. This organization derives its strength from the participation and close cooperation of the major nurserymen, the B.C. Fruit Growers' Association, the B.C.

Dr. Welsh is head of the Plant Pathology Section and Dr. Porritt is head of the Pomology Section at the CDA Research Station, Summerland, B.C.

Department of Agriculture and both the pomologists and plant pathologists of the Summerland Research Station. Its assignment is to ensure that B.C.-grown fruit trees are derived from propagating materials selected for trueness to variety and type, as free as possible from virus infection, and color-coded to minimize errors during the stages of propagation.

FOUNDATION ORCHARDS

The budwood was first distributed with the assurance that it was true to variety. In 1952 the pomologists and plant pathologists joined forces to ensure that the distributed budwood was healthy as well as being horticulturally acceptable. This demanded that special Foundation Orchards be planted and the budwood source trees propagated from virus-indexed clones. In the history of the program, there have been three such Foundation Orchards: the first for cherries only, the later ones diversified to include peaches, nectarines, apricots, plums, pears and apples. The most recent one, established in 1965, accepts only clones that are free from all detectable viruses. All trees are given a confirmatory virus-indexing within a year of planting, and subsequent indexing at selected intervals. All trees are fruited to ensure that they are true to variety before any budwood is cut.

All buds and scions, ordered by the cooperating nurseries for propagation of trees, or by growers for top-working their orchards, are cut by the orchard manager and promptly banded with paint in a color chosen to denote the variety or strain.

The plantings of nursery stock in the participating nurseries are inspected by B.C. Department of Agriculture officials. Trees that are not healthy and true to variety are destroyed; those reaching certification standards are color-coded to identify the variety and the rootstock. Later, after the stock has been dug and graded, the nurseries are issued certification tags.

The program's present structure was evolved in 1962, when the tree fruit nurserymen and the B.C. Fruit Growers' Association agreed to share the costs of salaries, wages, and operational expenses, the CDA Research Station, Summerland provided land, irrigation and housing, and the B.C. Department provided staff and facilities for inspection and certification. All these groups and agencies were able to contribute advice and assistance to the manager. The CDA Research Station has conducted the necessary background research in varietal characterization and virus indexing. Pomologists and plant pathologists cooperate in furnishing the horticulturally suitable and virus-indexed clones for the Foundation Orchard. Some are identified locally; others are acquired from research agencies elsewhere, notably the IR-2 Interregional Repository. The latter agency is funded by the U.S. Congress but maintains a Summerland staff member on its governing committee.

TWO CATEGORIES

From its inception, the B.C. program has provided budwood of all fruit varieties recommended for commercial planting in the region to ensure that member nurseries could propagate only fruit clones of known origin. Whenever possible, such budwood is from trees that are free from all detectable viruses. However some varieties are universally infected with one or more viruses. This has demanded that the program distribute two categories of budwood. One group is classified free from detectable viruses while the other is true to variety and merely free from serious and damaging viruses. There is hope that eventually all fruit clones can be freed from virus infection by heat therapy techniques. As viruses are eliminated from each variety by this means, trees are being propagated as rapidly as possible and planted in the isolated Foundation Orchard.

Between 1945 and 1969 the annual total of buds distributed increased from 34,000 to 925,000. There are fluctuations in demand as the fortunes of the fruit industry rise and fall, but all participants in the program have maintained their strong loyalty. They are now implementing improvements that include increased production of seeds for rootstocks, and distribution responsibility for new promising varieties developed in the Summerland Station's breeding and selection program. ■

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