Fall 1977
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Effectiveness of a soil insecticide is prolonged when incorporated in gelatin, gum-acacia capsules. See story page 12.

Les insecticides de sol sont efficaces plus longtemps une fois mélangés à de la gélatine et de la gomme arabique. Article à la page 12.

CANADA AGRICULTURE

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Agriculture Canada

NUTRITIONAL QUALITY OF GRASSES

J. E. KNIPFEL and
M. R. KILCHER

La difficulté de maintenir la qualité nutritive des pâturages à un niveau approprié au cours de la saison de croissance constitue un obstacle important à l'engraissement des veaux au sevrage. Une expérience menée à la station de recherche de Swift Current vise actuellement à mettre au point des systèmes de paissance qui permettraient de maximiser la production de veaux d'embouche. Le point saillant du programme porte sur la création de méthodes destinées à accroître la qualité nutritive des pâturages.

In southwestern Saskatchewan, under normal grazing conditions, range calves are weaned in late October or early November at body weights averaging 350-400 lb. Total calf gains over the grazing season (May 1 – Oct. 30, approximately) range from 275-325 lb, or 1.3-1.6 lb/day.

These gains are not uniform, but appear to consist of gains approaching 3 lb/day in early parts of the grazing season, and gains of 0.5 lb/day or less during late fall. Clarke and Tisdale, in a CDA 1945 publication, discussed seasonal distribution of weight gains of beef cattle at Manyberries, Alberta, which showed that only about 15% of total gains were made after the beginning of September. This pattern of rapid gains during the spring and early summer, followed by a progressive decrease as the grazing season advances, has been observed at numerous locations throughout the great plains of North America and for a great variety of pasture species. Decreased animal performance has been uniformly related to changes in chemical composition, digestibility, and/or palatability of the commonly used pasture species.

In order to meet the major nutrient requirements of the lactating beef cow, and allow maximum production, forage should contain approximately 10% crude protein, 0.32% phosphorus and 58% TDN (Milligan 1973), assuming an intake of 28-30 lb/day. If the available forage does not have this quality, decreases in calf gains or weight losses of the cow, or both, may occur, with the severity of the reduction proportional to the deficit in nutritional quality of the forage.

In the shortgrass prairie region of southwestern Saskatchewan, crested wheatgrass, Russian wild ryegrass and Altai wild ryegrass appear to be the major species suitable for seeded pasture (along with the vast native ranges). Collections of forage from each of these species were made each year over a 4-year period at intervals shown in Table 1, with samples analyzed for protein, phosphorus and *in vitro* organic matter digestibility (OMD).

All three species were adequate in crude protein content until approximately July 1. After that date, protein content declined more rapidly in crested wheatgrass than in the ryegrasses. Altai wild ryegrass retained a higher crude protein level than the other two species until September. As a result of regrowth of Russian wild ryegrass after August 20, it was highest in crude protein content at later sampling dates. Crested wheatgrass also showed some regrowth potential as evidenced by an increased protein level at the September 19 sampling date (Table 1). Phosphorus levels of all grasses were below optimum levels by June 17 and continued to decline for the remainder of the grazing season (Table 2). *In vitro* OMD may be used as a measure of digestible energy of forage species. In this study *in vitro* OMD in crested wheatgrass declined much more rapidly than in Russian wild ryegrass, while in Altai wild ryegrass it initially declined more slowly than in the other species (Table 3). Regrowth of Russian wild ryegrass between August 20 and September 19 resulted in an increase in *in vitro* OMD which altered the ranking of Russian wild ryegrass and Altai wild ryegrass.

A factor which must be considered in any discussion of nutritional quality of grass under grazing conditions is the selectivity of grazing by the animal. Selective grazing may alter the animal's nutrient intake but the effect is difficult to measure. This intake may differ markedly from that in the case of total forage harvested and fed from feed bunks.

Dr. Knipfel and Mr. Kilcher are forage evaluation and pasture management specialists at the CDA Research Station, Swift Current, Sask.

TABLE 1 PROTEIN CONTENTS OF CRESTED WHEATGRASS, RUSSIAN WILD RYEGRASS, AND ALTAI WILD RYEGRASS THROUGHOUT THE GRAZING SEASON

Date	Crested wheatgrass	Russian wild ryegrass	Altai wild ryegrass
June 3	17.5	17.4	16.8
June 17	12.9	11.4	14.9
July 2	9.6	9.5	11.0
July 15	8.3	7.6	10.0
July 29	6.1	7.8	8.6
Aug. 20	4.3	6.3	8.6
Sept. 19	7.2	9.3	8.3
Oct. 14	5.2	7.0	6.5
Nov. 19	4.0	7.8	4.7
Dec. 16	4.0	6.3	4.2

TABLE 2 PHOSPHORUS LEVELS OF CRESTED WHEATGRASS, RUSSIAN WILD RYEGRASS AND ALTAI WILD RYEGRASS THROUGHOUT THE GRAZING SEASON

Date	Crested wheatgrass	Russian wild ryegrass	Altai wild ryegrass
June 3	.351	.336	.329
June 17	.254	.235	.270
July 2	.193	.194	.205
July 15	.148	.178	.186
July 29	.106	.118	.154
Aug. 20	.089	.100	.140
Sept. 19	.119	.162	.162
Oct. 14	.076	.100	.103
Nov. 19	.067	.086	.068
Dec. 16	.054	.086	.098

TABLE 3 *IN VITRO* ORGANIC MATTER DIGESTIBILITIES OF CRESTED WHEATGRASS, RUSSIAN WILD RYEGRASS AND ALTAI WILD RYEGRASS THROUGHOUT THE GRAZING SEASON

Date	Crested wheatgrass	Russian wild ryegrass	Altai wild ryegrass
June 3	70.7	73.1	71.7
June 17	62.4	63.3	65.6
July 2	55.6	58.0	60.9
July 15	50.5	53.9	58.9
July 29	46.3	55.0	55.2
Aug. 20	45.7	50.0	54.6
Sept. 19	44.7	56.2	54.0
Oct. 14	40.8	52.1	49.0
Nov. 19	39.7	51.2	47.8
Dec. 16	34.5	47.1	43.3

Our results to date indicate that voluntary intake of the ryegrasses remains relatively constant as these species mature, while that of crested wheatgrass shows a noticeable decrease. Actual nutrient intake would therefore be considerably higher with the ryegrasses, which would account for much of the greater performance by animals pastured on ryegrasses late in the year.

The study by Clarke and Tisdale published in 1945 indicated that native grasses show changes in nutritive value similar to those observed with the tame species above. It is apparent from both studies, and others, that a major obstacle to increased calf weaning weights, i.e., increased productivity of the cow-calf unit, is the maintenance of an adequate nutritional quality in pastures as they mature. While the various grasses suitable for pasture in southwestern Saskatchewan vary in their respective abilities to retain nutrients during the later stages of the grazing season, none appear to be adequate in themselves to maintain production at high levels. This suggests that other ways of increasing the productivity of the cow-calf unit may be required. Some of these may include:

- Weaning calves earlier, since gains are reduced during later stages of the grazing season. The available forage from the ryegrass appears to be more suited to maintenance of the dry cow.

- Supplementing the pasture with high quality feedstuffs. A variety of supplements such as alfalfa pellets, hay, range pellets or cubes, protein (dry or liquid), or others are available and may be of considerable value. The economics of supplementation must be carefully worked out, however.

- Creep feeding of calves, which has until the past several years, been viewed skeptically as a result of the price structuring of calves. With changes in feeding margins and prevailing prices of calves and feeders, a second look at this practice would be worthwhile.

- Including alfalfa with the seeded grass so that a mixture of grass and legume will be grazed rather than straight grass.

At the Swift Current Research Station, considerable effort is being made to develop pasture based systems which would provide for optimum cow-calf production. A major component in this program will be the development of methods to increase the nutritional quality of pastures. ■

WINTER NURSERY

D. W. MacDONALD

Les améliorateurs canadiens font bon usage de la pépinière d'hiver du ministère de l'Agriculture du Canada située à la Station américaine de recherche d'Imperial Valley à Brawley en Californie, où ils effectuent des travaux de sélection dans le but d'améliorer leurs lignées.

Plant breeders in Canada produce new lines at various locations across the country. Rarely do they have an opportunity to compare their lines with others in other regions. The winter nursery at Brawley, Calif. is an exception. Here, one finds the widest assortment of Canadian plant breeding lines anywhere, all in one place. It's a preview of new varieties to come in Canada.

How does a collection of this kind happen to be in southern California?

This past winter, over 35 plant breeders from government and university research establishments applied to the Seed Increase Section, Regina Research Station for space in the winter nursery. As it has been doing since 1944, Agriculture Canada rented the required acreage from the Imperial Valley Conservation Research Station at Brawley, in southern California.

Back in the forties Dr. C. H. Goulden, then Officer-in-Charge of the Dominion Laboratory of Cereal Breeding at Winnipeg and A. W. Platt, at Swift Current, recognized the value of a winter nursery in developing stem rust resistant wheat varieties. Dr. Goulden had an agreement with plant breeders in Australia, whereby each increased the other's material during the off season. But transportation in those days made it difficult to get the material back to Canada in time for spring seeding.

Mr. MacDonald is Head, Periodicals Services Unit, Information Division, Ottawa.

A University of Saskatchewan team of plant breeders and technicians makes some decisions on plant material in southern California nursery. L. to r.; Dr. Bryan Harvey, Rick Boyer, Bill Zalamolsky and Dr. Brian Rossnagel.

Then, in the winters of 1944-45 and 1945-46, the Cereal Division of the Experimental Farm Service arranged to grow winter crops of cereals in the Imperial Valley of California. Ten pounds (4.54 kg) of a promising wheat hybrid, seeded on half an acre (.2 ha) of land, produced 14 bu (381 kg) the first year.

In 1944-45, wheat, oats, barley and flax, in various stages of development from F_1 seed to 2-acre (.81 ha) increase plots of new varieties were grown on 5 acres (2 ha) of rented land. Samples came from the Cereal Division, Ottawa; the Laboratory of Cereal Breeding, Winnipeg; and Experimental Stations at Swift Current, Brandon and Scott. Because the seed came from many programs designed to produce new varieties for a wide range of conditions in Canada, it varied widely in genetic background and adaptability.

B. C. Jenkins, assistant cerealist, Dominion Experimental Farm, Swift Current, journeyed to the Imperial Valley in October 1944 to supervise planting and harvesting. By 1950, supervision came from the Lethbridge Research Station. Since the fall of 1964, the winter nursery has been a project of the Seed Increase Section, Regina Research Station headed by Ed Mallough. Glenn Boughton has supervised planting and harvesting since that time.

"There's a distinction between the winter nursery, and a winter increase." says Mallough. "Small increases of a large number of early generation progeny lines are produced in the nursery, whereas larger increases of more established lines are grown under the winter increase section".

In 1976-77, Boughton planted close to 45,000 progeny in single hills or rows 5, 8, 25 or 73 feet (1.5, 2.4, 7.5 or 22 m) in length to preserve their identity and permit selection and harvesting on an orderly basis. It required 14 acres (5.6 ha) to grow all the progeny from recent crosses last winter, and another 5 acres (2.0 ha) to increase the more established lines.

Any government or university plant breeder can make use of the service. Primarily, it gives breeders the facility to reproduce a generation in the off season. But if there is an urgent need to advance a new variety, as in the case of the low erucic, low glucosinolate Tower rapeseed in 1971, and rust resistant Sinton wheat in 1975, the Seed Increase

...bonus generation

Section will undertake to contract additional land to produce Breeder seed.

Canadian wheat, barley, rapeseed and flax generally yield well in the California nursery, Boughton observes. Annual rainfall averages about 2 in. (5 cm), so irrigation is essential. Day-length insensitive crops, including certain Canadian oat varieties, tend to produce vegetative growth under the shorter hours of daylight. This complicates selection for maturity. However, Dr. V. D. Burrows, Ottawa Research Station, actually uses this reaction to develop new varieties for Canada. By introducing day-length insensitive genes from wild oats common to southern California into Canadian varieties, and combining these with other genes derived from winter oats that condition specific temperature responses, he hopes to delay their maturity and improve yield and quality.

Day-length insensitivity genes have contributed greatly to the success of wheat and rice crops, Burrows contends, and it is hoped they will do the same for oats. It may lead to new varieties that are not only adaptable to Canadian conditions, but can be exported to other parts of the world.

The winter nursery is an excellent location to select for day-length insensitivity, as well as tolerance to barley yellow dwarf virus, straw strength, plant vigor, seed quality, and possibly even salt tolerance.

The winter nursery gives Canadians a different perspective of segregating material. Dr. R. M. DePauw, Beaverlodge Research Station categorizes wheat lines according to their day-length requirements in the winter nursery. Dr. D. S. McBean, Swift Current Research Station claims the California nursery aids his program of breeding sawfly resistant bread wheats because stem-solidness (the sawfly resistant character) is well expressed under the irrigation conditions of southern California.

Working on feed barley, Dr. Brian G. Rossnagel, Crop Development Center, University of Saskatchewan says the winter test site allows him to remove a lot of poorer material, and hence handle more crosses in the total program back home. It's also an opportunity to meet other Canadian plant breeders, and compare stocks in the early stages.

Dr. R. K. Downey, Officer-in-Charge of oilseed crop breeding at the Saskatoon Research Station reports that breeders, in addition to himself, who avail themselves of the winter nursery facilities, include Dr. Allan J. Klassen on rapeseed; Dr. Donald L. Woods, mustard and other Brassica species; Dr. Gary R. Stringam, Brassica geneticist; Dr. Stewart Campbell, sunflowers; and W. L. Crowle, wheat.

"We can carry forward a greater number of progenies from a larger number of crosses than would be possible with our limited greenhouse and growth chamber space", states Dr. Downey. "We can frequently gain a full year on a program by making our crosses in the summer, and growing the F_1 plants in the greenhouse in the fall. We plant F_2 rows at Brawley in January. This permits selection within the F_2 for quality in the spring and ample seed to sow F_3 rows of desirable plants in Canada."

"This past year, special genetic stocks of *B. napus,* containing a single induced, chlorophyll mutation from Tower was increased in California. We needed the increase", Dr. Downey relates, "to have sufficient pure seed to sow test plots adjacent to farmers' fields growing Tower, and determine whether the isolation distance regulations for production of pedigree seed of B. napus in Canada are correct. Without this winter increase, the isolation program conducted by Dr. Stringam would have

Dr. Jim Helm, University of Alberta, shows range of progeny in selection for high lysine feed barley.

Dr. George Fedak, Ottawa, notes lodging resistance in barley for high fertility soils.

been delayed a year."

The Imperial Valley Conservation Research Station isn't the only winter nursery used by Canadian plant breeders. CIMMYT (Centro Internacional de Mejoramiento de Maiz Y Trigo) at Obergon in Mexico is favored by some, particularly those working with wheat, because of the prevalence of rust in Mexico and the opportunity to select against that factor. Crops also mature earlier in Mexico providing more time to transport seed back home.

Canadian corn breeders use winter nursery facilities in Florida and Hawaii. And Canadian cereal and oilseed crops have been increased in New Zealand, Chile, British Honduras, Texas and Arizona. Various locations have certain advantages Boughton points out, but generally, Brawley is a good choice because it is reasonably accessible, and relatively free of disease. Harvesting may be late some years, he says, but this can usually be controlled by withholding irrigation water. In any case, more plant breeders use the Brawley facility than any other, giving them a unique opportunity to increase their stocks, and observe the progress and reaction of material from all parts of Canada.

Other plant breeders who used the winter nursery at Brawley in 1976-77 were:

SPRING WHEAT Dr. K. A. Briggs, University of Alberta; Dr. Hugh McKenzie, Lethbridge; Dr. T. F. Townley-Smith, Dr. E. A. Hurd, Swift Current; Dr. D. Lisle, Winnipeg: Dr. D. Bastien, School of Agricultural Technology, Ste. Hyacinthe; Dr. H. G. Nass, Charlottetown.

BARLEY Dr. D. G. Faris, Beaverlodge; Dr. James H. Helm, University of Alberta; Dr. M. L. Kaufmann, Lacombe; Dr. S. A. Wells, Lethbridge; Dr. B. L. Harvey, University of Saskatchewan; Dr. K. W. Buchannan, Dr. D. R. Metcalfe, Winnipeg; Dr. S. A. Wells, Dr. R. I. Wolfe, Brandon; Dr. E. Reinbergs, University of Guelph; Dr. George Fedak, Dr. S. O. Fejer, Ottawa; Dr. J. P. Dubuc, Ste. Foy; Dr. C. A. St. Pierre, Laval University; J. D. E. Sterling, Charlottetown.

OATS H. T. Allan, Lacombe; Dr. J. P. Dubuc, Ste. Foy.

OILSEED CROPS Dr. Z. Kondra, University of Alberta; Dr. E. O. Kenaschuk, Morden. ■

Glenn Boughton consults with the Director of the Research Center, Burl D. Meek.

COMPUTER MAPPING FOR GRASSHOPPER SURVEY

STUART H. GAGE

La cartographie est un aspect important de l'analyse des données sur les sauterelles, car elle permet de déterminer la répartition des diverses populations, et ainsi localiser les endroits où les récoltes pouvaient être gravement infestées. On a mis au point une méthode informatisée permettant de traiter, de résumer et de transposer sur carte les chiffres démographiques des sauterelles.

Grasshopper surveys are an integral part of a crop protection program. The grasshopper population level must be determined to forecast damage potential. Grasshopper surveys have been conducted annually in late summer since the 1930s to measure adult and egg numbers throughout the crop-growing region of Saskatchewan. From these estimates, damage potential is forecast for the next crop year so that decisions regarding preparations for crop protection can be made in advance.

Mapping is an important feature in the analysis of grasshopper survey information because distribution of different grasshopper population levels must be determined to indicate where severe damage to crops may occur in the province. An automated method was designed to process, summarize and map the distribution of grasshopper numbers by computer. The general procedure for analysis and mapping is shown in Figure 1. The system incorporates SYMAP, a mapping program developed by the Laboratory for Computer Graphics and Spacial Analysis at Harvard University. The mapping component produces contour maps of transformed grasshopper densities based on the average ratings determined in each of 38 zones within the crop-growing region of the province from up to 2,500 survey locations per year.

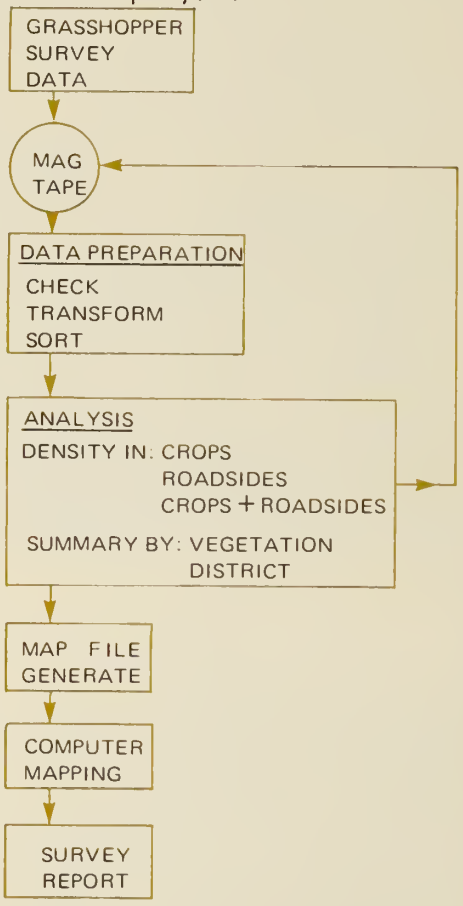


Figure 1. The general procedure for computer processing and mapping the annual grasshopper survey in Saskatchewan.

Mapping the annual grasshopper survey Computer maps of the distribution of adult grasshoppers for 1973-1976 provide a visual presentation of grasshopper infestation levels in four different years. The grasshopper numbers reached a maximum in 1974 and showed a significant decline by 1976. A key to the map symbols is given below the maps in Figure 2 and in Table 1.

Forecasting grasshopper damage is difficult because the damage they do to crops is largely dependent on the weather during the current crop-growing season. The same grasshopper population level in 2 successive years can result in very different damage regimes, depending on how the crop responds to grasshopper feeding and how the grasshopper population responds to the state of crop and roadside vegetation growth.

Mapping components related to the survey The computer-based system was designed to map historical as well as current survey data. Flexibility of the system allows incorporation of other factors with grasshopper survey information so that the interaction of grasshoppers with weather and crop growth can be mapped and evaluated. Computer mapping used to illustrate distribution of grasshoppers, precipitation, and wheat yields in 2 successive years. (Figs. 3-5), show the variability possible in 2 years. In 1961 there was more damage to crops by grasshoppers even though the popu-

TABLE 1 KEY TO COMPUTER MAPPING FOR THE ANNUAL SASKATCHEWAN GRASSHOPPER SURVEY

Map level	1	2	3	4	5
Grasshopper rating classes	0-1	1-2	2-4	4-6	6-10
Grasshopper damage potential	normal	light	moderate	severe	very severe
Map symbol	—	•	x	†	‡

Dr. Gage is an entomologist at the CDA Research Station, Saskatoon, Sask.

lations were higher in 1960 (Fig. 3). This resulted because crop yields were poor in 1961 (Fig. 4) due to low precipitation accumulations between April and July. Maps which show this can be examined and compared for a visual effect of the potential interactions and, with proper quantification, models relating these interactions can be developed.

Mapping long-term grasshopper survey data There is an alternate method of displaying contour maps. Instead of overprint shading, a number corresponding to each level is printed on the map. The average distributions of all grasshopper species during 1943-74 are shown in Figure 6. A key for the map is given in Table 2.

TABLE 2 KEY TO GRASSHOPPER ISOPLETH MAP (1943-74)

Level	All Species
1	0.00-1.00
2	1.00-2.00
3	2.00-3.00
4	3.00-4.00
5	4.00-5.00
Level interval	1.00
Total range	0.00-4.06
Mean for all districts	2.966
Coefficient of variation	57

TABLE 3 COST COMPARISON BETWEEN MANUAL AND COMPUTER METHOD FOR ANALYSIS AND MAPPING ANNUAL GRASSHOPPER SURVEY DATA

Computer processing	Cost
Cards punched	$ 50.00
Edit, transform, sort	20.00
Analysis and summary	20.00
Mapping	15.00
	$105.00

Manual processing	Cost
Edit	$ 500.00
Compile	1,000.00
Summarize	1,000.00
Map	1,000.00
	$3,500.00

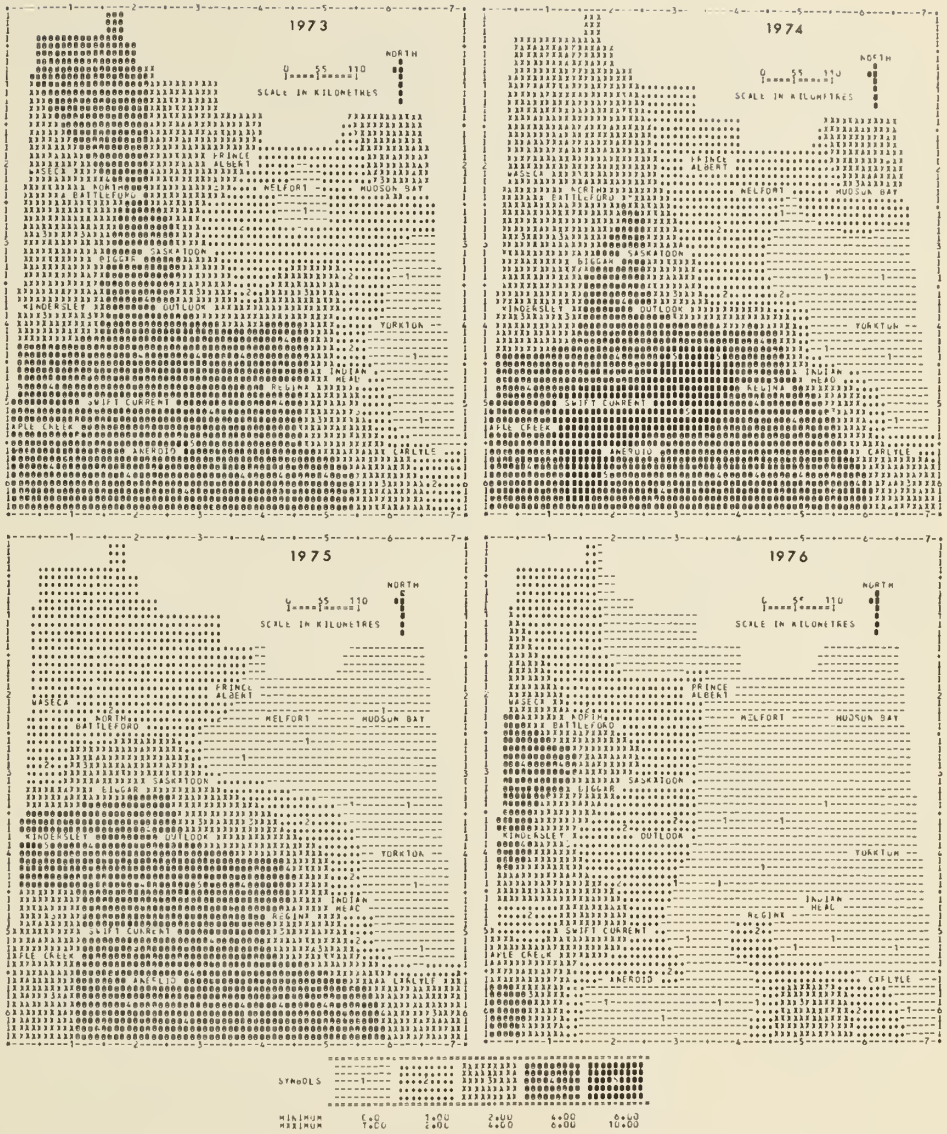


Figure 2. Computer maps of the infestation levels and distribution of adult grasshoppers (1973-76).

...damage potential

A set of maps showing the distribution of the various species can be useful for defining areas in the province where concentrations of grasshoppers occur on a regular basis. Separate maps of species or species combinations define regions where damage potential is greatest. Also, crop protection practices can differ depending on the abundance of a particular species.

Prior to 1974, all analyses and mapping for a single year's survey data was done manually and required over 3 man months for this process. Since the development of the automated analysis and mapping system, 34 years of historical survey data have been processed, analyzed and mapped. Table 3 shows a cost comparison between the manual and automated method for a single survey year.

There are many applications for mapping by computer, particularly when large amounts of information need to be mapped in a short time at low cost. Some examples of automated mapping of agricultural data have been given here. ■

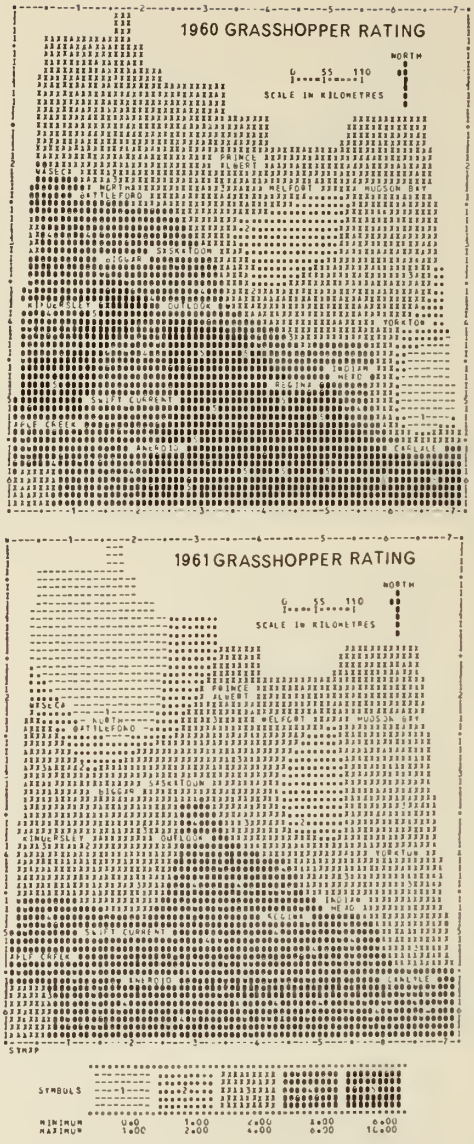


Figure 3. Grasshopper abundance and distribution during 1960-1961.

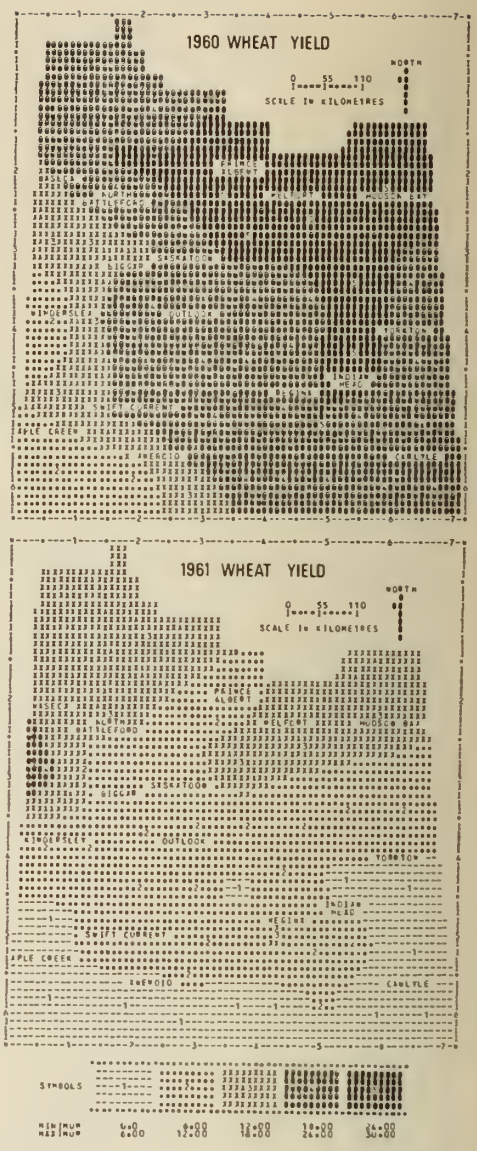


Figure 4 Wheat yields and distribution during 1960-1961 (bu/acre).

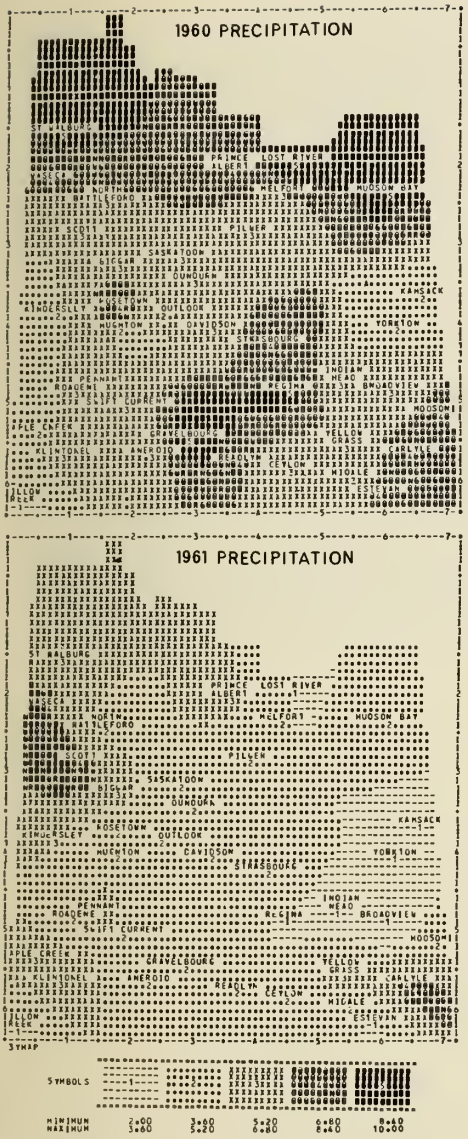


Figure 5. Precipitation amounts and distribution during 1960-1961 (inches) (April-July).

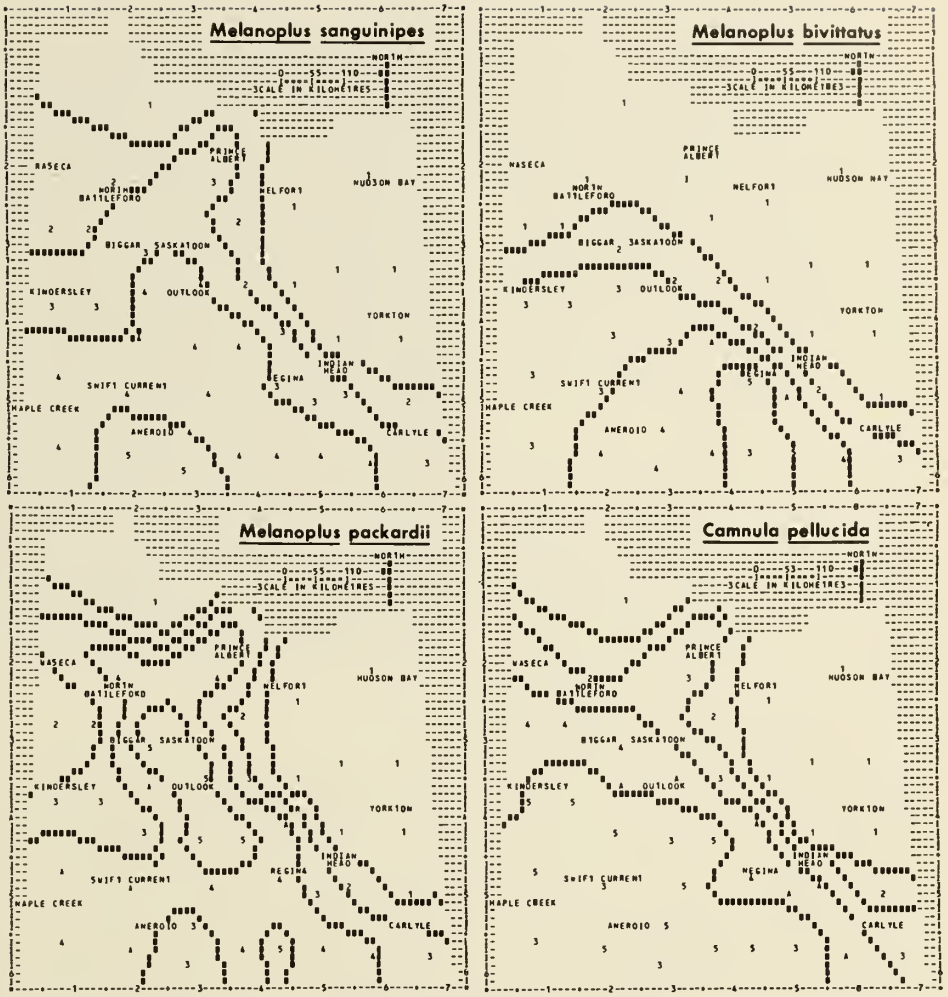


Figure 6. Thirty-two year average adult grasshopper abundance and distribution of four species (1943-74).

MICRO-ENCAPSULATION OF SOIL PESTICIDES

I. H. WILLIAMS

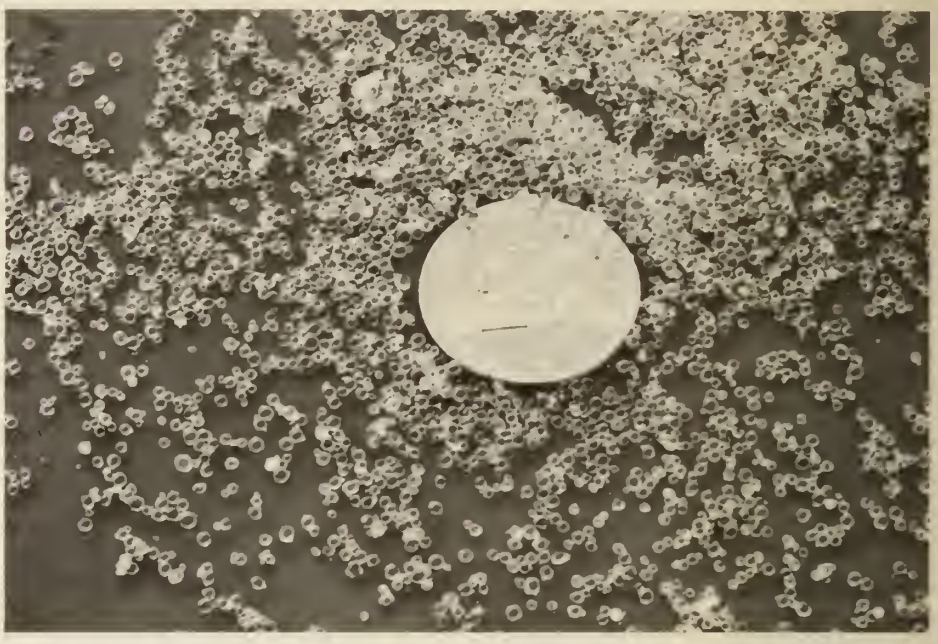
Bon nombre d'antiparasitaires modernes n'offrent qu'une très courte protection une fois dans le sol et nécessitent de nombreuses applications tout au cours de la saison végétative. Pour résoudre ce problème, on a innové une technique qui consiste à introduire l'antiparasitaire dans une capsule protectrice qui, une fois dans le sol, se désagrège lentement et libère son contenu à un rythme constant pour une longue période.

Many of our earlier pesticides such as DDT and dieldrin were so stable that soil applications remained effective for several years. In contrast, many of today's pesticides such as diazinon and malathion break down rapidly and do not protect the crop throughout the growing season. This deficiency is overcome at present by making repeated applications, which leads to higher costs both in materials and labor.

At the Vancouver Research Station we are seeking ways to prolong the effective life of pesticides in soil. If, for instance, the pesticide could be temporarily protected from air and water, it might be released at an effective rate over a reasonably long period.

One promising approach is microencapsulation. This is a process in which very small droplets or particles of a reactive compound are covered with an inert and protective material. This technique was originally developed to produce carbonless copying paper where the paper is coated with an encapsulated dye that is released by pressure to produce a copy. A more familiar application occurs in medicine where "millions of tiny time capsules" release medication over a prolonged period. It is also used in the food industry to keep liquid ingredients separate from dry ingredients in products such as cake mixes.

Mr. Williams is a specialist in pesticide chemistry the CDA Research Station, Vancouver, B.C.



Typical gelatin-gum acacia capsules contain an insecticide for soil application

Encapsulation of toxic insecticides would not only prolong their effectiveness, but would also make them safer to handle.

Encapsulated insecticides have already been used for foliage sprays. The microcapsules stick to the leaves of the sprayed plant until ingested by the attacking insect. In this case the nature of the material forming the capsule wall is not important so long as it is impervious to rain and can be ingested by the insect.

For soil application the nature of the capsule wall material is far more critical since it determines the rate at which the pesticide is released. The release must be fast enough to provide adequate protection, but slow enough to remain effective over the whole growing season.

Pesticide release may be by diffusion through a semipermeable capsule wall, or by a breaking down of the wall itself, either by moisture or bacterial action. If breakdown of the walls is not too rapid, this is probably the more effective method, especially if capsules have varying wall thickness, giving different rates of release.

Several materials have been developed for use as capsule walls. A particularly useful one, introduced by the National Cash Register Company for carbonless copying paper, consists of a mixture of gelatin and gum acacia. Formulation conditions are such that oil or a water-insoluble solvent can be readily encapsulated. This is a useful feature since such

compounds are suitable solvents for most pesticides. Other processes in which the capsule material is nylon, polyurethane or polyphthalamide are more suited to the encapsulation of aqueous solutions. These are usually unsuitable for insecticides because many insecticides are either insoluble or unstable in water.

One agricultural chemical company has used nylon to encapsulate the insecticide diazinon. The capsules are effective for foliage but U.S. workers recently showed that they release the insecticide too slowly to be effective in the soil.

Our preliminary experiments with gelatin-gum acacia capsules look more promising. In one experiment diazinon was released at a reasonably high and steady rate over a period of 6 weeks. Unencapsulated diazinon, applied to the same type of soil at the same rate degraded to less than half of its original concentration in 4 weeks.

It is too early to predict unqualified success for such capsules. In some soils, large numbers of microorganisms may degrade them far too rapidly; in other soils, breakdown may be too slow. Only further experimentation will prove whether this technique will be of significant benefit to the agricultural community. ■

PLANTS POISONOUS TO CATTLE

J. LOOMAN

Même si la situation s'est considérablement améliorée ces dix dernières années, les éleveurs et les agriculteurs des Prairies perdent chaque année un certain nombre de bovins empoisonnés par des plantes. *Delphinium* sp. *(Lower Larkspur)* et *Triglochin maritima (Seaside Arrowgrass)* en sont habituellement la cause, bien que l'on soupçonne parfois l'une ou l'autre de plusieurs autres espèces différentes.

Although there has been considerable improvement over the past 10 years, ranchers and farmers in the Prairie Provinces still experience cattle losses through poisoning by plants. This begins in early spring, and continues throughout the summer and well into the fall. Usually, losses can be attributed to either low larkspur or seaside arrowgrass, but in rare instances one of several other species must be suspected.

Dr. Looman is a range ecologist at the CDA Research Station, Swift Current, Sask.

In the spring, almost immediately after the growing season begins, low larkspur emerges and is often the only green plant material around. Although most ranchers have adjusted their management so that poisoning through this species is prevented, low larkspur still claims a few victims every year. In the Cypress Hills, where the species is more common than anywhere else in its range, poisoning has become rare. As a result, cattle losses are often blamed on other causes, or are considered normal losses. Up to 10 years ago, an average of 12 animals per year fell victim to low larkspur in cases reported to the Swift Current Research Station. That average has dropped to less than five per year over the last 5 years, and most of these deaths are not suspected, by the rancher or the farmer, to be due to larkspur poisoning.

Beginning in June, and occasionally earlier, cattle are lost throughout the Prairie Provinces through poisoning by seaside arrowgrass. It is rare when fewer than seven or eight cases per year are brought to my attention, and in several of these cases, four or five animals may have been lost. In 1975 eight cases of poisoning were traced with certainty to arrowgrass, while in another two cases there was a high degree of probability. The total number of cattle lost in these 10 cases was 42, and for the last 10 years the annual average has been almost 30.

It is impossible to estimate the actual total losses incurred through

low larkspur and seaside arrowgrass, because only the more severe cases come to my attention. Usually a farmer or rancher, who asks for a survey of a pasture in which cattle died, has one or more neighbors who also lost cattle, possibly through poisoning by the same species. Also, the loss of one animal is often considered normal; suspicion is aroused only when several animals die in rapid succession, or in the same location. How many calves are lost through abortion or infertility as a result of sublethal poisoning is a question to which there is no answer.

As far as other poisonous or potentially poisonous species are concerned, cases where cattle losses could be attributed to one of these species with absolute certainty have been very rare. In a few instances, water hemlock has been suspected. This plant is dangerous only in the spring, when the young leaves emerge and other green forage is scarce. Later in the season it is possible that cattle pull the roots out of the soft soil and eat them. Water hemlock is not very common; cases in which it was suspect were in the Parklands. The difficulty with this species is that if the plant is pulled out by the roots and eaten, suspicion can only be aroused if there are other plants around not eaten. Otherwise, the cause of poisoning remains a mystery.

Milkvetches and locoweeds are other potential trouble makers, but do not often cause problems. In the last 10 years no cases have been reported to the Swift Current Research Station in which milkvetches or locoweeds could have been suspected. Any loss caused by a species in this category is probably considered normal. How great the hidden losses are is again impossible to estimate, but since most of the range has been in good condition, these losses cannot be very severe.

Low larkspur.

Occasionally, death camas, smooth camas and chokecherry occur in situations where they are the only apparent or possible cause of cattle poisoning. Usually the cattle are severely ill, but eventually recover. Death can, and sometimes does, occur. However, death camas, smooth camas and chokecherry appear to be the major causes of sheep losses in the prairies. There are hidden losses which may be attributed to predators. In one instance, I found 70 sheep carcasses, all in the vicinity of chokecherry bushes. In two other cases, 25-30 sheep carcasses were found in pastures with a great abundance of death camas. In all three cases, the owners of the sheep blamed their losses on coyotes. The year after I had discussed the possibility of death camas poisoning with one of the sheep ranchers, one of his neighbors found more than 100 of his sheep in various stages of distress, and I easily found the areas in which large amounts of death camas had been grazed.

As mentioned, losses through abortion and loss of fertility cannot be reliably estimated. However, there are indications that such losses may be far greater than realized. Thus, work in Utah has shown that the alkaloids, responsible for the poisonous properties of death camas and other members of the lily family, have much the same effect on sheep embryos as thalidomide has on human embryos. For example, monkey face in lambs has been shown to occur if pregnant ewes ingested sublethal doses of the poison during a brief period after conception. My investigations indicate that conception in cows which eat small amounts of seaside arrowgrass is lower than normal, and early abortion can also occur.

Although remedial action is possible in most poisonings if discovered early enough, the best way to avoid losses is through prevention of poisoning. The greatest risks are incurred when animals are put into

Seaside arrowgrass in shallow water.

fresh pastures hungry, thirsty and tired. In the early spring, low larkspur infested range should be avoided; the succulent new growth of the larkspur attracts the animals after a winter diet of hay. In the summer, thirsty, tired animals will seek out seaside arrowgrass, which grows in wet saline areas and accumulates salt which the animals need. Locoweeds are eaten only after severe overgrazing of the range leaves the hungry animals little choice.

Good range management does not take unnecessary risks, and thereby avoids cattle losses caused by poisonous plants. ■

DETECTING PEA SEED-BORNE MOSAIC

RICHARD I. HAMILTON

Des chercheurs de la station de Vancouver ont mis au point des méthodes permettant de dépister le virus de la mosaïque transmis par les semences de pois chez les plantes et les semences. Ces méthodes nécessitent l'utilisation d'un sérum contenant des anticorps du virus.

Canadian pea breeding programs have been affected by a seed-borne virus called the pea seed-borne mosaic virus (PSbMV), which has resulted in the loss of some breeding lines as well as a delay in the advancement of new varieties. The disease, which was detected in Canadian breeding lines in December, 1974, has been under study at the Vancouver, British Columbia and Morden, Manitoba Research Stations of Agriculture Canada since that time (see article "New seed-borne virus of field peas" by R. C. Zimmer and S. T. Ali-Khan, Canada Agriculture, Spring, 1976, pp. 6-7). Methods have recently been developed at the Vancouver Station which can be used to detect the virus in plants and in the seeds from infected plants.

Dr. Hamilton is a virologist at the CDA Research Station, Vancouver, B.C.

The methods depend on the use of a serum containing antibodies to the virus. The serum was obtained from rabbits which had been immunized after injection with a highly purified virus. The virus used in the immunization program was obtained from PSbMV-infected peas grown in greenhouses at the Vancouver Research Station. Several kg of infected tissue were homogenized in an alkaline buffer solution and the virus was separated from the plant proteins and other contaminating substances by centrifugal methods. About 20 mg of the purified virus was used to immunize several rabbits.

A month after the injection schedules were completed, blood was collected from the rabbits and the serum fraction, which contains the antibodies to the virus, was prepared for use in the virus-detection systems.

...virus infection

Both methods are based on the knowledge that the antibodies in the serum will combine with the virus to form a precipitate which can be visualized. For example, if a small amount of the serum is added to a test tube containing a sample of the virus, a precipitate will occur within a few minutes. The antibodies are specific to the pea virus because no precipitate is obtained with viruses from other crops.

With the first method, the serum is used in a diffusion-in-gel-procedure. Serum is deposited in a well cut from an agar gel in a petri dish. Sap from plants suspected of being infected with PSbMV is deposited in peripheral wells, 6 mm from the central well. The gel contains a detergent (sodium dodecyl sulfate) which breaks the virus into small protein fragments; these fragments diffuse readily through the gel to be precipitated by the serum (Fig. 1). Because the virus is so long, it does not diffuse readily; the use of the detergent, however, results in diffusion of the small virus fragments which can be precipitated. The agar gel test for the detection of PSbMV is ideally suited for testing samples of leaf tissue from pea plants used as parental plants in a pea-breeding program.

The second method involves the use of an electron microscope to detect virus particles which have been trapped by antiserum. The method, developed by K. S. Derrick at Louisiana State University, is applied in the detection of PSbMV in homogenates of seeds. Drops of homogenates from seeds which have been soaked in water are deposited on electron microscope grids coated with a thin film of antibodies to PSbMV. The coating of these anti-

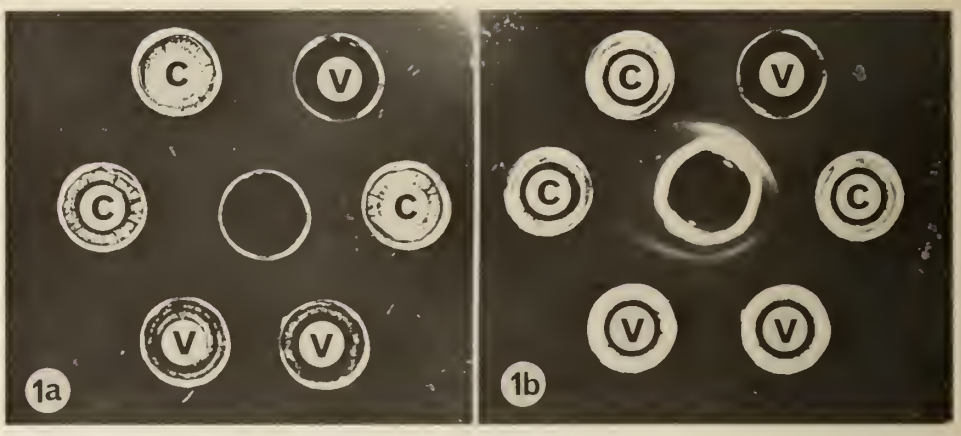


Fig. 1 Gel diffusion method for detecting PSbMV in plant extracts. Figure 1a shows gel containing detergent (sodium dodecyl sulfate) while Figure 1b shows gel without detergent. Wells marked "V" contained extracts from PSbMV-infected seedlings while those marked "C" contained extracts from virus-free plants.

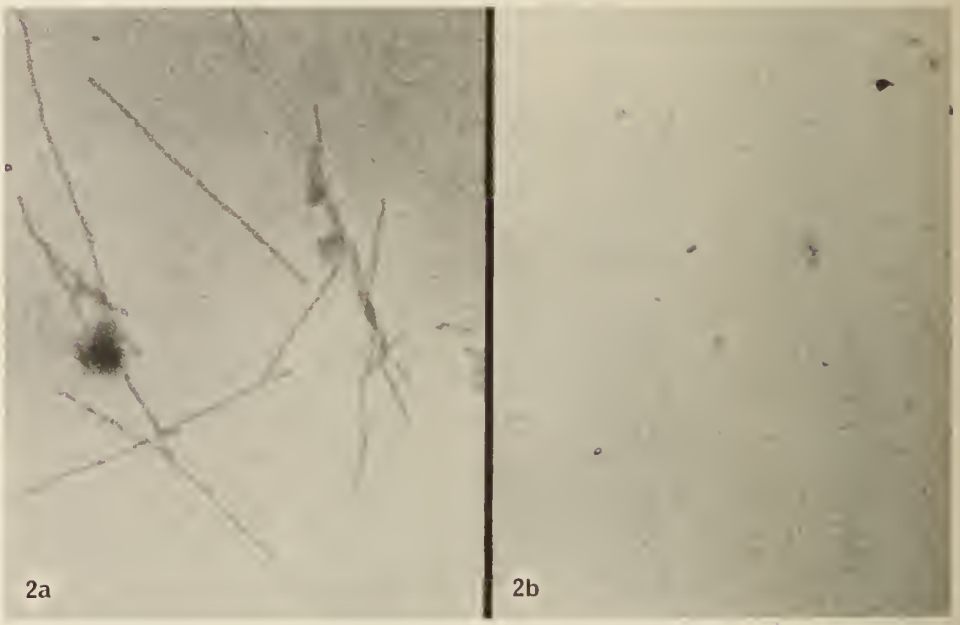


Fig. 2 Pea seed-borne mosaic virus detected in homogenates from infected pea seed using the serum-electron microscopy method. Figure 2a shows virus particles of PSbMV from infected seed; no particles are seen in homogenates from healthy seed (Figure 2b). (× 80,600)

bodies causes the virus particles to stick to the grid during a rigorous washing procedure while the usual debris from plant extracts is washed away. The grids are then dipped in a solution of uranyl acetate in order to make the virus particles visible in the electron microscope (Fig. 2). Seedlots containing only 0.5-1.0% of PSbMV-infected seed can be readily detected using this method. The procedure represents a significant advance in the detection of PSbMV in seeds. The usual procedure has been to examine pea seedlings from suspected seedlots for symptoms and to test suspicious samples for the presence of virus by inoculating extracts to indicator plants; the process requires about 3-5 weeks. The new procedure requires less than 24 hours after receipt of the seed.

Both of these serological methods will find application in the control of PSbMV in Canada and elsewhere. Because the virus is seed-borne and present in many breeding lines all over the world, often in the absence of symptoms, it is imperative that the pea breeder uses breeding material that is known to be free of this virus. The diffusion-in-gel method can be used to ensure that virus-free plants are being used as parents in the breeding program while the serum-electron microscopy method can be used to monitor the presence of PSbMV in bulk samples of advanced breeding lines. The serum-electron microscopy method is also ideally suited for detecting PSbMV and other seed-borne viruses in seeds imported to Canada for research or commercial purposes. ■

GROWING CUCUMBERS IN SAWDUST

R. M. ADAMSON

Le succès remporté par les producteurs des régions côtières de la Colombie-Britannique à l'égard de la culture des tomates de serre dans un lit de sciure ont incité les chercheurs à utiliser cette méthode pour la production de concombres. Destinée à l'origine à pallier les mauvaises conditions du sol, la méthode s'est révélée avantageuse à beaucoup d'autres points de vue.

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

Success in growing greenhouse tomatoes in sawdust has led producers in coastal British Columbia to consider sawdust for cucumbers, the number two greenhouse vegetable crop.

At the Research Station, Sidney, where studies with tomatoes were conducted, the original intent was to overcome difficult soil conditions. Gradually, however, there has developed a general recognition of other advantages to soilless methods. With cucumbers, our investigations have been mainly with European or seedless type cultivars which have a texture and flavor superior to American or seeded varieties. Although early trials were with wooden-sided troughs to contain the growth medium, more recent trials have been with white polyethylene bags, each containing one plant in 28.3 litres of sawdust, about three times the volume used for tomatoes.

Either Douglas fir or western hemlock sawdust proved satisfactory when a 1.25-2.5 cm layer of medium-coarse sand was applied to the surface shortly after transplanting. The sand ensures effective distribution of moisture throughout the sawdust and its more efficient use by the plants' root systems. Although

not an ideal growth medium, sawdust used in this way is satisfactory and is inexpensive, clean, light in weight and easy to handle.

Because of high seed cost, particularly for the newer all-female hybrids used in recent trials, consistent production of a high percentage of good quality transplants is imperative. Considerable attention, therefore, has been paid to the raising of plants from sowing to the transplanting stage. Soilless methods are used, the seed being first sprouted at 25°C on blotters or the equivalent in a saturated atmosphere. After about 40 hours, the germinated seedlings are transferred to a 2:1 peat-vermiculite growing mixture in plastic pots 10 cm in diameter. The temperature is reduced to 20°C. The seedlings are kept moist with a nutrient solution and, after 2 weeks in the greenhouse, the pots are spaced so that maximum light will be received. After 3 to 3½ weeks, when the plants have developed four true leaves, they are transplanted into the sawdust-filled growing bags.

Moisture and plant food requirements are supplied by nutrient solutions. They are pumped through pipes from the tanks in which they are prepared and distributed to each plant through small bore plastic trickle tubes (1.14 mm in diam) at low pressure. It is a wasting rather than a recirculating system, with surplus solution draining through holes in the bottom of the bags. This slight flushing action helps to keep salt levels in the solution in the root zone under control. The duration and frequency of applications are programmed by means of time clocks to start and shut off the pumps at preset times.

Success with seedless cucumbers depends on the grower's knowledge and ability to achieve a high level of production and quality throughout the year. The area he can devote to the crop will be limited by the amount of experienced labor available. Since pruning and training are critical in the successful management of seedless cucumbers, procedures which can be followed readily by inexperienced labor have been important considerations in our soilless culture studies.

In our investigations, we have devised a system which has shown promise for achieving the desired objective. It is based on producing six short-term crops, each occupying the same greenhouse space and the harvest period extending, with the exception of the last crops, about 1 month. The first crop, from an early January sowing, commences to produce in mid-March and the sixth in mid-August. Since the latter is the last crop of the season, the plants can be pruned and trained to produce for a longer period and harvesting can be extended into October. By this method, yields for the full season of from 5½ to 6

Cucumber plants ready for transplanting.

The first transplanting of the season just completed

First and second plantings before sand topping of the latter.

dozen fruits per plant space have been obtained. Quality has been excellent and continuity of fruit production has been good.

The management system involves placing sawdust-filled bags close together in rows at the beginning of the season, and then planting into alternate bags. The empty bags are available for the second planting. For the third planting, the bags used are those from which the first crop plants have been removed, and so on. A 1.25-2.5 cm layer of medium coarse sand is spread over the sawdust shortly after transplanting to facilitate lateral movement of moisture and to ensure a more uniform wetting of the sawdust growth medium. Two trickle tubes are provided for every bag, so that by varying the duration of feeding and number of tubes per bag from one to four, the volume can be adjusted to meet the requirements of two plantings of different ages.

The plants are trained up plastic twine supported by horizontal wires in the usual way. In each of the six plantings there is about 0.84 m^2 of greenhouse space per plant. Since all lateral shoots are removed, and only a single fruit permitted to develop at each main stem node, pruning is simple and quick, with an estimated saving in time of approximately 30% compared to time spent in lateral stem fruit production. Furthermore, less room is required by each plant, making possible the close spacing necessary for the method. Since fruits are produced on young, vigorous plants, they mature quickly and are of good quality. Cultivars suitable for the method include Pepinex, Farbio, Pandex and Uniflora D. Many of the new ones becoming available are also expected to be suitable.

Ready for the first picking.

The end result.

Pruning studies have shown that it is important to remove flower buds and lateral shoots from the axils of the first eight leaves. This delays fruit development but permits the plant to develop subsequent fruits with a minimum of aborting.

One of the main essentials is proper timing of sowings to achieve continuity of fruit production and to ensure that the older planting does not unduly restrict light reaching the succeeding planting. The latter problem has been largely overcome by initially training young plants up 4-ft wooden stakes pushed into the growth medium to keep the new plants well separated from the old ones. As fruit matures on the old plants, the lower aging leaves are removed to provide better light conditions for the young plants when they reach the top of the stakes and must be trained into the row and up the plastic twine.

The following formula has proved suitable for cucumbers grown in sawdust:

	per 1,000 l dilute solution
potassium sulphate	499 g
OR	
potassium chloride	416 g
phosphoric acid (75%)	89 g
calcium nitrate	1081 g
magnesium sulphate	499 g
minor element solution[1]	208 ml

Depending on the water source, the nutrient solution may have an acidic reaction requiring adjustment by potassium hydroxide granules to a pH of 6.0-6.5.

[1]Soilless culture of commercial greenhouse tomatoes. Agr. Can. Pub. 1460, p. 5.

While the system may appear overcomplicated, it involves straightforward procedures easily repeated for each planting. These can be carried out readily by inexpensive labor, and the results of studies to date offer promise for satisfactory season-long production of high quality fruits. ■

THE NEMATODE FACTOR IN RASPBERRIES

F. D. McELROY

Une étude visant à déterminer le rôle des nématodes dans le dépérissement des framboisiers a été entreprise à la station de recherche de Vancouver en collaboration avec le ministère provincial de l'Agriculture. Plusieurs facteurs peuvent être à l'origine de cette maladie en Colombie-Britannique, mais l'importance des nématodes a été prouvée à cet égard. La méthode de lutte la plus prometteuse consiste en l'application de Nemagon au moyen d'un système d'irrigation par percolation.

The central Fraser Valley is known as the raspberry capital of British Columbia. The more than 1200 hectares devoted to raspberries are the most productive in the world. Under optimum conditions, the plants remain productive for 10-15 years and yield 9-11 metric tons/ha.

Dr. McElroy is a nematologist at the CDA Research Station, Vancouver, B.C.

In the last 2 decades, however, many raspberry plantings have weakened and declined. Yields have dropped by half and productivity has ended after 7-8 years. Because of intensified agriculture in the Valley, growers can no longer move to new land, and a restrictive market prevents them from rotating with other crops. Consequently, raspberries are grown almost continuously on some lands.

The term decline disease is an all-encompassing term. In the case of raspberry decline it is very appropriate; we do not know the exact cause of the disease. It may be caused by different pathogens under different circumstances, or by a combination of biotic and abiotic factors.

Symptoms vary, but generally include slow or nondevelopment of leaf buds in the spring, decrease in the number and size of new canes, and finally, plant death. The disease spreads from plant to plant and row to row in an everenlarging elipse

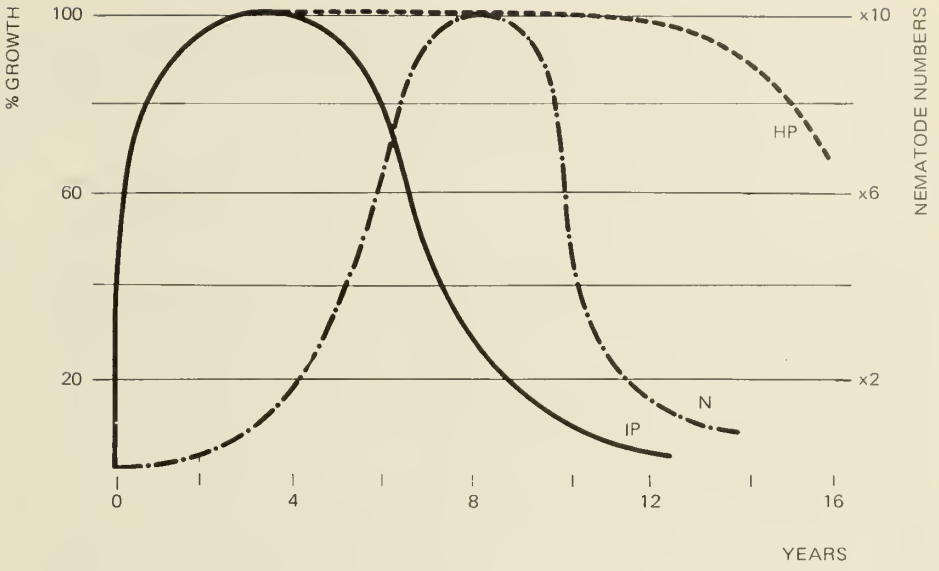
with its long axis parallel to the row. Eventually, the affected area becomes so large that the planting is uneconomical to maintain.

Greenhouse studies showed that nematodes cause serious damage to raspberries (Canada Agriculture, Summer 1971), but our knowledge of the field situation was limited. The Agriculture Canada Research Station, Vancouver, in cooperation with the provincial Ministry of Agriculture, therefore undertook a study to determine the role of nematodes in raspberry decline.

Low-flying aircraft were used to detect declining fields. Thirty-five mm photographs (Fig. 1) gave excellent records of the extent of damage and, over a 3-year period, allowed us to follow the spread of the decline. Most plantings showed damaged areas ranging from a few small target spots, 3-6 m in diameter, to large areas encompassing 0.5 ha or more.

Soil and root samples were collected from areas in which the photographs indicated extensive damage. Nematode counts showed that *Pratylenchus penetrans* and *Xiphinema bakeri* were the most prevalent species in the central valley loam soils. In the heavier soils near the eastern end of the valley, *P. penetrans* and *X. americanum* were the predominant parasitic species. *P. penetrans* and *X. bakeri* damage raspberry directly through their feeding. The former enters the roots, feeding on and destroying cells as it goes; the latter remains outside the roots and feeds on the growing tips, causing swellings and distortions. *X. americanum* causes little or no direct damage but it is a vector of the tomato ringspot virus which reduces raspberry growth and causes crumbly fruit.

A declining raspberry field heavily infested with *Pratylenchus penetrans*.



An illustration of the relationship between raspberry growth and nematode numbers. As nematode populations increase plant growth begins to decline. Eventually, food for the nematodes becomes limited and populations also decline. HP – healthy plants; IP – infected plants; N – nematode numbers.

Since *P. penetrans* and *X. bakeri* were the nematodes most consistently associated with raspberry decline, we studied their effect on growth and yield. Field plots were fumigated and then reinoculated with the two species, separately and together. The growth of plants in inoculated and noninoculated fields was compared for 2 years. *P. penetrans* alone had the greatest effect on plant establishment, resulting in 24% mortality of the plants. *X. bakeri*, *X. bakeri* + *P. penetrans* and *P. penetrans* reduced plant weight during the first year by 43%, 53% and 66% respectively. In the second season cane numbers were reduced by 23-30% in all nematode-infected plants. *X. bakeri*, *X. bakeri* + *P. penetrans* and *P. penetrans* reduced yields the first fruiting year by 26%, 35% and 47% respectively.

The rate of increase of these nematodes under field-grown raspberries was also determined. Samples collected during 4 successive summers showed that populations increased by over 130% per year.

At this rate, a population of only 20/200 ml of soil at planting time would in 6 years increase to over 1000/200 ml, well above the damage threshold of X No./200 ml of soil. This would account for the decline of 6-8 year old plants, even in soil fumigated before planting. Continued destruction of the roots would eventually result in population decline due to lack of food. (Fig. 2)

Since *Pratylenchus* invades root tissue, vegetatively propagated raspberry roots serve as an excellent means of nematode distribution. The common practice of exchanging root cuttings may explain why over 90% of the fields are infested with this nematode. To provide growers with nematode-free planting stock, a hot-water treatment was developed. Dormant root cuttings of most cultivars dug in the winter can be dipped in water at 48°C for 15 min to kill nematodes without injury to the roots. This treatment actually stimulates the growth of some cultivars.

A 7-year old raspberry field heavily infested with *Pratylenchus penetrans* and *Xiphinema bakeri*.

The same field as in Figure 3, 2 years after treating with DBCP.

To devise a control measure to restore declining fields without pulling and replanting, two post-plant nematicide treatments were tested: Nemagon (DBCP) was chisel-injected in the fall between th rows; and Vydate (Oxamyl) was applied as a foliar spray four times at 2-week intervals, beginning at full leaf in May. Both treatments reduced nematode populations and increased growth and yield by almost 30% the year following treatment. (Fig. 3). Unfortunately, only Nemagon is currently registered for use on raspberry.

The most promising control method under study is the application of Nemagon through a trickle irrigation system. This method gives the grower an easy, inexpensive means of keeping nematode populations at a level below the damage threshold.

While raspberry decline in British Columbia may be caused by several factors, the importance of nematodes has been demonstrated and their control is a giant step toward better raspberry production. ■

CLUBROOT-RESISTANCE TRANSFERRED TO CABBAGE

M. S. CHIANG, B. Y. CHIANG and W. F. GRANT

Des hybrides des interspécifiques furent obtenus entre l'espèce amphidiploïde *Brassica napus* et le chou, afin d'incorporer chez les trois principales cultures de *B. oleracea*, soit le chou, le chou-fleur et le brocoli, le gène existant chez le rutabaga et la navette pour la résistance à la hernie des crucifères causée par *Plasmodiophora brassicae*. Des observations cytologiques faites à la méiose chez les hybrides F_1 révèlent l'occurrence d'échanges génétiques entre les chromosomes des espèces parentales.

Since the publication of "Clubroot-resistant Cabbage for Quebec" (Chiang and Crête, Canada Agriculture, Spring 1969), there has been a marked shift in the race of the clubroot pathogen, *Plasmodiophora brassicae*, which is prevalent in the cabbage fields of Quebec. For the past 4 to 5 years, race 2 has gradually taken over the areas predominantly infested by race 6. Selected race 6-resistant cultivars and breeding lines have once again become susceptible to this destructive disease. Hence, to combat the present change in status of the races, as well as to anticipate future changes, it is necessary to breed for multi-resistant cabbages.

In our search for germplasm resistant to clubroot disease, we have not been able to find resistance to race 2 of *P. brassicae* in any of the collections within the cole crop species *Brassica oleracea*. However, several cultivars of rutabaga and rape (both of *Brassica napus*) are highly resistant not only to race 2 but to many other physiological races of the clubroot pathogen. Thus, a joint program was initiated in 1974 by the CDA Research Station, St. Jean, Quebec, and the Genetics Laboratory, Department of Plant Science, Macdonald Campus of McGill University, to transfer clubroot-resistance from *B. napus* to cabbage by means of interspecific hybridization.

Brassica napus is a natural amphidiploid containing the entire somatic chromosome sets of two diploid species, namely, *B. campestris* (turnip, Chinese cabbage, etc, $2n = 20$, genome aa) and *B. oleracea* (cabbage, broccoli, cauliflower, kale, etc, $2n = 18$, genome cc). *B. napus* can be crossed rather readily with *B. campestris*, and hybrids have been produced from them for breeding purposes by scientists around the world. However, due to genetic differences, which have accumulated during the course of evolution, hybridization between *B. napus* and *B. oleracea*, especially with cabbage, has always been very difficult. We thus began our program with a three-way approach: (1) by using cultivars of the two species (*B. napus* and *B. oleracea*) with different backgrounds as parents to ensure as much genetic diversity as possible; (2) by artificial culture of hybrid embryos to produce hybrids before endosperm and hybrid breakdown; and (3) by using colchicine doubled autotetraploids of cabbage (with four times the haploid number; $4 \times 9 = 36$ chromosomes) to bring the cabbage chromosome number closer to that of *B. napus* ($2n = 38$). Our results showed that the cross of *B. napus* with autotetraploid cabbage was somewhat easier to make, but hybridization with diploid cabbage could also be achieved without resort to embryo culture if the parental plants possess the necessary genetic diversity. Thus, a number of interspecific hybrids with chromosome numbers at three chromosomal levels were successfully obtained. The chromosome constitution of the parents and resulting hybrids are presented in Table 1.

None of the F_1 hybrids tested

TABLE 1 CHROMOSOME NUMBER AND GENOME CONSTITUTION OF THE PARENTAL SPECIES AND THEIR HYBRIDS

Parental species		Hybrids
B. napus somatic chromosome number $2n = 38$; genome $a_1a_1c_1c_1$; $a_1=10$, $c_1=9$	Gametic (pollen or egg) chromosome number $n = 19$; genome a_1c_1	Triploid hybrid $2n = 19 + 9 = 28$; genome a_1c_1c
B. oleracea Diploid cabbage $2n = 18$; genome cc; $c = 9$	As male parent $n = 9$; genome c	
Autotetraploid cabbage $2n = 4 \times 9 = 36$; genome cccc	As male parent $n = 18$; genome cc	Tetraploid hybrid $2n = 19 + 18 = 37$; genome a_1c_1cc
Autotetraploid cabbage $2n = 36$; cccc	As female parent with spontaneously doubled egg; $n = 36$	Hexaploid hybrid $2n = 19 + 36 = 55$; genome a_1c_1cccc

Dr. M. S. Chiang is a plant breeder at the CDA Research Station, St. Jean, Que. Drs. B. Y. Chiang and W. F. Grant are with the geneticists at Macdonald Campus of McGill University.

Fig. 1 Clubroot disease reaction to race 2 of *Plasmodiophora brassicae* in cultivars of *B. napus*, cabbage, and their F_1 hybrids. Left to right: club and nodules on root of rutabaga cultivar Laurentian (susceptible control); advanced stage of clubroot infection on cabbage Badger Shipper (susceptible to race 2) showing nodules on lateral root with already decayed tap root; disease-free roots of F_1 (resistant rutabaga X diploid cabbage); F_1 (res. rutabaga X autotetraploid cabbage); F_1 (autotetraploid cabbage X res. rutabaga); and the healthy root of resistant rutabaga Wilhelmsburger.

Fig. 2 Leaves from mature plants of cabbage and *B. napus* and F_1 hybrids of different chromosomal levels. Left to right: typical leaf of cabbage; 55-chromosome F_1 hybrid (autotetraploid cabbage X rutabaga); 37-chromosome F_1 hybrid (rutabaga X autotetraploid cabbage); 28-chromosome F_1 hybrid (rutabaga X diploid cabbage); and rutabaga.

in the race 2-infested field plots showed any symptoms of clubroot disease (Fig. 1). This indicated that resistance to race 2 of *P. brassicae* contributed by *B. napus* is completely dominant over susceptibility. Most morphological characteristics of the F_1 hybrids were intermediate except that they all had nonfleshy roots like the cabbage parent.

Among the hybrids with chromosome constitutions at three chromosomal levels, the more sets of cabbage chromosomes contained in the hybrids, the closer the leaves resembled that of cabbage (Fig. 2).

To recover cabbage qualities to meet market requirements with added resistance to clubroot disease, backcrossing to cabbage is essential. Because of the genetic and chromosomal unbalance brought forth by such hybridization, however, sterility was encountered. The degree of fertility in these hybrids with different chromosomal constitutions also indicates that the more sets of cabbage chromosomes present, the higher the fertility, and probably the higher the tolerance for the genetic unbalance. Furthermore, these hybrids will again give rise to aneuploid progenies (having more or less than an integral multiple of the haploid number) with varying numbers of chromosomes and varying degrees of fertility. Consequently, the scheme for producing desirable progeny has to be tailored to suit the individual plants according to their chromosome number, cytogenetic behavior, and fertility.

Fortunately, cytological studies on the chromosome behavior of the various F_1 hybrids reveal that the *oleracea* genome from *B. napus* (c_1) has maintained close homology with the c genome of cabbage, and that the *campestris* genome of *B. napus* (a_1) shows partial homology with the c genomes contained in the hybrids. In other words, the close pairing of c_1-c-chromosomes and partial pairing of a_1-c_1-c-chromosomes in the hybrids indicate that genetic exchanges can take place between chromosomes from the two parental species, thus making it possible to select resistant individuals from progenies derived from the cross between *B. napus* and *B. oleracea*. (Figs. 3-5).

During the past year, we have produced progenies from which it has been possible to select a number of individuals resistant to race 2. Further breeding from these selected plants will include backcrosses to broccoli and cauliflower in addition to cabbage. By broadening the genetic base, we are hoping that our species hybrids can serve as the foundation genotypes for building many multi-resistant cultivars of all three major cole crops to cope with

BIOLOGICAL CONTROL OF MOSQUITOES

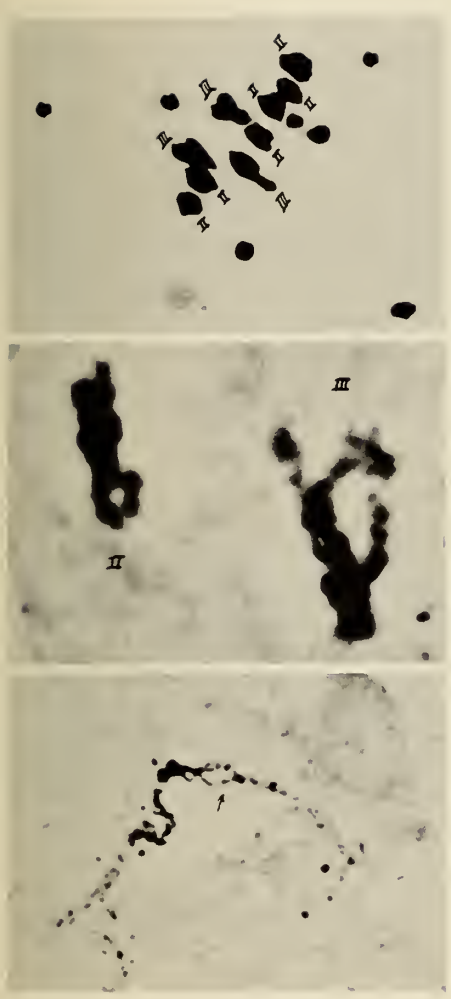


Fig. 3-5 Chromosome pairing during meiosis in pollen mother cells of triploid hybrids ($2n = 28$, genome a_1c_1c). Fig. 3 Metaphase I configurations with three trivalents (pairing of a_1-c_1-c-chromosomes), six bivalents (pairing of c_1-c-chromosomes), and seven univalents (unpaired a_1-chromosomes). Trivalents are indicated by the Roman numeral III, bivalents by II, and the remaining are univalents. Fig. 4 Late diplotene, a bivalent and a trivalent in a triploid hybrid. Fig. 5 Pachytene, a trivalent showing good pairing except for a section (arrow) next to the dark stained hererochromatin block.

the clubroot problem in a wide area and over a long period. ■

J. A. SHEMANCHUK

Une étude a été entreprise afin d'évaluer l'efficacité du champignon *C. psorophorae* comme agent de lutte biologique contre le moustique *C. inornata*. Au cours de son cycle biologique, le champignon passe par un hôte intermédiaire: le copépode *Cyclops vernalis*. Ces recherches ont permis la mise au point d'une technique permettant d'infecter méthodiquement le moustique hôte dans des conditions de laboratoire.

A study to determine if the fungus *Coelomomyces psorophorae* could be used as a biological control agent for mosquitoes has been initiated at the Lethbridge Research Station. The fungus, parasitic on mosquito larvae of *Culiseta inornata*, has persisted in irrigated areas of southern Alberta, and larva mortalities up to 80% have occurred in some of the breeding ponds. *Coelomomyces psorophorae* was first discovered in the irrigated areas of southern Alberta in 1956 and has been found there every year since.

The fungus was found near Maple Creek, Eastend, Vidora, Val Marie and Swift Current in a survey conducted by the Lethbridge Station in the irrigated areas of Saskatchewan in 1974. No infected larvae were found in the irrigated areas near Outlook.

Infected larvae have not been found in any survey of nonirrigated areas of Alberta and Saskatchewan.

Mortalities in populations of *C. inornata* vary with season and location. On several occasions, a few larvae of *Aedes vexans* were found

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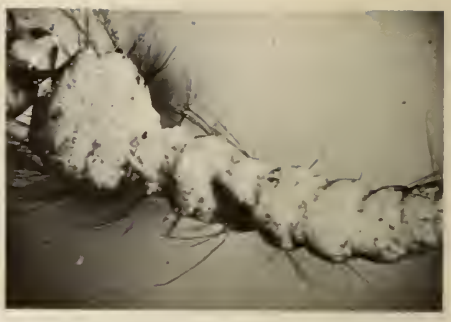
to be infected with this pathogen. In all instances it was associated with high infections in *C. inornata* larvae.

Our studies in collaboration with Dr. H. C. Whisler and Mr. S. L. Zebold of the Department of Botany at the University of Washington have resulted in the discovery that a copepod, *Cyclops vernalis*, is an alternate host of *C. psorophorae* in *C. inornata*. This discovery led to the development of a technique whereby the host mosquito can be consistently infected under laboratory conditions.

In further laboratory experiments, the original strain of *C. psorophorae* from the Alberta *C. inornata* mosquitoes would readily infect other species of mosquitoes. Infection was achieved in laboratory strains of *Culex pipiens pipiens*, *C. p. quinquefaciatus*, *A. aegypti*, *A. sierrensis*, *A. triseriatus*, and *C. inornata* (Louisiana strain). These results indicated that perhaps this strain of *Coelomomyces* could be used against other species of prairie mosquitoes, and especially *A. vexans*, since it has been found to be infected on occasion under field conditions. However, despite repeated attempts to date, larvae of *A. vexans*, *A. dorsalis*, and *A. flavescens* from southern Alberta, did not become infected when exposed to zygotes of *C. pso-*

...common pest

Life cycle of *Coelomomyces psorophorae*. Zygote (A) infects larva of *Culiseta inornata* (B) leading to development of hyphal bodies, mycellium, and ultimately, thick-walled resistant sporangia. Under appropriate conditions, these sporangia (C) release zoospores of opposite mating types (D) and these infect the alternate host *Cyclops vernalis* (E). Each zoospore develops into a thallus and eventually gametangia. Gametes of opposite mating types (F) fuse either inside or outside the copepod to form the mosquito-infecting zygote (A).



A larvae of *Culiseta inornata* heavily infected with sporangia of *Coelomomyces psorophorae*.

A roadside ditch and field pond in the irrigated areas of southern Alberta heavily overgrown with cattails, a suitable mosquito-breeding ground from which infected larvae of *C. inornata* were common.

rophorae, whereas *C. inornata* (Alberta strain) did become infected. The reasons for the lack of infection in these species are unknown, but investigations are continuing.

Despite the lack of success in infecting prairie *Aedes* species, the pathogen has a great potential even if it is only effective against *C. inornata* mosquitoes. *C. inornata* is a common pest of livestock and occasionally of man in the prairie region and is a vector of Western Equine Encephalomyelitis.

Our ability to mass-produce this pathogen in the laboratory in the original host mosquito as well as in other laboratory strains of mosquitoes is a step closer to testing under practical field conditions. It is envisaged that initial field tests will involve the seeding of *C. inornata* mosquito breeding ponds with fungus-infected copepods produced in the laboratory. ■

WHEN TO REPLACE LAYERS

A. T. HILL

There are a number of factors that the egg producer must consider in timing the replacement of his flocks. The age of bird on production is a key factor. As the bird grows older, production declines after the peak has been reached. Also egg quality is affected by the age of the bird. The younger the bird is, the better the shell and internal quality of its eggs. However, smaller eggs and higher bird inventory are associated with the young pullets. When to replace layers thus becomes a difficult question to answer.

It is for this reason that an analysis was done of the performance records of two flocks, each of 2,000 WLs of two commercial strains. These flocks were kept for 15 months of production at the Agassiz Research Station.

Graph 1 shows the monthly laying pattern which peaked at nearly 90% and dropped to 55% by the 15th month. The monthly average production was obtained by adding the monthly percent of egg productions and dividing this sum by months in production plus 1. This extra month allowed for the clean-out of the house. In Graph 1, the two curves cross between the 11th and 12th months of lay and the average monthly egg production peaks at about 65% and then declines. Thus, if the decision is to be made on egg production alone, this flock should be replaced at approximately 11½ months of lay.

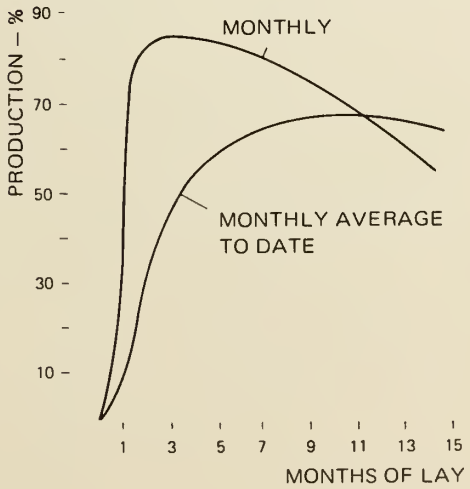
To convert production into net income, values were assigned for eggs, birds and feed (Table 1). The value of the bird was charged at housing and again 1 month was allowed for laying house clean-up between populations. Any decline in egg quality was included by giving Grades B and C 60% and 30% respectively, of the value of Grade AL eggs. Smaller eggs were similarly given values proportionately lower than large eggs. With this information, monthly and monthly average net egg returns were calculated. Results in Graph 2 show that the peak monthly average net egg returns was reached between 13 and 14 months of lay. Thus, peak profitability was achieved from the use of the flock by keeping it in lay approximately 13½ months.

Graph 3 shows that with relatively

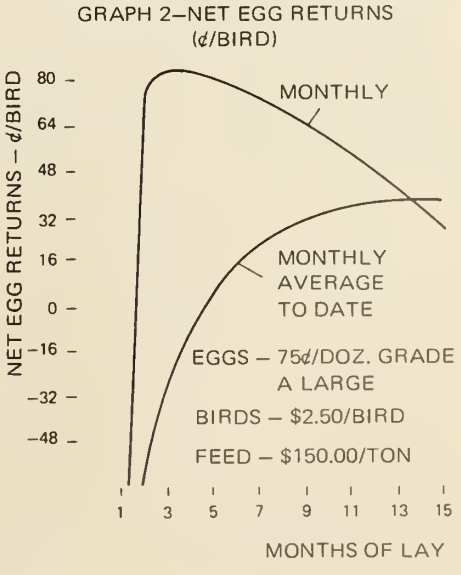
TABLE 1 EGG, BIRD AND FEED COSTS USED

Egg return to bird and feed cost combination	Eggs/doz Grade AL equiv. ¢	Bird cost $/bird	Feed cost $/ton
1. Relatively low egg returns	60	3.00	180.00
2. Relatively high egg returns	90	2.00	120.00
3. Medium egg returns	75	2.50	150.00

GRAPH 1 –EGG PRODUCTION (%)



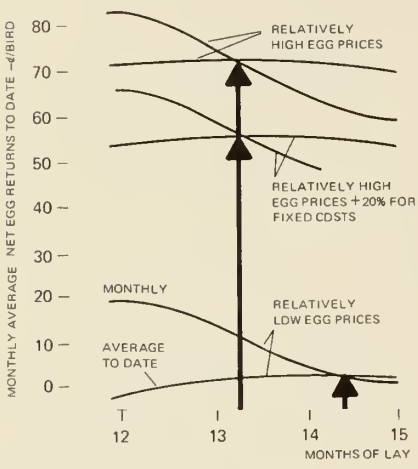
GRAPH 2–NET EGG RETURNS (¢/BIRD)



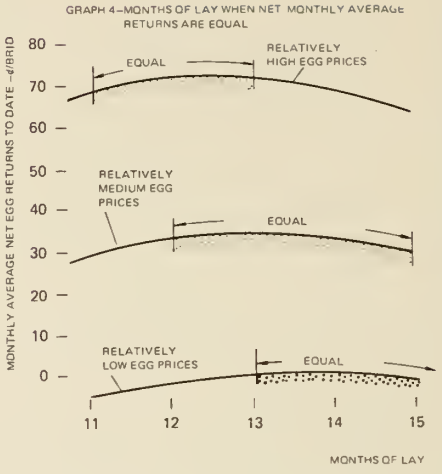
Dr. Hill is a specialist in poultry management the CDA Research Station, Agassiz, B.C.

...production flocks

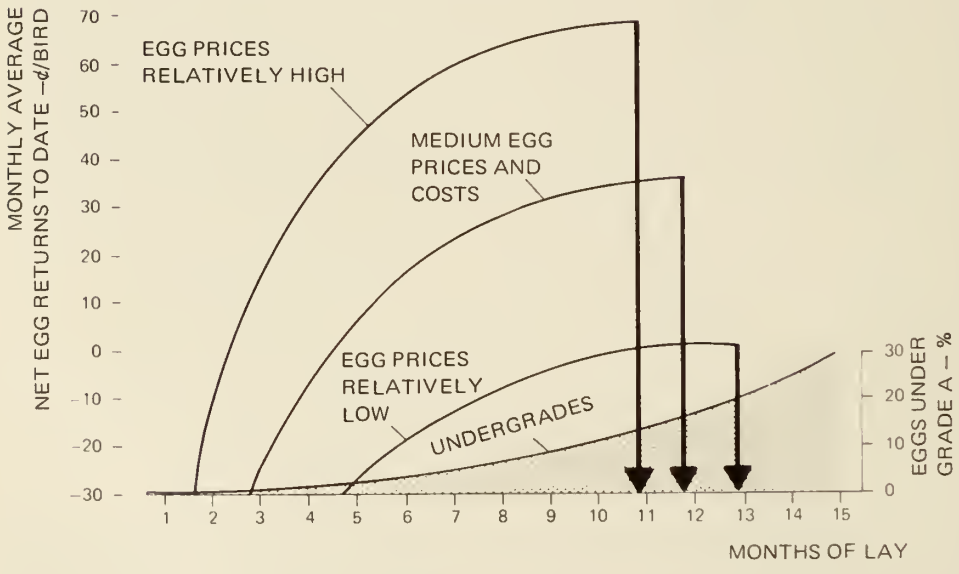
GRAPH 3 –EGG, BIRD, FEED AND CAPITAL COST EFFECTS ON THE MAXIMUM MONTHLY AVERAGE NET EGG RETURNS TO DATE



GRAPH 4–MONTHS OF LAY WHEN NET MONTHLY AVERAGE RETURNS ARE EQUAL



GRAPH 5–TIMING OF LAYER DEPOPULATION



high egg prices, the point of maximum monthly average net returns is reached at 13 months of lay. With low egg prices and high bird and feed costs, maximum net egg returns are not reached until almost 15 months. The inclusion of an allowance for fixed costs, like depreciation and interest on loans, did not alter the number of months to reach maximum monthly average net egg returns. It merely lowered the level of net egg returns.

In calculating monthly average net egg returns to date, the results on either side of the peak tend to be quite similar (Graph 4). When analyzed statistically with eggs relatively high in price, there were no significant differences ($P<0.05$) in the net monthly average returns between 11 and 13 months of lay. Similarly, for relatively medium and low egg returns, these monthly intervals were 12 – 15 and 13 – 15 respectively.

In the lower part of Graph 5, attention is focused on the sharp rise in eggs not meeting Grade A standards in older flocks. By 10 months of lay these undergrades reach 10% of all eggs laid and thereafter increase at a very rapid rate.

Considering the impact of declining egg quality and egg numbers from birds past 10 months of lay, results obtained in two experiments involving 4000 WLs of two commercial strains suggest that egg production flocks should be replaced after no more than 12 months of lay. To maintain them beyond this age generally results in lowering the profitability of the layer operation. ■

MOMENT DE LA REFORME DES PONDEUSES

A. T. HILL

Nombre de facteurs doivent être pris en considération lorsqu'il s'agit de déterminer le meilleur moment pour remplacer les pondeuses. L'âge des oiseaux en production en est un des plus importants car, après la période de pointe, le taux de ponte ne cesse de fléchir. L'âge influe en outre sur la qualité des œufs: plus les pondeuses sont jeunes, meilleurs sont la coquille et le contenu de l'œuf. Toutefois, les jeunes poulettes donnent des œufs plus petits et nécessitent un plus gros troupeau si l'on veut garder la même production. Le moment le plus propice pour remplacer les pondeuses demeure donc difficile à déterminer. En vue de déterminer le moment opportun de remplacer les pondeuses, une analyse a été effectuée sur les relevés de performance de deux troupeaux comprenant chacun 2000 White Leghorns tirées de deux souches commerciales et gardées pendant 15 mois de ponte à la Station de recherche d'Agassiz.

Le diagramme 1 présente la courbe mensuelle de la ponte, qui atteint un sommet à près de 90% et qui baisse à 55% au quinzième mois. La moyenne mensuelle de ponte à jour est obtenue en additionnant les pourcentages de production des divers mois et en divisant la somme par le nombre de mois de ponte plus un. Ce mois supplémentaire permet de tenir compte du nettoyage du poulailler. Dans le diagramme 1, les deux courbes se croisent entre les 11e et 12e mois de ponte, la production atteignant son point culminant à environ 65% et diminuant par la suite. Ainsi, si on se base uniquement sur la production d'œufs, il y aurait lieu de remplacer le troupeau après 11½ mois de ponte.

L'attribution de valeurs aux œufs, aux poules et aux aliments permet de convertir cette production en revenu net (tableau 1). La valeur de la poule est facturée au moment de l'occupation du poulailler, tout en allouant un mois pour le nettoyage entre chaque occupation. Toute baisse de la qualité des œufs est inscrite en attribuant aux catégories B et C 60% et 30% respectivement de la valeur de la catégorie AL. De même, les œufs de faible calibre reçoivent une valeur proportionnellement moindre par rapport à celle des gros œufs. C'est à partir de cette information que s'effectue le calcul du pourcentage mensuel et de la moyenne mensuelle à jour des recettes nettes sur les œufs. D'après le diagramme 2, il appert que la moyenne mensuelle des recettes nettes atteint son sommet entre les 13e et 14e mois de ponte. Il semble donc que la rentabilité maximale du troupeau est obtenue en le gardant pendant environ 13½ mois de ponte.

Par ailleurs, le diagramme 3 indique que, lorsque les prix des œufs sont relativement élevés, la moyenne mensuelle de recettes nettes atteint son maximum au 13e mois de ponte, mais lorsque les prix sont moins élevés pour les œufs et plus élevés pour les poules et les aliments, il est préférable de garder le troupeau pendant 14 mois de ponte.

DIAGRAMME 1 – PRODUCTION D'OEUFS (%)

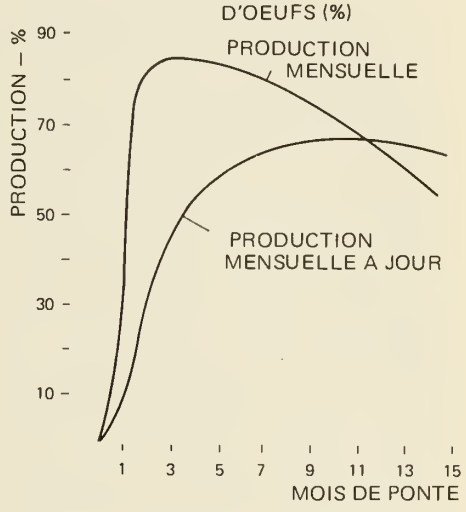


DIAGRAMME 2 – RECETTES NETTES EN PROVENANCE DES OEUFS (c. /poule)

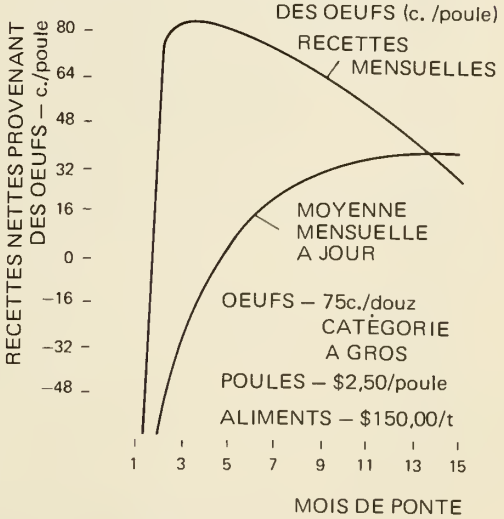


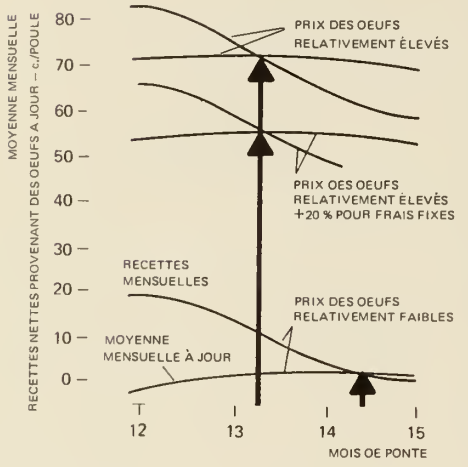
TABLEAU 1 TROIS NIVEAUX DE PRIX UTILISES POUR LES ŒUFS, LES POULES ET LES ALIMENTS

Recettes provenant des œufs par rapport au coût des poules et des aliments	Oeufs/dz Catégorie AL ¢/douz	Coût des poules $/poule	Coût des aliments $/tonne
1. Recettes relativement faibles en provenance des œufs	60	3.00	180.00
2. Recettes relativement élevées en provenance des œufs	90	2.00	120.00
3. Recettes moyennes en provenance des œufs	75	2.50	150.00

Monsieur Hill est au service du ministère de l'Agriculture du Canada, à la Station de recherche d'Agassiz (Colombie-Britannique).

...les troupeaux de pondeuses

DIAGRAMME 3 – EFFETS OU COÛT OES OEUFS, OES POULES, OES ALIMENTS ET DES IMMOBILISATIONS SUR LA MOYENNE MENSUELLE MAXIMALE DES RECETTES NETTES A JOUR PROVENANT DES OEUFS



OIAGRAMME 4 – MOIS OE PONTE OÙ LES MOYENNES MENSUELLES OES RECETTES NETTES SONT ÉGALES

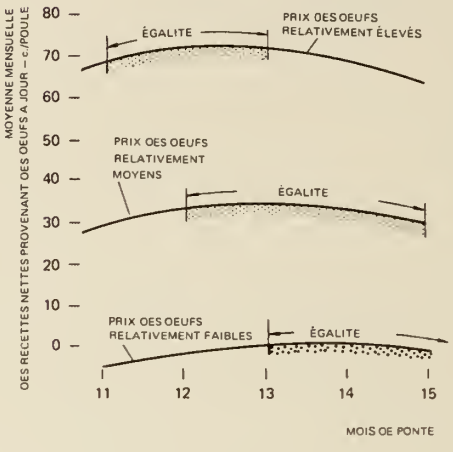
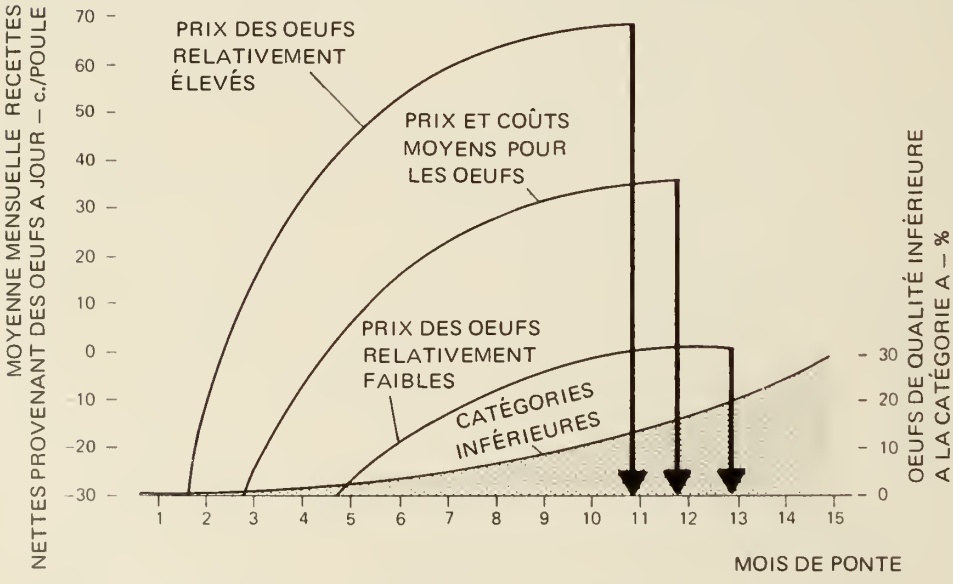


DIAGRAMME 5 – MOMENT DE LA RÉFORME DU TROUPEAU DE PONDEUSES



ments, cette moyenne maximale n'est obtenue qu'après presque 15 mois de ponte. L'inclusion d'une réduction pour frais fixes, tel l'amortissement et l'intérêt sur les emprunts, ne modifie en rien le nombre de mois requis pour atteindre la moyenne maximale et réduit simplement le niveau des recettes nettes.

Le calcul de la moyenne mensuelle des recettes nettes à jour sur les œufs donne des résultats analogues de chaque côté du sommet de la courbe (diagramme 4). Lorsque les prix des œufs sont relativement élevés, l'analyse statistique ne révèle aucun écart significatif ($P<0.05$) entre les moyennes mensuelles des recettes nettes du 11e et 13e mois de ponte. De même, dans le cas de recettes relativement moyennes et faibles, ces intervalles mensuels se situent entre les 12e et 15e mois et entre les 13e et 15e mois respectivement.

La partie inférieure du diagramme 5 fait ressortir l'augmentation marquée, chez les troupeaux plus âgés, d'œufs qui ne répondent pas aux normes de la catégorie A. Au 10e mois de ponte, ces œufs de catégorie inférieure atteignent 10% de la production et leur nombre augmente très rapidement par la suite.

Compte tenu des effets de la baisse de qualité et de la diminution du nombre d'œufs chez les poules après le 10e mois de ponte, les résultats de deux essais effectués chez 4000 White Leghorns issues de deux souches commerciales indiquent que les troupeaux de pondeuses devraient être remplacés au plus tard au cours du 12e mois de ponte. Le fait de les conserver plus longtemps entraîne généralement une réduction de la rentabilité de l'exploitation. ■

ECHOES
FROM THE FIELD AND LAB

ECHOS
DES LABOS ET D'AILLEURS

OATS: WILD AND CULTIVATED An Agriculture Canada priced publication on all species of oats has been released. It provides a comprehensive taxonomic treatment of all the known species of oats and their hybrids. This group of plants contains some species that are in worldwide cultivation, others that are wild, and some that cause serious problems as weeds.

To reinvestigate the classification of oat species, the author has combined micromorphological techniques with the most recent methods of numerical taxonomy and the use of computers. He has used the latest advances in methods for revising a plant genus, such as modern techniques of classification, phylogenetic analysis, automatic generation of keys, and computer mapping. The text is well illustrated.

The publication is entitled "Oats: Wild and Cultivated" and is available from the Publishing Centre, Supply and Services Canada, Ottawa, K1A 0S9. The price is $17.50 in Canada and $21.00 in other countries.

PEST REACHES EPIDEMIC PROPORTIONS The Sidney Research Station reports that during the past 7 or 8 years the Bruce spanworm has reached epidemic proportions on many deciduous trees in the Victoria area and on the Saanich peninsula of Vancouver Island. Commercial tree fruit growers have had to time control sprays carefully or face severe crop losses from the continuing infestations of the caterpillars. This year infestations were the largest yet, suggesting even greater outbreaks for next year. As this pest has occurred elsewhere in British Columbia, and has a wide range in feeding habits, it may become established in other areas and be of greater significance in commercial plantings.

BLACK FLY PROGRAM EXTENDED The Athabaska Black Fly Program, an interagency effort by the Departments of Agriculture and Environment of Canada and Alberta and the Alberta Research Council to develop controls for *Simulium arcticum* outbreaks on farms, has been extended for one year, the Lethbridge Research Station reports. The extension was necessary to monitor the Athabaska River System without pesticidal treatment and to assess the impact of the experimental operations of the preceding 3 years on nontarget organisms. A consolidated report with recommendations for future control of black flies in the area is expected to be complete by April 30, 1978.

The Morden Research Station reports that potato growers in south-central Manitoba harvested their earliest ever potato crop this summer. Some began digging fields July 7, 3 days before the previous record start. An early spring and above-average temperatures and precipitation in May and June contributed to the quick maturing of the crops in the area.

WHITE BEAN SELECTIONS Plant breeders at the Harrow Research Station have developed four new white bean selections. White beans, also known as pea beans or navy beans, are one of many dry edible beans of the same family as red and white kidney beans, pinto beans, great northern, wax, and green beans. The four new selections yielded significantly higher in regional field trials than Sanilac, Seafarer and Kentwood, the varieties currently recommended. One of these known as 82A3-1-1 was released in March 1977, under the variety name Fleetwood and is now in the hands of pedigreed seed growers. The seed size is comparable to Seafarer and Sanifar and has been found acceptable by the trade.

MUSHROOM PRODUCTION INCREASING The value of Canada's third most important vegetable crop is mushrooming. Canadian mushroom production last year reached more than 42 million lb, with a total value of $31 million. Projections for 1977 and 1978 call for increased production to 50 and 57 million lb respectively. Ontario and Quebec account for more than 80% of total production, with Ontario producing roughly 60% of domestic needs.

Total investment in mushroom growing and processing in Canada reached more than $41 million in 1976, up about 17% from the 1975 level of $35 million. While the crop has not advanced from its third position behind potatoes and tomatoes, production of both fresh and processed mushrooms continues to grow to meet increasing domestic demand.

BOTRYOTINIA AND BOTRYTIS SPECIES A publication on the Botryotinia and Botrytis species, which are some of the most widespread plant pathogens and saprophytes, has been released by Agriculture Canada. The author deals with the taxonomy, physiology and pathogenicity of these species. Botryotinia and Botrytis are particularly important on grapes, small fruits, vegetables, bulbous monoctyledons, forest tree seedlings, and glasshouse crops. These pathogens occur wherever their host crops are grown, ranging from the cool temperate zones of Alaska, Canada, Greenland and Lithuania to subtropical areas like Egypt and northern New Zealand. Most species occur in all continents.

The publication is entitled Botryotinia and Botrytis Species: Taxonomy, Physiology and Pathogenicity and is available from the Information Division, Agriculture Canada, Ottawa, K1A 0C7.

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