Research
FOR FARMERS

SUMMER — 1958

CANADA DEPARTMENT OF AGRICULTURE

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CANADA DEPARTMENT OF AGRICULTURE
Ottawa, Ontario

HON. DOUGLAS S. HARKNESS, *Minister*
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NOTES AND COMMENTS

The ill effects of overeating are not limited to humans. Chickens reared on a restricted diet have proved healthier and more profitable than comparable birds given all the feed they would take during the rearing period. Results of a uniform experiment carried on at five Experimental Farms across Canada have shown increased returns from egg production of from 2 to 36 cents per bird in favor of the chickens raised on the restricted diet. In addition to the actual savings in feed costs, other factors responsible for higher profits included larger eggs during the early laying period, and slightly lower mortality.

* * *

Atomic energy is much in the public eye these days and agriculture is getting its share of attention in this regard. Applications that are no longer news include the use of radioactive tracers in nutritional studies and the employment of radiation by plant breeders to induce new gene combinations. A more recent study in which horticulturists and bacteriologists of the Department are engaged, involves the use of atomic radiation in the preservation of peeled and packaged potatoes. So far the results are encouraging. Shelf life has been extended and quality maintained by the treatment under laboratory conditions. Commercial application may be a long way off but the possibilities are interesting in this age when so much of our food is being offered in ready-to-use packages.

* * *

Nurserymen and others who propagate plants from green cuttings are faced with the problem of keeping them from wilting during the period before roots develop. Frequent syringing of the foliage and shading to reduce transpiration are common practices, and cuttings are often 'stuck' in small enclosed cases where high humidity can be maintained. While these methods give satisfactory results, they are not well adapted to large-scale propagation. This has led to the development of the so-called 'mist' propagation technique, where both the foliage and the surrounding atmosphere are moistened mechanically at regular, pre-determined intervals. A supply of water under pressure, a system of piping with fine spray nozzles at suitable intervals, and an electrical control system are the main requisites. Propagation beds in the open in full sunlight are proving satisfactory, provided they are sheltered from winds. The technique seems equally well adapted to greenhouse use and should be a boon to plant propagators.

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Cover Photo—Rust culture compartments in the plant pathology greenhouse at Department's Winnipeg Laboratory. Dr. G. J. Green (left), author of article on page 3, is determining rust reaction of wheat seedling plants with Dr. T. Johnson.

Above: Stem rust uredospores. *Left:* Susceptible wheat variety (right) severely damaged by rust; resistant variety (left).

RESISTANT VARIETIES

Best Answer to Wheat Rust Problem

G. J. Green

RESISTANT varieties provide the only effective method for controlling the cereal rusts. The production of new varieties with suitable rust resistance depends largely on a thorough knowledge of the pathogenic capabilities of the rust population. This population is made up of many strains, distinguishable only by their ability to attack different host varieties. The strains may be separated into fairly well-defined groups called physiologic races, according to the type of infection they produce on a group of differential host varieties. The identification of the physiologic races in an area reveals a great deal about the pathogenic capabilities of the rust population. We identify the races of wheat stem rust on twelve differential hosts. These varieties were adequate for the purpose until recently when varieties with new types of resistance became widely grown.

Some rust strains that can attack these new varieties produce the same reactions on the twelve differential hosts as strains that cannot attack the new varieties. This means that an important variety which is not a standard differential host may be resistant to one culture of a race but susceptible to another culture of the same race. Usually most cultures of the same race are alike, and differences between cultures are few and unimportant. The rare but important variants are detected by using supplementary hosts along with the twelve differential hosts. For convenience these variants have been called sub-races, designated by the addition of a letter to the race number—thus race 15B.

Dr. Green is a Plant Pathologist specializing in Cereal Rusts at the Canada Dept. of Agriculture Research Laboratory, Winnipeg, Man.

Race Prevalence Fluctuates

Besides knowing the races present in an area we must know how the prevalence of these races changes from year to year. Usually four or five races comprise most of the rust in Canada but ten years hence the predominant races may be quite different. Sometimes new races are no more destructive than the old ones, but often it is a dangerous race that builds up and replaces earlier predominant races. Such a build-up usually results from the selective action of the widely cultivated wheat varieties. The popular varieties encourage the increase of races able to attack them by eliminating competition from races to which they are resistant. The situation in the rust area before 1954 will illustrate the point. The varieties Regent, Renown, Redman, Thatcher, Stewart and Carleton, occupied most of the acreage and were susceptible only to race 15B.

This race became predominant almost to the exclusion of other races. Selkirk, the first variety capable of resisting race 15B, now occupies nearly all the wheat acreage in the rust area of Western Canada and much in the adjacent states. Thus a race able to attack Selkirk would be expected to increase quickly. Selkirk is resistant to all the common races but at high temperature it is moderately susceptible to a few rare races, including race 29 which has been present in Canada in each of the last five

years. Fortunately race 29 has not increased in prevalence; apparently it is not especially virulent on Selkirk under the field conditions usual in Western Canada.

In 1953, just as Selkirk was being released to farmers, a new threat, race 15B-3, was discovered. Like other strains of 15B it could attack all the older varieties but, unlike them, it could also attack Selkirk. It occurred rarely in Western Canada in 1953, 1954, and 1955 but it disappeared in 1956 and 1957. This does not necessarily mean race 15B-3 no longer exists but more likely that it exists in much smaller amounts than formerly and the probability of collecting it is small. This race may reappear to threaten Selkirk but in the meantime a breeding program is under way to produce a variety with resistance to 15B-3 and the other common races.

Obtaining Rust Resistance

A good source of resistance is essential to the breeding of rust-resistant commercial wheats. All known varieties that serve as sources of resistance are unsuitable for commercial production in Canada because of poor quality, yield or agronomic type. They are valuable mainly for the rust resistance they can contribute to our varieties.

Satisfactory sources of resistance did not become available in Canada until resistance from other wheat species (Yaroslav emmer and Iumillo durum) was transferred to common wheat. All of the Canadian resistant varieties before Selkirk possessed resistance derived from Yaroslav emmer. The variety Apex had, in addition, resistance from Iumillo durum and the common wheat Kanred. Thatcher wheat, produced in the United States, acquired its resistance from Iumillo and Kanred. The discovery of race 15B, which could attack all sources of resistance known in 1939, seemed to nullify the achievements up to that time. But the threat of this race was a great stimulus to research on the rusts. New sources of resistance were sought by new methods and by a greater number of workers. As a result of international co-operation we have today a considerable number of varieties that are resistant to most, if not all, the stem rust races found in Canada.

Probably the most important source of stem rust resistance now used in Canada is the variety Kenya Farmer. This variety has been tested intensively in the field and greenhouse for a number of years and is resistant to all races found in Canada. It is resistant throughout North America and many other countries with the notable exception of Kenya, its place of origin. The races that attack Kenya Farmer in Africa are not important to the Canadian farmer today, but they serve as notice from the rust that it can produce strains virulent on the Kenya Farmer type of resistance.

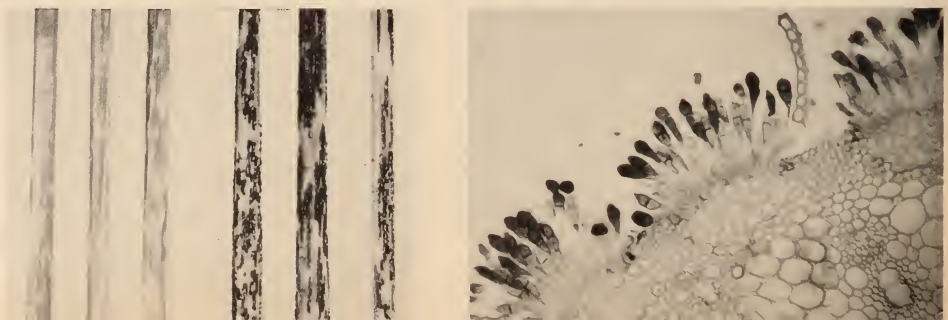
No Permanent Solution in Sight

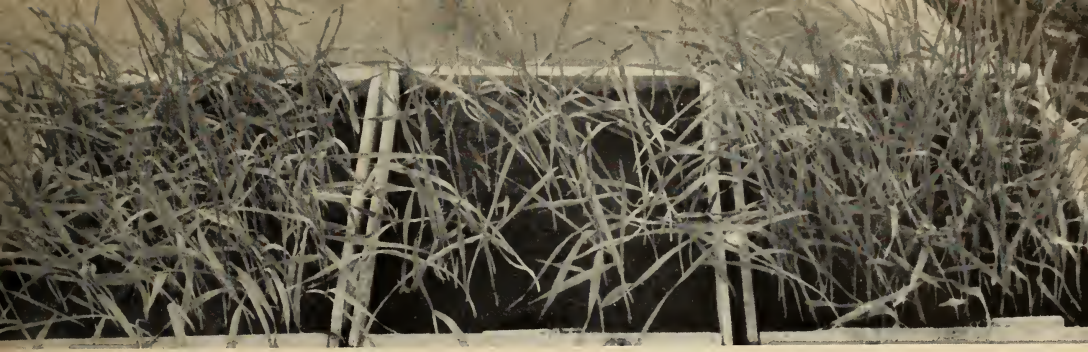
The dynamic nature of the rust problem renders a permanent solution improbable. A practical solution more likely will come from the manipulation of different types of resistance to counteract changes in the rust. Already much has been achieved through a very simple application of this method. There seems to be no good reason why it cannot be extended and made more effective in the future. Success will depend on a continuing and painstaking study of the rust to detect promptly any new and dangerous races. It will require also a continuing search for new sources of resistance and the prompt transfer of these different types of resistance to commercial varieties. These measures may never entirely eliminate rust but they can greatly restrict its development and leave little chance that our crops will suffer appreciable losses from rust.

International Co-operation

New sources of resistance have become available to us largely through international co-operation. Rust workers from many countries decided that the best way to find new sources of resistance and to test new varieties was through an International Rust Nursery. This nursery, which is made up of wheat varieties contributed by plant breeders and plant pathologists throughout the world, contains the world's most rust-resistant wheats. Co-operators in Africa, Asia, Australia, Europe, North America and South America plant the nursery in areas where the most severe rust epidemics occur. In this way new varieties are tested throughly in a short time and the best sources of resistance are revealed quickly. A variety which shows good resistance in this nursery for several years is obviously a valuable source of resistance. The time saved by having available good sources of resistance and a world-wide testing service should result in a large reduction in rust losses throughout the world.

Left: Resistant wheat variety (left) and susceptible variety (right) inoculated with the same race of stem rust. *Right:* Teliospores of stem rust. A very thin cross-section of a wheat stem infected with stem rust.





Effect of different soak treatments on emergence of barley in soil. Average difference in favor of the salt-water treatment was about 25 per cent.

SALT'S THE SECRET

Improved Soak Treatment for Barley Smut Control

R. C. Russell and S. H. F. Chinn

For over 60 years the only practical means of controlling loose smut was the hot water treatment—effective when properly used but difficult to apply on an ordinary farm. Special equipment is needed to hold the temperature of the hot water bath at the proper level. If the temperature drops too low some of the smut will survive, and if it gets too high the seed will germinate poorly. Therefore the hot water treatment has not been used extensively.

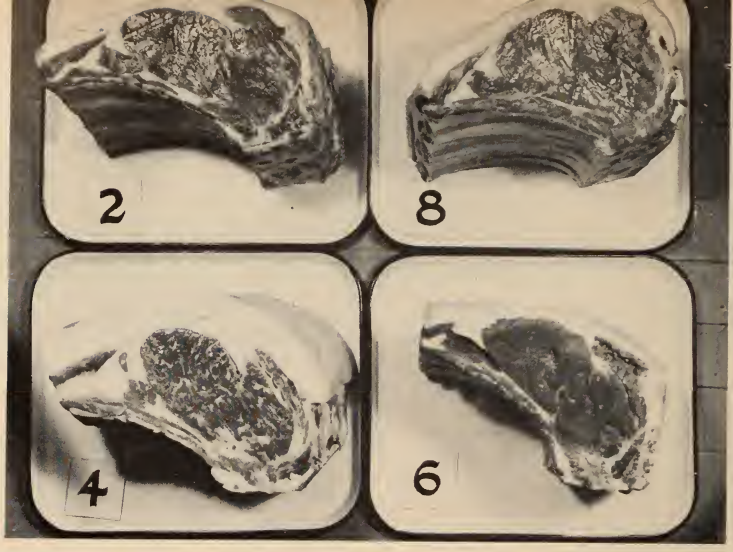
About the year 1950 investigators began experimenting with different types of soak treatments for controlling loose smuts of barley and wheat. Various materials were added to the water in which the seed was soaked. These included chemicals, antibiotics, and pure cultures of antibiotic organisms. Later it was discovered that pure water would give complete control of the disease, if the infected seed was soaked in it for the proper length of time at any temperature from 66°F to 126° F.

The water soak treatment at present recommended will give complete control of the disease but it has two distinct drawbacks. It is cumbersome and usually causes an appreciable amount of injury to the seed. The amount of this injury varies a great deal between different samples of seed, but generally the percentage emergence is lowered and the rate of germination is retarded to some degree. This difficulty can now be overcome. In our work at Saskatoon we recently discovered that the addition of a small proportion of common salt to the water before soaking the seed reduced the injury to a considerable extent. Using a 1 per cent solution of salt in water we have found the following schedules satisfactory for treating barley: 35 hours at 86°F; 60 hours at 76°F; or 75 hours at 70°F. The influence of the water soak treatment and the salt-water soak treatment on germination was compared in germination tests with thirty different lots of seed barley. The tests were run in flats of soil using 300 seeds of each sample for each treatment. The average difference in germination in favor of the salt-water soak treatment was about 25 per cent.

During the past year we conducted numerous tests using the salt-water soak treatment for the control of loose smut of barley both in the greenhouse and in the field. The seed used was infected by natural means and carried from 5 to 15 per cent smut. Besides our own experimental plots we had demonstration plots sown on five experimental farms in Saskatchewan. The treatment completely eliminated the smut from many of the plots and reduced it to negligible proportions in others. Compared with the water soak treatment, the salt-water soak resulted in equally thorough control and less injury to the seed.

The salt-water soak treatment will give good control of loose smut of barley with relatively little injury to the seed. The treatment is still somewhat laborious as the seed has to be dried to prevent premature sprouting or molding after it is treated. Therefore we do not recommend that it be used on a large scale unless special equipment is available for drying the seed. However, any farmer can treat a few bushels each spring and raise enough seed from it to fill his requirements for the succeeding year. The treatment of a few bushels would not require the expenditure of much time and energy. By following this practice his barley crops should always be relatively free of true loose smut.

The authors are with the Canada Dept. of Agriculture Research Laboratory, Saskatoon, Sask. Dr. Russell is a Plant Pathologist specializing in Cereal Smuts; Dr. Chinn is a Soil Microbiologist.



Set of prime rib roasts displayed. Cuts were unidentified as to grade and numbered at random.

New Beef Grade Based on Consumer's Choice

Leslie E. Drayton

CONSUMER preferences as revealed by studies carried out during the past two years were the basis for the new "Standard" grade of beef introduced last January. Standard grade beef comes only from carcasses of young steers and heifers, and represents the best quality meat from the former "Commercial" grade.

Consumer preference studies were carried out in two downtown department stores in Vancouver, at the Royal Agricultural Winter Fair, Toronto, and in an Ottawa supermarket. The objective was to determine which grade of beef consumers rate best on the basis of its appearance. No effort was made to evaluate consumer ability to recognize grade from appearance, or to learn the reasons for expressed preferences of individual consumers. Since few consumers are able to judge the tenderness of meat from its appearance, preferences based on eating the meat might be quite different from those reported in this study.

Method Used

In each study eight unidentified but numbered pieces were displayed for several days in refrigerated cases. A complete set of cuts consisted of four standing rib roasts and four porterhouse steaks. For both steaks and roasts there was one representing each of the following qualities: Fat A or Red Brand; Average A; Average B or Blue Brand; and Average C or Commercial[1]. An effort was made to secure as representative a sample as possible of each grade and the selection was made by experienced beef graders.

Identified by number only, the cuts were re-arranged frequently to cancel out any effect of relative positions of cuts in the display. All grade markings were removed and the cuts were trimmed according to standard retail practices.

An interviewer drew attention to the display and asked four simple questions: "Which roast do you like best? Which do you like least? Which steak do you like best? Which do you like least?" Respondents were asked to assume that the cuts were identical in size and price.

Consumer preferences differed considerably from store to store and city to city. There was, however, no consistency in ratings among the three studies. In one Vancouver store the average A grade was preferred above all

Dr. Drayton is an Economist with the Economics Division and specializes in Consumption Economics.

[1]These were the grade designations in use at the time this study was conducted. Under the revised grading system, A becomes Choice, B becomes Good, and the top quality C grade beef, Standard.

others for both steaks and roasts, and the B grade ranked second. In the other Vancouver store the B grade roast was preferred to the average A but the average A steak was preferred to the B.

The average A roast and the B steak had top preference in Toronto, but fat A cuts were considerably less popular than in Vancouver. On the other hand, the C cuts were more popular than in Vancouver and in the steaks were as highly rated as the A cuts. In Ottawa, the C cuts were most popular of all, closely followed by the B. The fat A cuts were selected as "best" by very few respondents.

Comparison of Sets of Cuts

Some of the inter-city variations may have resulted from differences in the sets of cuts actually displayed. On the basis of pictures taken at Toronto and Ottawa the massed fat areas on the upper surface of each cut were measured and estimated as a percentage of the total. Considerable variation in these fat areas appeared in the cuts selected for each grade, especially in Toronto. Moreover, the average red brand, blue brand, and commercial cuts used in Ottawa were somewhat fatter than those of corresponding grades used in Toronto. This may have been a factor in the higher ratings given to the blue brand and commercial cuts in Ottawa.

Surface Fat Affects Ratings

Comparison of ratings with the estimated fat areas suggested that the amount of surface fat influenced the average rating more than any other characteristic of the meat. The ratings of the steaks tended to be lower as fatness increased. However, there were exceptions and the fattest commercial steak selected was the most popular among those displayed in that grade. Roasts with a 30 to 35 per cent surface fat area were preferred.

This study revealed no marked differences in the preferences of men and women. Generally fewer men than women were critical of the fatter cuts displayed but there was little difference in average ratings given to specific cuts.

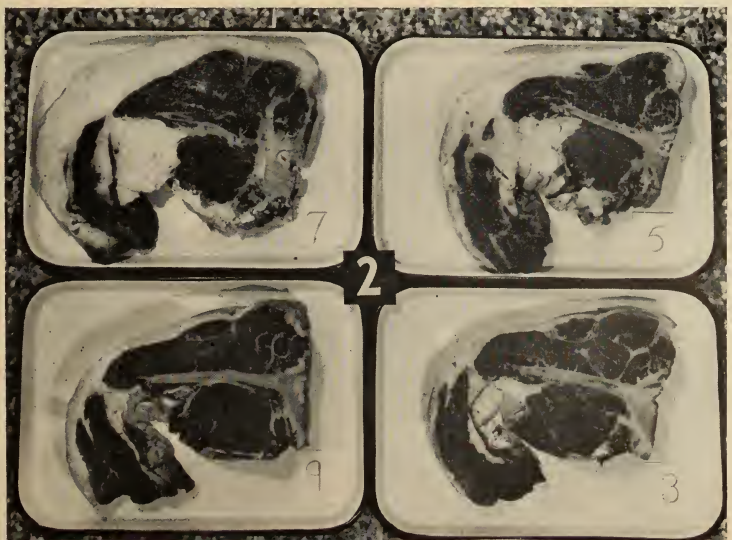
These studies indicate that if housewives were forced to make their selections of beef on the basis of its appearance only, many would select commercial beef in preference to the top grades. Studies of the same type conducted in the United States led to similar conclusions.

In practice, however, red and blue brand beef sells at a substantial premium over commercial beef even though the top grades constitute a large proportion of all beef sold in retail stores. One reason for this may well be that housewives appreciate the difficulty of judging the cooking quality of meat from its appearance and want the assurance of the top grade name or brand mark when they buy beef. Another reason may be that the commercial grade includes too wide a range of qualities, some of which most housewives find undesirable. Moreover, many butchers who handle commercial beef also sell ungraded beef and cow beef and do not tell the buyer what quality he is getting.

Consumer Given Wider Choice

Consequently, it is expected that the introduction of "Standard" beef will widen the effective choice of beef consumers. It will succeed in doing this only if "Standard" beef is offered in the same market areas as red and blue brand beef and identified and advertised as such. Then those consumers who consider the top grades of beef too fat will have an opportunity to buy leaner beef with an assurance that it comes from young animals of a good beef type. If such beef does not satisfy them when cooked, red and blue brand beef will still be available. If there is a strong demand for "Standard" beef, as these studies suggest, producers will benefit from improved outlets for less highly finished cattle.

Set of unidentified but numbered porterhouse steaks displayed in the study.



Virus Reseorch. Technicion (left) examining tissue cultures of bovine skin ond kidney which ore used for growing viruses. Scientist (right) seeding flosks of tissue culture with virus. *Inset:* Electron microscope used in virus studies.

Animol Diseoses Rese

Problems in A

A continuous research program on diseases of animals is vital to agriculture and, in this connection, animal pathologists of the Department study the cause and control of animal diseases. The Animal Diseases Research Institute, Hull, Que. is primarily concerned with problems of national scope, diagnosis, and basic research. Regional laboratories at Sackville, N.B., Macdonald College, Que., Regina, Sask., Lethbridge, Alta., and Vancouver, B.C., handle assigned research problems and perform routine diagnosis, some purely regional or local.

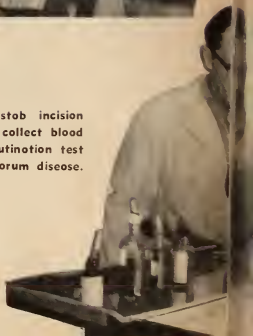
Virus diseases being studied include Newcastle disease, infectious bronchitis, epidemic tremor of chicks, vesicular diseases of domestic animals, rabies, ornithosis, and others. Modern techniques have made it possible to propagate many of these invisible viruses in embryonated hens' eggs and tissue cultures so that vaccines can be prepared and diagnostic tests carried out with measurable quantities of virus. This permits precise identification by serological means. The electron microscope makes it possible to see the form of some viruses after suitable treatment renders them visible. Filterable viruses must have living cells in which to grow and these are made available to them in the developing egg, or in living cultures of kidney or other organ cells kept growing in special media.

Another disease group of great economic importance is the leucosis complex in poultry. A cause of heavy losses in poultry, this group is receiving particular attention.

Tuberculosis and the production of tuberculin for diagnostic tests, and improvement in diagnostic methods for Johne's disease are special projects.

As brucellosis, the common abortive agent in cattle, is being brought under control, vibriosis

Tuberculosis Studies. *Mycobacterium tuberculosis* growing in flosks of liquid medium for the preporotion of tuberculin.



Pullorum Investigotions. Making stob incision (upper) in wing vein of turkey to collect blood tube ond (lower) whole blood ogglutinotion test with experimentol ontigens for pullorum diseose.

stitute, Hull, Que.

imal Diseases

and trichomoniasis are assuming greater importance. At the same time, leptospirosis (RfF, Spring '58) which causes reproductive disturbances in cattle, is also under study.

Pullorum disease requires endless vigilance to keep it under control. Since bacteria and viruses may change with time and altered conditions, a constant study of bacterial strains and experimental antigens is necessary to ensure the best antigens being available for pullorum disease tests. The complement-fixation test is a valuable but delicate method employed to test blood serum for antibodies that develop during the course of infection. However, the serum of chicken and certain other birds could not be tested by this method until the development by A.D.R.I. scientists of the 'indirect' complement-fixation test by which the inherent difference in chicken blood could be overcome. Research in pullorum and a number of viral diseases in poultry, has advanced as a result of the 'indirect' method.

Studies are continuously going on in connection with the cause and control of rhinitis in swine (RfF, Fall '57). All known techniques are being used to try to determine the cause of the disease, which is readily transmissible to baby pigs by contact.

The enteric group of diseases in swine is under investigation. Since some of the conditions are transmissible, it is highly important to develop satisfactory means of differentiation if treatment and prevention are to prove satisfactory. This work is difficult because one type at least appears to be associated with a virus, the action of which can only be demonstrated in very young pigs which have not been exposed to infection.

Parasitic infestations of many kinds have been brought under control. The present methods of preventing and controlling coccidiosis were devised at a regional laboratory.

Nutritional factors are always under scrutiny. Most of the trouble encountered in pigs has its origin in faulty nutrition, in spite of all the available information.

Brucellosis. Plate agglutination test for the serum diagnosis of brucellosis.

Epidemic Tremor. Intra-ocular injection of chicken embryos through cellulose tape windows in the shell for the diagnosis of epidemic tremor, a disease common in baby chicks.

Author testing self-fertility in tetraploid red clover by tripping flowers. Tetraploid red clover is partially self-fertile.

INDUCED POLYPLOIDY

What Does it Offer For Improving Forage Crops?

J. M. Armstrong

POLYPLOIDY, the phenomenon of multiplying the number of chromosomes in a plant species, occurs naturally and is widespread in forage crop species. Apparently it has played an important role in the evolution of crop plants and may help to adapt plants to varying environments. In recent years, geneticists have discovered how to induce polyploidy and in the Forage Crops Division at Ottawa this technique is being used in an effort to develop improved grasses and clovers.

To explain more fully the term polyploidy, studies of wheat show that einkorn has 14 chromosomes, macaroni wheats 28 chromosomes and common or bread wheats have 42 chromosomes. Each of these three distinct types of wheat has a chromosome number that is a multiple of seven. This is known as the n chromosome number for the species. Thus einkorn is a diploid ($2n$ chromosomes), macaroni wheat is a tetraploid ($4n$ chromosomes) and bread wheat is a hexaploid ($6n$ chromosomes). However there are two distinct kinds of polyploidy and an understanding of what is involved in each is necessary before going on to the discussion of induced polyploidy as a means of improving forage species.

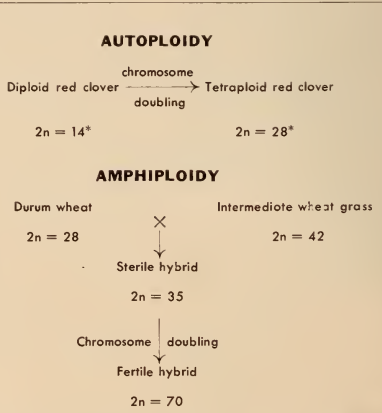
Dr. Armstrong is a Cytogeneticist with the Forage Crops Division, Central Experimental Farm, Ottawa.

Two Types of Polyploids

Polyploids are classified into two types, *autoploids* and *amphiploids*. Autoploidy results from reduplication of the same set of chromosomes—that is it occurs within the same species. It is brought about by chromosome doubling in the somatic tissue (such as in the rapidly dividing cells of germinating seeds or seedlings) or by meiotic disturbances leading to the suppression of the reduction division while the reproductive cells (gametes) are forming. This leads to the formation of gametes with the somatic ($2n$) number of chromosomes instead of the reduced n number. Brought together in fertilization, the progeny resulting from two $2n$ gametes will be a $4n$ or tetraploid individual with twice the normal number of chromosomes for the species.

Successful crosses between species or genera result in the second type of polyploid, the amphiploid. The progeny will contain the summation of the two distinct sets of chromosomes. Chromosome doubling may or may not follow this process. But where the parents contain widely different sets of chromosomes, doubling of the number of chromosomes must follow before the sterile hybrid can become fertile and perpetuate the new species.

The phenomena of induced autoploidy and amphiploidy are illustrated schematically with forage crop species produced by the Forage Crops Division.



* The number of chromosomes in the somatic tissue for any species is expressed as 2n whether o tetroploid or higher multiple. In the case of red clover the bosic n chromosome number is 7. Thus diploid red clover has 14 chromosomes in its somatic tissue and 7 chromosomes in its gametes; similarly etraploid red clover has 28 and 14 chromosomes.

The economic forage species are mainly polyploids rather than diploids; the number of natural autoploids is rather limited. On the basis of chromosome behavior and the occurrence of tetrasomic inheritance, orchard grass and alfalfa are considered to be autoploids. Grasses such as timothy, brome, the Poas and the Agropyrons are regarded as amphiploids while among the legumes white clover and soybeans represent amphiploids. There are, however, a number of diploid crops—such grass family members as meadow fescue, perennial rye grass and corn, and among the legumes, red clover and alsike.

Most of the experimental creation of polyploids is currently confined to autoploids with a few notable exceptions in amphidiploids. Better success results when the investigator chooses experimental material from the diploids rather than tetraploids. Each genus and species appears to have an optimum number of chromosomes that allows it to reach maximum development. Above and below this chromosome range viability decreases and if pushed far enough a lethal condition is reached. Unfortunately, most plant species have, during the course of their evolution gravitated to their optimal chromosome range; their natural response to experimental polyploidy is a decrease in viability.

Comparison of growth in greenhouse of tetraploid red clover (left) and diploid or normal red clover (right).

Colchicine, used first in 1934 by the French geneticist Dustin to produce polyploids, provided a considerable impetus for further research in this field. An alkaloid drug extracted from meadow saffron and related chemically to morphine and codeine, colchicine inhibits spindle formation in the dividing nucleii of rapidly multiplying cells. As a result, a double number of chromosomes is reconstituted in the daughter cells. With forage crops the drug proves most effective on germinating seeds or seedlings; treatment lasts long enough to cover one complete division cycle (12 to 24 hours for most plants).

Tetraploid Red Clover Sought

In our work at Ottawa a major long-term project has been to develop a tetraploid red clover that will prove superior to present diploid strains. A similar program has been under way with alsike and comparisons of tetraploids with diploids of seven species of grasses have been made.

Among the 40 species of Trifolium of which the chromosome numbers are known, most are diploids with $2n$ chromosome numbers of 14 or 16. Induced doubling has been carried out with red clover, alsike and white clover. The two former have given promising results but white clover, a natural tetraploid, has proved more vigorous than its induced octoploid.

A program at Ottawa to develop a tetraploid red clover has been under way for about 10 years, using the double-cut variety 'Ottawa' as the basic diploid material. Results obtained compare favorably with those observed elsewhere. The tetraploid strain initially exhibited good vegetative vigor but was low in fertility. Repeated selection of more fertile plants and intercrossing them has lead to a marked improvement in seed setting. Use of growth chambers and of honeybees for pollination has reduced the work involved. Fertility in the eighth generation averages 65 seeds per head compared with 75 to 85 seeds per head for the diploid. The superior forage yield of the tetraploid has been maintained in the later generations. Chemical

Induced amphidiploidy in wheat-agropyron hybrids. L/r: Vernal emmer wheat; sterile f_1 of Vernal × *A. intermedium*; fertile amphidiploid; *A. intermedium*.

analyses of the forage show diploid and tetraploid red clover to be much the same. Selection has resulted in improved resistance to such diseases as Sclerotinia root rot, mildew and virus. These strains have reached the stage when they can be increased and tested more widely.

Good results have come from our breeding program to produce a tetraploid alsike. In this case selection for improved fertility in the tetraploid was more rapid; our strain of tetraploid alsike is now fully equal to the diploid in this respect. Tests show that the tetraploid is a very fine nectar plant. It produces more nectar than the diploid and equals it in sugar concentration.

Honeybees readily carry out cross-fertilization in tetraploid alsike but the tetraploid red clover depends more on the prevalence of bumble bees for good seed-setting.

One noteworthy effect of tetraploidy in red clover and alsike has been an increase in self-fertility. In the diploids self-sterility is the rule but in the tetraploids, plants with a fertility of 30 to 50 seeds per head are not uncommon. In the greenhouse this self-fertility becomes apparent only when the flowers are tripped with a toothpick. Under field conditions cross-

(Concluded on page 14)

Concentrate sprayer applying dinitro-cresol blossom sprays to apple orchard in full bloom at Summerland.

Chemical Thinning of Fruit in British Columbia

D. V. Fisher

Hand methods of thinning apples used to cost $3.00 a tree. Then came chemical thinning and the cost tumbled to 35 cents a tree. The methods discussed in this article apply to the fruit growing valleys of B.C. but the principles outlined are valid in other orchard areas.

THE progressive orchardist, whose aim is to sell good sized attractive fruit, emphasizes the quality not the quantity of his crop. To accomplish this aim, the grower thins his fruit crop leaving only as many fruits on the tree as will attain satisfactory size at maturity.

Until 15 years ago, fruit thinning required costly hand labor performed when the fruits had grown to a diameter of ¾ inch or more. The introduction of chemical thinning, for apples in particular, has revolutionized this orchard operation. Apple trees which used to cost $3.00 to thin by hand methods, now may be thinned chemically for 35 cents.

Chemical thinning also stimulates development of fruit buds for the next year's crop by reducing, in the current season, competition between fruit buds and young fruits for the available food supply within the tree. A more regular bearing habit is established, thus eliminating extreme fluctuations in size of crop and the resulting unprofitable extremes in size of fruit from one season to another.

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Chemical thinning has proved most successful with apples, although the method is used less extensively for thinning other tree fruits such as apricots, peaches and prunes.

Thinning Apples

Two general types of thinning chemicals are used with apples—dinitro-cresols and hormones. Both are applied as sprays.

Dinitro sprays—The dinitro-cresols (DNOC) are applied from the time when the tree is in full bloom until about two days later. Full bloom is interpreted as the stage when 95 per cent of blossoms are open or when petals first fall if limbs are lightly tapped. The blossom killing action of the chemical results from selective killing of less developed side blooms and sparing the further advanced terminal or king bloom in each cluster. Results of work at the Summerland Experimental Farm indicate that a good thinning job brings about single-fruit setting on 35 to 40 per cent of blossoming spurs.

Dinitro-cresol thinning sprays are used in most British Columbia orchards. Varieties that respond best to dinitro thinning are McIntosh, Newtown, Golden Delicious and Jonathan; Delicious and Rome are often subject to over-thinning. There is some evidence that Winesap is more subject to leaf burning from DNOC sprays than other varieties.

The concentrations of dinitro-cresol blossom thinning sprays recommended in British Columbia by a joint committee from the Experimental Farm and B.C. Department of Agriculture appear in Table 1. Recommendations are given both for concentrate sprayers applying about 90 gallons per acre and for gun machines applying dilute sprays at a rate of 600 to 800 gallons per acre. Most blossom spraying in B.C. is done with concentrate sprayers, following the results of Summerland

Experimental Farm research. Many growers, however, would prefer to use gun sprayers if time permitted because they could obtain more uniform spray coverage in gusty weather.

Dinitro-cresol sprays are caustic in their action and cause burning of flowers and leaves. The ideal application kills the proper proportion of flowers without significant leaf burning. These sprays should only be applied in dry weather; rain at time of application or during the following four days may cause severe overthinning and damage to foliage. Medium to low relative humidity at time of application results in medium to fast drying and minimizes leaf burn. Because of the drier climate, dinitro sprays are favored in the West but they must be used sparingly in more humid Eastern Canada.

Dinitro chemical thinning of apples should not be practiced unless trees are in a good state of vigor, carry a medium to heavy bloom and are adequately interplanted with pollenizing varieties. Severe overthinning frequently follows if blossom sprays are used where pollination conditions are unfavorable. Where pollination has been satisfactory, concentrations of DNOC considerably stronger than those recommended may not cause overthinning. The above has been strikingly demonstrated in tests at the Summerland Experimental Farm.

Hormone sprays — Hormones used for thinning apples are naphthalene acetic acid or naphthalene acetamide. The chemicals cause the young embryos within the seeds to abort, thereby cutting off the hormones produced by the seeds that prevent abscission of the fruit stems. The immediate effect is to prevent apples from dropping. This is followed in one to two weeks by light to heavy dropping, depending on variety and strength of application.

Table 1.—Concentrations of Sodium Salt of Dinitro-cresol for Blossom Thinning Apples

Variety	Pints of 20% Material		Ounces of 75% Dry Mix	
	Concentrate spray per acre	Dilute spray per 100 gal.	Concentrate Spray per acre	Spray per 100 gal.
Early varieties: McIntosh, Winesap, Stayman, Spartan, Newtown, Golden Delicious	12	1½	40	4
Rome and Delicious	10	1	33	3½

Apple bloom at correct stage for chemical thinning.

Naphthalene acetic acid sprays are applied from 7 to 10 days following bloom which permits early appraisal of the fruit set; this helps the grower determine the need for thinning. If the chemical is applied earlier, overthinning may result and if applied later, the thinning effect is lessened and the size of fruit at harvest may be reduced.

Naphthalene acetic acid sprays should not be applied to varieties maturing earlier than McIntosh. Summerland results show that severe and persistent flagging of the leaves ensues, little thinning occurs, and fruit size at harvest usually suffers. Naphthalene acetamide sprays, on the other hand, are applied one or two days after full bloom. They are milder in action and do not produce harmful growth effects on early varieties.

Where hormone sprays are applied, the general recommendation for naphthalene acetic acid compounds is a dilute spray of 10 to 15 parts per million. Concentrate spray applications with these materials are not recommended. The Summerland Experimental Farm has found a tendency to more severe leaf damage with concentrate sprays than when dilute sprays are used. In Eastern Canada, the hormone thinners are preferred. Dinitro thinning compounds are not favored because under more humid conditions there is a danger of overthinning.

Additional hand thinning may be needed—With varieties such as McIntosh and Delicious, which tend to produce large sized fruit, it is frequently unnecessary to perform any further hand thinning. However, in some seasons and in certain orchards further hand thinning may be needed to supplement chemical thinning. This thinning should be done cautiously because chemically thinned trees normally are capable of maturing 15 to 20 per cent greater fruit load than trees hand thinned only.

Thinning Peaches and Apricots

Various chemicals have been tried by the Summerland Experimental Farm for thinning peaches and apricots, including dinitro-cresol and dinitro-secondary butyl phenol (DN 289, Elgetol 318) both applied at bloom, and also various hormones applied from shortly after bloom until approximately 30 days after bloom. The hormones used included maleic hydrazide, naphthyl phthalamic acid, naphthalene acetic acid and 3, chloro-I-P-C.

These fruits are not nearly as easy to thin chemically as apples. They have smaller tolerances in safe rates of application of spray chemicals. Peach and apricot flowers also occur individually (not in clusters like apples) and selective killing of certain blooms as in an apple spur is therefore not possible. As a rule hormone materials, although fairly safe to use from the standpoint of foliage injury, frequently do not give consistent thinning results. For example, naphthyl phthalamic acid at Summerland gave very good peach thinning in one season but failed for two following seasons.

Five years' work with dinitro materials by the Summerland

Experimental Farm has shown that DN 289 (Elgetol 318) applied at ¾ pint per 100 gallons dilute spray at 60 per cent of full bloom will give fair thinning. However, spray applications should be strictly avoided in damp weather to guard against overthinning and leaf burning. This material when applied in very dry weather may not produce enough thinning.

Thinning Prunes

Normally, prunes are not thinned but the crop benefits greatly from a reduction in set from the standpoint of size, quality and earliness of maturity. Dinitro materials, either DNOC or DN 289 (Elgetol 318), have proved satisfactory for thinning prunes. No leaf burning has occurred at any concentrations used. Timing of spraying is very important. Satisfactory results are obtained only when chemicals are applied at full bloom. Applying the chemicals two days before full bloom results in severe overthinning; applied two days after full bloom, no thinning occurs. Recommended concentrations are dilute sprays of ⅓ pint and ½ pint per 100 gallons for DN 289 and DNOC (Elgetol 20) respectively. Chemical thinning of prunes advances maturity by one week and increases size of fruit by one-third compared with no thinning.

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TRANQUILLIZERS

New Aids to Livestock Management

Preliminary trials at Ottawa suggest that tranquillizing drugs can be a valuable aid in solving some livestock management problems. Drs. Kristjansson, Carman and Hickman of the Animal and Poultry Science Division have used tranquillizers successfully to treat sows that are savage at farrowing or refuse to accept their young, to train heifers to accept milking machines, and to quiet ewes on which lambs are being fostered.

Seven sows that were extremely savage or that refused to accept their young at farrowing were treated with an intramuscular injection of 200 milligrams of Chlorpromazine. In all cases the sows relaxed and accepted their pigs within 40 minutes after the injection. Farrowings were normal and neither sow nor litter showed undesirable after effects. When the effect of the drug wore off, the sows remained calm and continued to rear their litters.

The first heifer treated was one that strongly resisted being milked. When 2,400 mg. of Meprobamate was administered orally during the early afternoon, the milking machine was accepted that evening without excitement. A similar dose following the evening milking resulted in a quiet morning milking. Production rose from 20 to 25 pounds of milk per day to 35 to 40 pounds, and there was no further resistance to milking. Other cases responded equally well. Mature bulls became docile under similar treatments, indicating that tranquillizers may be a possible safeguard when handling bulls.

When lambs were being fostered, three 400 mgm. tablets of Meprobamate given orally in each 24-hour period during the first three days had a quieting effect on the ewes. After the doses were stopped the ewes continued to accept the lambs without protest. Even ewes that killed their own lambs shortly after birth, later accepted others when this treatment was used. Young ewes that were extremely nervous immediately after parturition responded well to single oral doses of the drug, and could be handled with relative ease.

Tranquillizing drugs should, of course, be administered to livestock only on the advice of a veterinarian.

Induced Polyploidy—*from p. 11*

fertilization is probably absolute. This is a fortunate combination because experimentally some line breeding is possible. At the same time there is no loss of vigor under field conditions, resulting from the production of selfed seed.

One of the best examples of successful autoploidy in the grass family is tetraploid rye. Varieties such as Tetrapetkus are replacing the diploids and are generally acceptable in commerce.

Morphological comparisons of seven species of grasses including meadow fescue and perennial rye grass have been made. In most cases, however, autoploids derived from diploid grasses show no specific advantages for the tetraploids.

At Ottawa amphiploids between species of wheat and intermediate wheat grass were produced. Wheat species cross readily with this grass but the resulting hybrids are sterile. By treating the crossed seed with colchicine, fertile amphidiploids were obtained. The wheat and grass parents have a chromosome set in common, thus there has been some chromosome loss in later generations resulting from meiotic irregularities. These amphidiploids have lacked winter hardiness and are of little use for forage under Canadian conditions.

Induced polyploidy also has been investigated at Ottawa with such crops as field roots and oilseed rapes. In tetraploidy of field roots, chromosome doubling has had adverse effects on mangels and swedes but in sugar beets the work shows some promise. The tetraploid sugar beet proves inferior to the diploid but the triploid hybrid between them excels in yield and sugar content. The hydrid seed balls have turned out to be single-germed which simplifies planting and thinning operations.

One variety of oil-seed rape, German, or Polish, readily yielded fertile tetraploids which slightly excelled the diploid in seed yield though not in percentage of oil. Black Argentine, another variety which is already a tetraploid showed adverse effects from chromosome doubling.

Despite some promising results, it is clear that there are distinct limitations to the use of induced polyploidy as a method of plant improvement.

Sunflower head (top) affected by aster yellows, showing sector of sterile leaf-like flower parts. Six-spotted leafhoppers (lower) on sunflower seedling. *Inset:* Author transferring leafhoppers in laboratory cages. (Lower photo by R. D. Bird.)

ASTER YELLOWS

A Virus that Attacks Many Plants

W. E. Sackston

ASTER YELLOWS is a plant disease that last year 'exploded' across Western Canada and the adjacent United States, and was also very destructive in portions of Eastern Canada. This disease, caused by a virus, has been known in Canada since 1914, but in no previous year was it so widespread or so destructive as in 1957. Infection generally occurred early in Western Canada, and losses were heavy. Yield loss in flax was at least 15 per cent in Manitoba, and only slightly less in Saskatchewan. Head lettuce in Manitoba was almost a complete failure. Practically no healthy asters were grown, and damage to other susceptible crops was correspondingly severe.

Aster yellows received its name because it was first studied on asters, but it has since been found that the same virus attacks many other plants. More than 300 plant species have been reported as hosts of the disease either in nature, or in infection experiments. In Canada among the plants attacked are the following: field crops—flax, sunflowers, rapeseed, and buckwheat; vegetables—carrots, potatoes, head-lettuce, onions, and celery; ornamentals—asters, marigolds, petunias, gladioli, and zinnias; and weeds—stinkweed, plantain, sowthistle, and ragweed.

Two distinct strains of aster yellows have been identified, eastern and western, differing in their ability to infect specific hosts. Among the differential hosts are zinnias, celery, and onions, which are attacked by the western, but not by the eastern.

Symptoms caused by aster yellows on its many unrelated host plants naturally differ, but some effects are common to most hosts. The effects of the respective strains on a common host are usually identical. Yellowing is induced on most hosts, particularly on the upper portion of the plant, and stunting is also a common effect. The most characteristic symptoms, however, are various abnormalities of the floral parts.

Crop damage varies with the stage at which infection occurs. Early infected plants may be killed or, at least, may produce no crop. With late infection, symptoms may be slight and confined to a few flowers or to scattered plants. In either case, affected flowers produce only sterile seed or none at all. Seed from apparently healthy portions of affected plants may be reduced in size and vigor.

Aster yellows cannot be transmitted by seed, by juice inoculations, nor by mechanical contact of diseased and healthy plants. While it has been transmitted experimentally by grafting, in nature it is spread from plant to plant only by leafhoppers. The six-spotted leafhopper, *Macrosteles fascifrons,* is the sole species proved to spread the eastern strain, and is the main carrier of the western strain. Leafhoppers become infective in nature

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Flax flowers affected by aster yellows, showing leaf-like structures and sterile boll.

by feeding on infected plants but then remain so for life.

Aster yellows virus can live from one year to the next in certain perennial plants such as sowthistle, in biennials such as carrots and onions, and in such winter annuals as stinkweed. It can also survive in adult leafhoppers where they overwinter.

We do not yet know how the six-spotted leafhopper overwinters in Western Canada, if at all. We do know that in Wisconsin and Minnesota it overwinters in the egg stage. In the spring, long before nymphs have hatched from locally overwintered eggs, migrant adult leafhoppers appear in considerable numbers. The first waves of migrant leafhoppers are predominantly females; later, as the population stabilizes, the sex ratio is approximately equal. In Manitoba, as in Wisconsin and Minnesota, the first leafhoppers collected early in the season are mostly females, indicating that the migration extends on into Canada.

It is believed that the overwintering region is in the valleys of the Ozarks. Northward migration seems to be accomplished in stages as crops develop with the advent of spring, much as the cereal rusts work their way up from Mexico and Texas. As with the rusts, the leafhoppers are carried on southerly winds. They differ from rust spores, however, in their ability to take off when winds are favorable, and to come to earth again when conditions are adverse. The direction of their spring migration is controlled by temperature. The insects will not fly, and be caught up by winds, unless the temperature is above 50°F.

In most years, only a small proportion of the migrant leafhoppers carry aster yellows on arrival. They pick up the virus by feeding on overwintered infected plants. Even after feeding on such plants, the insects cannot transmit the virus until the completion of an incubation period which varies with temperature, but is usually about two weeks. A similar incubation period, varying with temperature and plant species from about 10 to 30 days, is required before symptoms appear on a plant after infective insects have fed on it. The seasonal build-up of aster yellows in northerly localities is therefore usually rather slow, and rarely attains serious proportions. In 1957, migrant leafhoppers arrived in tremendous numbers, and a very high proportion, up to 14 per cent, were infective on arrival, thus accounting for the exceptionally heavy outbreak of aster yellows.

There are two main ways in which the disease may be controlled, other than abandoning all susceptible crops. The first is to destroy or repel the leafhoppers that carry the virus. This is possible with such common insecticides at DDT. Because of the great mobility and large populations of the insects, however, insecticides must be used early and the applications repeated at weekly or shorter intervals throughout much of the growing season. Even in a small flower or vegetable garden this is costly and time-consuming; for most field crops the cost in materials and labor is prohibitive. Systemic insecticides that persist in the treated plants may perhaps overcome some of the difficulties.

The second possible method of control is the production of varieties of plants resistant to the virus or to the leafhoppers that transmit it. No practical progress has yet been made along these lines, but some interesting information is already available. We have observed slight differences in apparent susceptibility among varieties in a world collection of flax. Much more striking were the differences found in our sunflower plots at Winnipeg. With some lines, almost all of the plants were affected by aster yellows; with certain other lines practically none showed the disease. Under laboratory conditions, leafhoppers develop equally well on young plants of both a resistant and a susceptible line. We do not yet know the nature of the apparent field resistance, but it appears to be inherited.

In the absence of more specific controls, good cultural practices can reduce losses from aster yellows. Early seeding helps plants escape the most destructive early infection. Control of weeds may reduce the sources from which leafhoppers can pick up the virus. Routine applications of insecticides to those crops on which they are used, may reduce infection even if it fails to control it.

Edmond Cloutier, C.M.G., O.A., D.S.P., Queen's Printer and Controller of Stationery, Ottawa, 1958