OATS IN CANADA

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OATS IN CANADA

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Introduction

THE purpose of this bulletin is two-fold. In the first place it summarizes certain phases of the results of experimental work with oats carried on by the Experimental Farms Service. In the second place, it gives a brief history of the oat crop and discusses varieties, diseases and other subjects of vital interest to the grower.

As a cultivated crop, oats are of more recent origin than wheat or barley. Records show that common oats probably originated under cooler, more moist condition than wheat, but it is not possible to trace the origin of the oat plant from ancient history as can be done with wheat. From information available it appears that the cultivation of oats dates back only to the beginning of the Christian era, before which time most writers refer to oats as a weed.

The earliest records on cultivated oats refer to two types, namely, oats which were used for breadmaking and oats sown particularly for fodder. These records indicate that the crop was first brought under cultivation from its wild state in parts of Central Europe and in Western Asia. Wild forms, however, were probably known by the ancient Greeks but no record is available indicating that the grain was used for food. It is probable that oats were used mainly in the form of grass or hay.

The oat plant was introduced into the North American colonies soon after the Europeans had settled there. Records show that oat crops were grown on the Elizabeth Islands in 1602; in Newfoundland in 1622, and in Massachusetts Bay in 1629. It is thought that the first Scottish settlers introduced oats to Canada. The climate of this country is particularly favorable to oat production and now more bushels of oats per capita are grown in Canada that in any other country.

Distribution and Production

The oat crop ranks second in total value among grain crops in Canada as a whole, but in Ontario and other Eastern Provinces it takes first place by a large margin.

The greatest volume of oats is produced in Manitoba, Saskatchewan, and Alberta. About 70 per cent of the Canadian total is produced in these provinces. In Eastern Canada, the value of the oat crop is less than hay in Ontario and Quebec and less than hay and potatoes in the Maritime Provinces. In Saskatchewan, oats are second to wheat in value, while in Manitoba the value of this crop falls below wheat and barley. Wheat and barley also exceed oats in value in Alberta, but this is true only since 1951 when the acreage of barley in this Province was greatly increased. While the production of oats in British Columbia is, on the average, only slightly more than one per cent of the total Canadian production, the yield per acre is substantially higher than in any other province.

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Table I, which was compiled from reports of the Agricultural Division, Dominion Bureau of Statistics, shows the acreage, production, and yield per acre by provinces in Canada based on a 5-year average, 1947-51.

TABLE I: DISTRIBUTION OF ACREAGE AND PRODUCTION OF OATS IN CANADA (1947-51 AVERAGE)

Province	Area in acres	Production in bushels	Yield per acre in bushels
Prince Edward Island	116,600	4,612,600	38·6
Nova Scotia	68,800	2,641,000	38·4
New Brunswick	187,360	6,961,800	37·2
Quebec	1,470,540	41,287,000	28·0
Ontario	1,891,760	77,208,800	40·1
Manitoba	1,585,000	56,400,000	35·5
Saskatchewan	3,594,400	101,200,000	28·4
Alberta	2,455,000	79,400,000	32·0
British Columbia	84,000	3,657,800	43·7
Canada	11,455,680	373,603,000	32·4

Adaptation

A large part of the area under crop production in Canada is well suited to the growing of oats. While the oat crop thrives best under cool moist conditions and on soil of good fertility, it is grown successfully under a variety of soil types, moisture and temperature conditions and often on land considered too low in fertility for barley or wheat. Many low yields result either from the generally accepted opinion that "oats will grow anywhere" or from a lack of appreciation that to get maximum yields, good soil management must be practised.

The water requirement of the oat crop is higher than that of wheat or barley but this requirement is limited to some extent by temperature. In areas where moisture is limited, the average daily temperature is often lower than in areas of higher precipitation. The lower temperature tends to offset, in part, the low precipitation and provides conditions suitable for the production of good crops.

Since oats draw heavily on moisture, this crop favors soils that do not dry out quickly. Clay and clay loams may be considered as most suitable for the production of oats. Lighter soils, although more dependent on the proper distribution of moisture, will normally produce fair yields of good quality. Soils high in fertility tend to produce rank growth, which is susceptible to lodging, therefore the oat crop is usually preceded by crops that demand greater soil fertility and that do not readily suffer from lodging. Varieties differ in their environmental requirements, and in many cases, even within a comparatively small area, soil type plays a large part in determining the best variety to grow.

Extensive tests and observations have shown that oats should be sown early, at approximately $2\frac{1}{2}$ bushels per acre under normal moisture conditions for best results. In dry areas, however, this rate of seeding should be reduced.

Utilization

Oats are used as a general purpose feed for livestock more than other cereal crops and are particularly valuable for horses. When mixed with more highly concentrated feeds, oats constitute a standard feed for all classes of livestock and poultry. From the standpoint of feeding value, oats may be classed with wheat in protein content but have a higher content of fat and

vitamin B_1 than either wheat or barley. Oats have a relatively higher percentage of fibre which is of value in many rations. In total digestible nutrients per pound, oats are lower than wheat or barley.

TABLE II: COMPARATIVE ANALYSIS OF OATS, BARLEY AND WHEAT

Crop	Water	Ash	Crude protein	Fat	Fibre	N-free extract	T.D.N.*
	%	%	%	%	%	%	%
Oats	10·0	3·2	12·1	4·2	11·0	59·5	70
Barley	10·0	2·7	12·1	2·2	5·4	67·6	79
Wheat	10·0	1·8	14·1	2·0	2·7	69·4	84

* Total digestable nutrients.

A comparatively small proportion of the oat crop in Canada is used for human consumption. In the milling of oats for this purpose, the hull and the adhering portions are removed, while the germ and other parts rich in vitamins and minerals are retained. Cereals made from oats are therefore high in energy value and provide a good source of protein. Oatmeal is richer than whole wheat in certain important vitamins, notably vitamin B_1. In addition, oatmeal is a rich source of iron and is well supplied with phosphorus.

The most important use for oat hulls is in the manufacture of furfural. This product is made use of in the manufacture and processing of resins, lubricating oils, nylon, and pharmaceutical products.

Varieties

In every oat producing country, varieties or types are being grown that have some particular adaptation to the prevailing environmental conditions. In those areas where growing conditions are satisfactory for the production of both high quality and high yield, the varieties used belong mainly to the species *Avena sativa*, and represent the highest standard of excellence in cultivated oats. In the more arid areas, types are grown that are more closely related to the wild species, since such forms are in general, more resistant to drought and heat.

Oat varieties differ widely in color of hull or lemma. In the common oat species, (*A.sativa*) there are groups of varieties with white, yellow, grey and black hulls. Good varieties exist in each of these color groups, but the demand of the trade may influence the color type generally grown. In European countries colored varieties predominate in many oat growing areas. In Canada the trade demands a white oat and practically no colored varieties are being grown. In the United States the market classes include varieties having the lemma colors white, red, grey, and black. Yellow varieties are classed as white.

There are comparatively few oat varieties that are well adapted to the wide diversity of soils and climate found in Canada. For many years the old varieties Banner and Victory were grown extensively in both Eastern and Western Canada. Both are still grown to a considerable extent but with the development of new disease-resistant varieties in recent years these older varieties are rapidly losing their popularity.

The use of better adapted varieties and of good quality seed is becoming more wide-spread among growers throughout the country. Lesser known varieties highly recommended by salesmen have often been sold to growers at high prices.

Too often such varieties have proved unadapted and inferior to the standard varieties recommended by experimental institutions. Varieties respond differently to different seasonal conditions and the one that gives the best results from year to year regardless of season must be considered the most desirable one to use.

Early varieties are available that mature in from 80 to 90 days. These are suitable where the land is late for seeding or when an early crop is desired. Early varieties are also useful when mixtures of barley and oats are being grown, or as a nurse crop for grasses and clovers. Crop seasons vary widely from year to year and it often happens that in some years early varieties are the high yielders, whereas in other years late varieties are more productive. It remains, therefore, for each grower to study his particular local conditions in order to determine the relative merits of early and late varieties. In certain areas, early fall frosts may be the determining factor in the choice of early or later maturing varieties.

In more recent years, the trend in the creation of new varieties by plant breeders has been towards a more limited adaptation as regards soil and climate. Varieties have been developed which have proved well adapted only for comparatively small areas and it would seem that this trend will be more evident in the future development of new varieties.

It is difficult as a rule to distinguish between oat varieties and it is usually necessary to study characters of the growing plant in conjunction with panicle and grain characters before a reasonably accurate identification can be made. Brief notes are given below on the origin and description of the more common oat varieties being grown in Canada at present.

Ajax—developed at the Dominion Laboratory of Cereal Breeding, Winnipeg, Man., from a cross between Victory and Hajira and first distributed in 1941. This variety is early maturing, high yielding and has good length and strength of straw. The kernels of Ajax are white and rather small. Ajax is moderately resistant to stem rust and has shown wide adaptability to the soils and climate of Canada.

Abegweit—selected from the cross Erban × Vanguard at the Cereal Crops Division, Central Experimental Farm, Ottawa. This strain, formerly known as 2806-K, proved well adapted to the Maritime Provinces and particularly to Prince Edward Island. Abegweit is similar to Erban in plant and kernel characteristics, but carries some resistance to crown rust and moderate resistance to stem rust. It has the same parentage as Beaver but is two to three days later in maturing. Certified seed was distributed to growers in Prince Edward Island in 1947. Registered seed of a reselected strain of Abegweit will be available in limited quantities in 1954.

Beaver—developed at the Cereal Crops Division, Ottawa, from the cross Erban × Vanguard. Like Abegweit, Beaver carries some resistance to crown rust and moderate resistance to stem rust. This variety has proved fairly well adapted to conditions in Eastern Canada, having good kernel size and fair straw strength. Beaver is classed as a medium early maturing variety and was first distributed to growers in Ontario in 1945. It is also grown to a considerable extent in northern Alberta.

Banner—a medium late maturing variety introduced from the United States by the Ontario Agricultural College in 1890. Many strains of Banner have been selected by institutions in Canada, among which Banner Ott. 49 and Banner M.C. 44 have proved to be two of the best. This variety is of fair quality, producing straw of good length and of fair strength. It is a good yielder and, being widely adapted to Canadian conditions, has been one of the

most popular varieties. Banner is susceptible to the rusts and smuts and is rapidly losing popularity in favor of disease-resistant varieties, particularly in the rust areas.

Beacon—developed at the Cereal Crops Division, Ottawa, from a multiple cross involving the following parents: Gold Rain, Alaska, Legacy, Victoria, Vanguard, and R.L. 453. Because of its medium short straw, good root anchorage and consequent lodging resistance, Beacon was considered to be specially adapted to fertile soils. This variety is medium early maturing and possesses good resistance to crown rust and moderate resistance to stem rust. The kernels are short and plump when grown under normal conditions. After its release, Beacon proved susceptible to a new disease called Victoria blight, caused by the fungus *Helminthosporium victoriae*. This disease has practically eliminated the growing of this variety in Canada.

Brighton—a hulless variety developed at the Cereal Crops Division, Ottawa, from a cross between Markton and Laurel. This variety is high yielding in the hulless oat class, medium early maturing and is highly resistant to the smuts. It is not so strong in the straw as Laurel, but is grown in most areas where hulless oats are used.

Bambu—a Swedish variety developed from the cross (Abundance × Victory) × (Victory × Storm Mogul). This variety was licensed for sale in Canada in 1946 with the recommendation that its distribution be confined to the lower mainland of the Fraser River Valley in British Columbia. Bambu is medium early maturing and is reported to be resistant to lodging on soils of high nitrogen content.

Cartier—produced at Macdonald College, Que., from a cross between Alaska and Early Triumph. Cartier is early maturing and practically identical with Alaska in plant characters but is somewhat higher yielding. It has been grown widely in Quebec and parts of Ontario, but because of its susceptibility to rusts, it has been replaced in some areas by rust-resistant varieties.

Clinton—developed at the Iowa Agricultural Experiment Station, Ames, Iowa, from the cross (Richland × Green Russian) × Bond. Clinton has yellow grain color, plump kernels and thin hulls. The straw is short and strong. It has good resistance to the rusts and smuts and to Victoria blight.

Clinton was licensed for sale in Canada in 1947 and has proved adapted particularly to conditions in southwestern Ontario. A new strain of Clinton, selected at the Indiana Agricultural Experiment Station has been accepted in Canada as elite and this stock has been used as a basis for the production of registered seed.

Erban—a production of the Ontario Agricultural College, Guelph, resulting from a cross between Early Ripe and Banner. Seed was distributed to farmers in fairly large quantities for the first time in 1935. Erban has white grain color, resistance to smuts and some resistance to crown rust. It is medium early maturing, high yielding, and has proved well adapted in Ontario and many other sections of Eastern Canada.

Eagle—an introduction from Sweden, the result of a cross between Victory and Von Lochow's Yellow. The latter parent is adapted to dry conditions in parts of Europe, has long thin kernels, and is weak in the straw. Eagle is medium late maturing and similar to Victory in many respects, but is a little earlier and shorter and stronger in the straw. It is grown to some extent in central Alberta and British Columbia.

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Exeter—developed from the cross Victory × Rusota at the Dominion Laboratory of Cereal Breeding, Winnipeg, Man. Exeter has approximately the same maturity, straw qualities, and kernel type as the Victory parent along with moderate resistance to stem rust and the smuts. It is adapted, chiefly to the later oat growing sections of the stem rust areas of the West and to a limited extent to the central areas of British Columbia.

Fortune—developed at the University of Saskatchewan from the double cross Victory (Victoria × Richland) × (Markton × Victory). It is a little earlier maturing, taller and stronger strawed than Exeter with a lower hull percentage and slightly smaller kernel. Fortune has stem rust resistance similar to Exeter and is also highly resistant to the smuts. It also has the ability to resist sprouting after maturing under wet conditions.

Garry—developed at the Dominion Laboratory of Cereal Breeding, Winnipeg, Man., from the cross Victory × R.L. 1272, the latter coming from the cross Victoria × (Banner × Hajira). This variety, which was distributed to growers in 1947, was resistant to all prevailing races of crown and stem rust found in Canada and also to the smuts. It was susceptible however to Victoria blight.

A new stock of seed of Garry was distributed in 1953. It is resistant to Victoria blight, has the same resistance to stem rust and smut as the original stock but is susceptible to some races of crown rust that are associated with Victoria blight. Garry has good straw and an attractive kernel.

Larain—comes from a cross between Gold Rain and Alaska made at the Cereal Crops Division, Ottawa. The final selection was made at the Experimental Station, Lacombe, Alta. It is early maturing and very low in percentage hull, but is susceptible to the rusts and smuts. The straw is of medium length and reasonably strong. Because of its early maturity, it is grown to some extent in central Alberta where early fall frosts are common.

Laurel—A hulless variety developed at the Cereal Crops Division, Ottawa, from a cross between Banner and Chinese Hulless made in 1922. Although this variety is susceptible to the rusts and smuts it is more resistant to lodging than most other varieties. Laurel is medium early maturing and has large kernels.

Mabel—An early maturing variety developed at Macdonald College, Que., from a cross between O.A.C. 72 M.C. 214 and Early Ripe M.C. 213. This variety has some resistance to crown rust and also to the smuts. The grain is light buff in color, but has a very thin hull. Mabel is grown to a considerable extent in parts of Quebec where early maturity is advantageous.

Rodney—Produced at the Laboratory of Cereal Breeding, Winnipeg, Man., from a cross made in 1943 between R.L. 1574* and Roxton. This variety was first distributed in 1953. Rodney is in the same maturity class as Exeter and Victory but is superior to them in lodging resistance, kernel size, bushel weight, and disease resistance. It is particularly adapted to the rust area of Western Canada.

Roxton—Developed at Macdonald College, Que., from a cross involving the following parents: Siberian, Joanette, O.A.C. 72, and Early Ripe. Roxton is medium late maturing, ripening a day or two later than Banner. It is a long strawed, high yielding variety possessing considerable resistance to both stem and crown rust and producing grain with a very low hull content. Roxton is grown mainly in Quebec and eastern Ontario, particularly on the lighter soils.

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*A cross (Victoria × (Hajira × Banner)) × (Victory × Hajira)

Scotian—Developed at the Cereal Crop Division, Ottawa, from the cross Vanguard × Erban made in 1937. Final selection was made at the Experimental Farm, Nappan, N.S. Scotian matures in about the same time as Beaver and is similar in other respects except that it has shown better adaptability in Nova Scotia as regards yield, kernel size, and quality.

Shefford—Produced at Macdonald College, Que., from a cross between Roxton and Mabel made in 1939. This variety is early maturing with straw of medium length and strength and with kernels of medium size and high quality. Shefford is resistant to covered smut and has the same resistance to crown rust as its parents. It has shown adaptability in Quebec and eastern Ontario.

Simcoe—Developed at the Ontario Agricultural College from the cross Ajax × Erban made in 1940. It is early maturing, semi-resistant to stem rust and has tolerance to races of crown rust which attack Clinton. It is high yielding, has a medium size kernel and is adapted to most areas in southern Ontario.

Torch—Developed at the University of Saskatchewan, from the cross Nakota × (Hajira × Joanette) made in 1941. Torch is a mid-late, hulless variety, resistant to the smuts and to the prevailing races of stem rust. Its straw is strong and moderately long. The grain is slightly smaller and the bushel weight higher than Brighton. Torch is recommended as a hulless oat in Saskatchewan, particularly in areas subject to stem rust.

Victory—Originated by the Swedish Seed Association in Sweden as a selection from an old European variety called Milton. Victory was introduced into Canada in 1911 and quickly proved to be well adapted to Canadian conditions. It possesses many desirable characters such as good yield, fairly strong straw, and good weight per bushel. Victory is medium late maturing and because of its short broad grain makes an excellent exhibition oat. It is susceptible to the rusts and smuts and, therefore, has been replaced in many areas by disease-resistant varieties.

Vanguard—Introduced in 1936 in Western Canada as the first variety developed in Canada with moderate resistance to stem rust. It was produced at the Dominion Laboratory of Cereal Breeding, Winnipeg, Man., from a cross between Banner and Hajira. This variety has medium maturity, fair straw strength and resembles the Banner parent in kernel type. It is susceptible to the smuts and crown rust.

Winter Turf—Introduced from the United States where it has been grown for many years under the names of Winter Turf and Grey Winter. It was reselected at the Experimental Station at Saanichton, B.C. Winter Turf is a winter oat and will not survive the winters in Canada successfully except in the southern portion of Vancouver Island where it has outyielded spring oats by a considerable margin. This variety has grey to almost black kernel color; straw of medium size, height and strength; and is susceptible to the common oat diseases in Canada.

Diseases of Oats and Their Control

Diseases of the oat crop in Canada cause annual losses of millions of dollars. Some of these losses may be avoided completely or considerably reduced by practising seed treatment, good soil management, proper crop sequence or by growing resistant varieties. Most diseases depend upon a particular set of environmental conditions for suitable development and thus annual or seasonal variations in weather conditions may determine the prevalence of a disease or the severity of attack. In some areas certain diseases rarely appear partly because of isolation from sources of infection or because of an unfavorable environment.

Most of the oat diseases commonly found in Canada have been present in varying degrees since the early years of production. However, some diseases not previously known in the country have appeared in recent years and have now become serious. With several of the more important diseases annual losses are being reduced greatly by the use of resistant varieties.

Of the many diseases that attack oats, the rusts and smuts are the most common and cause the greatest damage. Both stem and leaf rust are common throughout the greater part of Canada, but in general, stem rust is more prevalent in Western Canada whereas leaf or crown rust is usually more widely distributed in the East. The two rusts are distinct in appearance and in their life histories.

Figure 1.—*Left*: Crown or leaf rust of oats (black spots are orange colored when leaves are green but black when ripe); *Right*: Stem rust of oats (spots are rust colored when leaves are green and black when ripe.)

Stem Rust—Stem rust attacks the stem particularly, but in severe epidemics it may be found on the leaves and glumes. The pustules are reddish brown in color, oblong in shape and usually begin to appear on the oat plants before heading. In contrast to crown rust, the pustules of stem rust are darker in color and cause a distinct rupturing of the plant epidermis. The pustules on

the oat plant are filled with spores which are rapidly scattered by the wind to infect nearby plants or those in more distant oat fields. Air currents transport the spores great distances. Investigations have shown that spores may be carried by the wind from the grain growing areas of the United States to Western Canada to start the early summer infections in that area. Most of the stem rust infection in the West originates in this manner although some primary infection does come from the barberry as described below.

During humid weather, which is very favorable for rust development, the first infections spread rapidly and may result in a destructive rust epidemic. Cool dry weather hinders the spread of the disease. The red rust stage is followed by the black stage as the crop matures. The black color is due to the black overwintering spores formed in the same pustules. The black spores which have overwintered on stubble, etc., germinate in the spring and are able to infect only the leaves of the common barberry, the alternate host of stem rust. Spores from small cup-like bodies formed on the under surface of the barberry leaves are in turn able to infect susceptible oat plants in the early summer. In Eastern Canada, a great deal of the early summer infection may be traced to the barberry, although it is probable that a certain amount is started by spores blowing in from other regions.

Stem rust lowers both the yield and quality of the grain, depending on the severity of attack and on the stage of growth at which rust develops.

Crown Rust—Crown rust of oats at first forms small bright orange-yellow pustules that are found almost entirely on the leaf blades and sheaths. Later-formed pustules are larger. They are long and somewhat irregular in shape. There is no conspicuous rupturing of the plant surface at the border of the pustule as with stem rust. The pustules of the black spore stage are covered by a thin layer of epidermis and hence are less noticeable than those of stem rust. The overwintering black spores germinate in the spring and cause elevated orange-yellow lesions to form on the leaves of the European buckthorn. The spores are then carried by the wind from the buckthorn to infect the young oat crop. In Eastern Canada observations on crown rust have shown that infection is often more localized than that of stem rust and usually the centre of primary infection can be traced to nearby buckthorn bushes. Secondary infection, which comes from an earlier infected oat plant, is responsible for the main losses. Where crown rust infection is heavy both the yield and quality of the grain are lowered and lodging may result.

The rusts, unlike the smuts, are not readily controlled by any simple process. The eradication of common barberry and European buckthorn from areas where these two hosts are found would undoubtedly lessen the ravages of rust. Such a practice has met with success in wide areas of the North Central United States. Some organized effort has been made in Ontario to eradicate the alternate host of both rusts. These diseases have been controlled successfully by dusting the crop with sulphur but the cost of treatment makes it impracticable.

The contributions of the plant breeders have proved that the most practical method of combating the oat rusts is by developing and growing resistant varieties.

Smuts—Both oat smuts may be controlled by seed treatment. Organic mercurials* have proved to be very effective for controlling smut in oats and if used correctly they have no harmful effect on seed germination. Treatment

* For further information regarding the use of organic mercurials for smut treatment in oats, apply to the Cereal Crops Division, Central Experimental Farm, Ottawa, or to the Botany and Plant Pathology Division, Science Service Building, Ottawa.

with organic mercury *dusts* has now largely been replaced with either *liquid* or *wettable powder* organic mercurials. Most of these control the oat smuts effectively and are less harmful to the operator of the treating machines. Organic mercurials are poisonous and precaution should be taken against inhaling these chemicals. There is less danger therefore when they are used in liquid or wet forms.

Hulless oats may be treated in the same manner as common oats but the rate of application should be reduced by one-half to avoid injury to the kernels.

Figure 2.—Smut of oats. *Left*: Covered smut. *Right*: Loose smut.

Root Rots—Root rots in Canada are less important in the oat crop than in wheat or barley. A root-rot fungus *Helminthosporium victoriae,* commonly called Victoria blight, which attacked oat varieties with parentage tracing to the South American variety Victoria, became serious in Canada in 1947. Varieties susceptible to this root rot were immediately removed from the recommended list and the spread of the disease was thus prevented. Other root-rot fungi have been found on oats in Canada but normally do little damage.

Halo Blight—Halo blight, a bacterial disease, is often prevalent in the more humid areas of Canada. The losses from this disease are small in comparison with those from the rusts and smuts. Symptoms usually appear on the leaves of plants 6 to 8 inches tall, in the form of small oval, light green, water-soaked blotches surrounded by a light yellow zone that has the appearance of a "halo". The blotches later enlarge and turn light brown in the centre. An abundance of moisture is necessary for a rapid spread of the disease. Halo blight seems to be more prevalent on light sandy soils, lacking in acidity and potassium. The disease is seldom found on heavy clay soils. Seed treatment and crop rotation help to reduce the amount of disease. Halo blight should not be confused with "grey speck" which is described below.

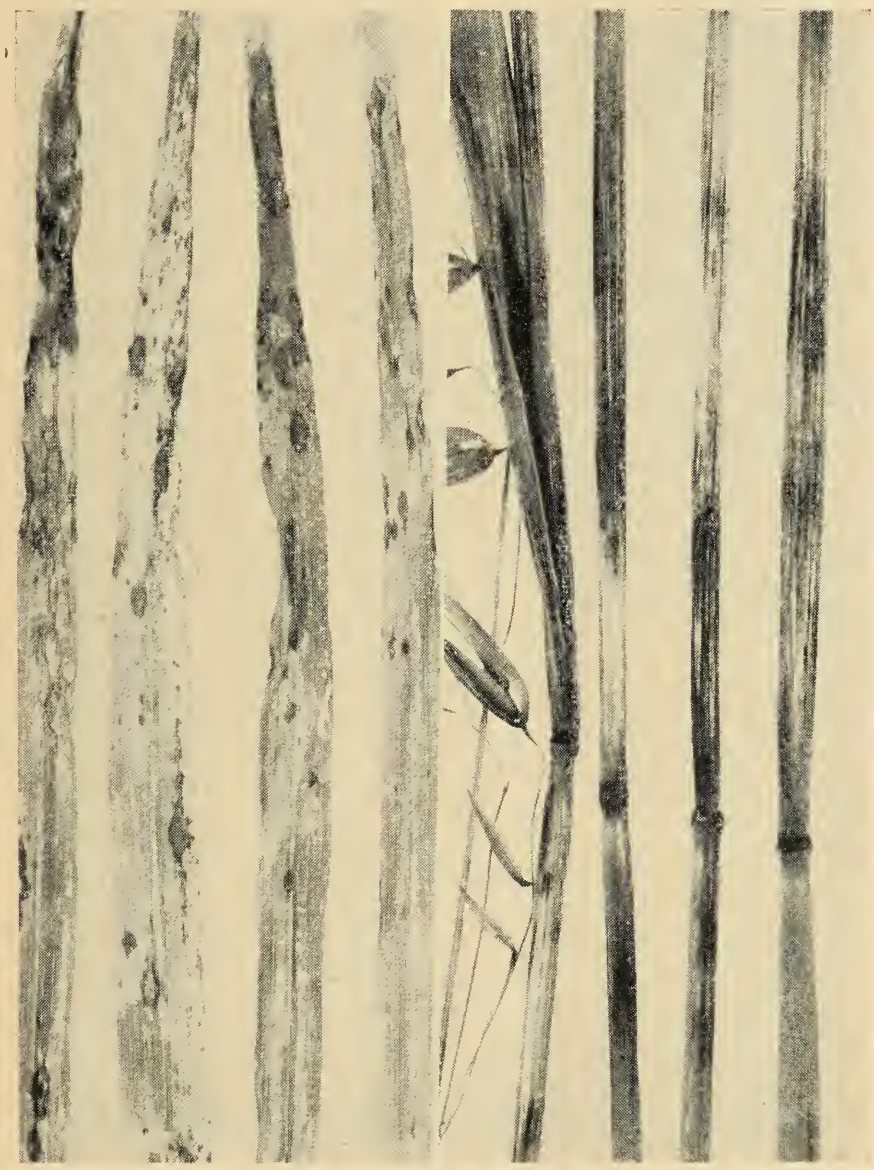

Figure 3.—Stages of black stem or culm rot. *Left*: Grey or brownish lesions on green leaves. *Right*: Darkened areas on straw which show up at maturity and often cause straw weakness and lodging.

Septoria avenae—The disease caused by this fungus is commonly referred to as black stem or culm rot and appears to be on the increase in Eastern Canada during the last few years. It was serious in 1951 and again in 1952 and many badly lodged crops resulted from weakened straw caused by this disease.

The disease first shows up in the form of darkened spots, on the green leaves particularly on the lower leaves early in the season. The culm rot or black stem stage appears when the crop approaches maturity. It is at this latter stage that the straw turns dark in color and is weakened to the point where lodging occurs very readily. Since there are no known precautionary measures to lessen the prevalence of the disease, the plant breeders are endeavouring to develop new varieties that will be resistant to it.

Figure 4.—Oat blast showing grainless spikelets.

Grey Speck—The non-parasitic disease called "grey speck" is caused by a deficiency of available manganese. Experiments have indicated that certain soil bacteria may be responsible for converting soluble manganese in the soil

into insoluble forms thus making it unavailable to the plant. The disease has been found in many areas in Canada, particularly on alkaline soils. The symptoms on the oat plant take the form of light green to grey flecks on the leaves. The flecked areas may enlarge and dry out. The plants may be stunted in growth while the leaves may be narrow and more erect than usual. Some varieties show resistance to grey speck. Application of manganese compounds to the soil or to the plants in the form of spray, in certain cases, has controlled this deficiency disease.

Blast—The term "blast" has been given to a type of spikelet sterility commonly found in the oat crop and which presumably lowers the yield considerably in some seasons. At the time of heading these sterile spikelets show up as white, empty glumes, particularly towards the bottom of the panicle. The amount of blast is often very high, some years reaching as much as 30 per cent.

The cause of oat blast has been traced to environment, and its presence is a symptom of subnormal growth conditions. The growth period most susceptible to adverse weather conditions or soil deficiency so far as blast is concerned is about 6 to 8 weeks after seeding. Blast is increased also by late seeding. Some varieties are more susceptible to blasting than others.

Investigation points to the probability that the production of blasted spikelets in oats is nature's way of reaching a balance between the yield potentialities of the plant and the general growth conditions to which the plant is subjected.

Diseases of less importance such as bacterial stripe blight, anthracnose, red spot mosaic, Helminthosporium leaf blotch, and others cause some damage to the oat crop in Canada, but on the whole have never become serious. These are mostly leaf infections.

Oats in Grain Mixtures

The practice of sowing grain mixtures, chiefly oats and barley, appears to be steadily increasing in Canada. While mixtures are not grown extensively in Western Canada they do occupy a place second only to oats in Ontario, Quebec, and the Maritimes. The main reason for this growing interest in mixtures is based on the assumption that a ready mixed crop of greater volume will result than when the crops are grown separately. Where soil conditions are uneven due to contour, fertility or drainage or where the seeding season is abnormal it may be difficult to decide whether to sow the crops singly or in mixture. Frequently the common tendency is to sow the two together with the hope that a crop of satisfactory yield and quality may result. Other reasons for the wide use of oats in mixture with barley are the greater strength of straw of the oats, and the fact that these two crops form a standard feed mixture on the average mixed farm. Since oats will thrive on less fertile soils than barley it may be better to avoid growing barley either alone or in mixture on such land.

Because oats and barley are two of the best adapted crops for conditions in Eastern Canada, one might expect to obtain better success with this mixture than when oats are grown with other crops. The mixing of wheat or peas with oats, mainly to increase the protein content of the feed, is common among some dairy farmers. In general, success or failure with mixtures is dependent upon the varieties used, maturity of varieties, date of seeding and proportions of seed used, soil fertility, etc.

From a labor standpoint it is easier to produce a "ready-mixed" crop than to grow each crop separately and mix them by hand. However, if a farmer has reason to believe that a particular field will produce more pounds per acre of one crop than another when grown by itself then, obviously, it will pay to grow the single crop and make up the desired feed mixture later.

Oats for Hay and Pasture

Oats cannot be excelled in the Maritimes, Quebec, and eastern Ontario as an emergency or supplementary hay or pasture crop. The young oat plants are very high in protein and could even be classed among the concentrates so far as this feed constituent is concerned. Oats allowed to reach the milk or early dough stage make excellent hay and can be considered comparable to good timothy hay both in quality and palatability.

Because of the nature of the root system oats will not stand so much continuous grazing as will the clovers and grasses and, therefore, care must be taken to avoid over-grazing and excessive tramping. For pasture purposes oats may be seeded at different times during the summer if such feed is required throughout the season, since oats may be grazed in four to five weeks after seeding. The usual practice, however, is to use this crop as a supplementary pasture during the hot part of the summer when the regular pastures are short. Oats will normally make a satisfactory growth after having been grazed off once or even twice, provided care is taken not to allow the stock to damage the roots too severely. A rate of seeding, slightly heavier than for grain production, is recommended when seeding oats for pasture.

Figure 5.—*Left*: Two plants with large, wide, spreading anchor roots and thick stems characteristic of varieties resistant to lodging. *Right*: Two plants with small, non-spreading roots and thin stems characteristic of varieties susceptible to lodging.

Work carried on by the Experimental Farms Service has shown that certain varieties are better able than others to produce abundant leaves and tillers and consequently to provide greater yields of forage. Some varieties also have the ability to recover more quickly than others after having been grazed.

When oats are seeded for pasture or hay in late spring or early summer, the use of rust-resistant varieties becomes more important, since the environment during this period may be more favorable for severe rust infections. Recommendations regarding varieties of oats for hay and pasture may be obtained from the Forage Crops Division, Central Experimental Farm, Ottawa.

Lodging

Lodging is often responsible for great losses to the oat crop in Canada. This is particularly true in those areas where moisture is abundant, where storms commonly occur or where the soil is rich in nitrogen or deficient in minerals. A lodged crop lowers the yield and quality of the grain; harvesting is made difficult and expensive, and severe damage to new seeding may result.

The actual damage caused by lodging depends largely on the stage of growth at which the crop goes down. When the crop lodges in the green condition the plants usually bend over at the ground level. During heavy storms much pressure is exerted on the stems and particularly at the point of anchorage to the ground. Varieties that are not too tall and that have thick stems near the bottom as well as large and branching anchor roots giving maximum support are the ones that do not lodge readily.

Lodging prior to maturity is most common in crops grown on very fertile land or on soils having an abundance of nitrogen such as legume sod or muck soils. Where moisture is the limiting factor in crop production the effect of previous crops on lodging is less noticeable. It is well known that phosphate fertilizers are important for good plant development and tend to hasten maturity of the crop, thereby lessening the damage from lodging caused by late summer storms.

Figure 6.—Improvement of lodging resistance in oats by breeding. Plots at Central Experimental Farm.

Results of work by the Experimental Farms Service bear evidence that as the rate of seeding increases the amount of lodging may also increase, because the plants are more spindly as a result of competition. Early seeding has tended to produce crops with stronger straw. This may be the result of a more suitable growing season which allows for better plant development. Early sown crops also have a greater chance of escaping heavy storms. Grazing or clipping the young oat crop to check growth and lessen the amount of lodging, although practised in parts of Great Britain, has seldom given satisfactory results in Canada.

Another type of lodging may occur as the grain approaches maturity when the straws gradually lose their flexibility and become brittle. At this stage breaking occurs higher up in the stem. This is particularly true in the case of an over-ripe crop, and is a great hindrance to combining. The production of oat varieties to resist lodging has been a problem of major importance at many plant

breeding institutions. One of the main projects of the Cereal Crops Division involves a study of the various factors concerned with lodging resistance. It has been found that varieties differ widely not only in internal stem structure and size but also in anchor root development. Such findings have had a direct bearing on the problem of producing a variety that will stand up under conditions of high fertility and abundant moisture and at the same time fulfil the requirements of high yield and good quality. Considerable progress has resulted from these efforts to develop lodging-resistant oat varieties, and it is expected that the lodging problem in oats may be partially solved when such varieties are introduced.

Hulless Oats

Hulless oats, so called because the kernels thresh free of the hulls, are recorded as having been grown and used as human food in Asia as long ago as the fifth century. Other records show that this crop was widely grown in England as early as the sixteenth century.

When hulless oats were first introduced into Canada, they were looked upon more as a novelty than as having a useful place on the average mixed farm. Actually they were introduced primarily for the benefit of farmers living in outlying districts, remote from grinding mills, and who might find it of advantage to grow a type of oats that could be fed to young stock and poultry without being ground and might even be used as porridge for human consumption.

Feeding tests conducted within the Experimental Farms Service have shown that hulless oats or oat groats are superior to hulled oats when used in the chop for young pigs. Evidence from the same source shows, too, that in a general way hulless oats can be fed profitably to all classes of poultry in preference to hulled oats and particularly to young birds. While machines for dehulling ordinary oats are now available at moderate cost, there are some who prefer to grow hulless oats to supply the need for such feed.

Normally, the best varieties of hulless oats yield slightly less than the better varieties of hulled oats even when allowance is made for lack of hull. The lack of higher yielding, well adapted, disease-resistant varieties, together with a tendency to shatter when ripe and the danger of heating in storage, undoubtedly explains why hulless oats have not shown a greater increase in popularity. It is true also that unless reselection of the hulless type is carried on fairly regularly there is a likelihood that the crop will gradually revert to the hulled type since in hulless varieties a small percentage of hulled or intermediate hulled plants appear and as these increase, the proportion of hulless to hulled grain decreases.

Up to recent years the most commonly grown varieties in Canada were Laurel and Liberty. In 1942 the variety Brighton was introduced by the Cereal Crops Division, Central Experimental Farm. This variety is resistant to the smuts but not to the rusts. Brighton is large seeded and high yielding but has somewhat weaker straw than Laurel, one of its parents. A new hulless variety named Torch has now been introduced by the University of Saskatchewan. This variety has resistance to smut and is semi-resistant to stem rust. Torch is recommended as a hulless oat in Saskatchewan. Hulless oats are usually sown at the rate of 75 pounds per acre. Harvesting should not be delayed after the kernels reach the medium dough stage because of the danger of loss from shattering.

Winter Oats

There are no oat varieties that will withstand the low temperature of the normal Canadian winter except in the case of a small area on Vancouver Island. Although winter oats are grown successfully in many parts of the United States

and in other countries, none of the varieties used can survive the winters in latitudes as far north as Canada.

There are no winter oat varieties that possess a degree of hardiness equal to that found in wheat, rye, or even barley. If it were possible to develop winter oat varieties that could survive in Canada they would be of great benefit, especially in those areas where spring droughts are common or where spring seeding is often delayed by unfavorable weather.

On Vancouver Island, in some years, even spring varieties seeded in the fall will survive the winter. At present, the Cereal Crops Division aims to improve winter oat varieties for growing on Vancouver Island. For the rest of Canada it seems that totally new sources of winter hardiness must be found and used to breed hardier oats.

Oat Quality

Quality in oats is partly determined by the proportion of hull to kernel. The hull or outer covering of the oat grain consists largely of fibrous material, very similar to oat straw in feeding value and making up, on the average, from 20 to 30 per cent of the bulk, in well-cleaned oats. The weight of oats in Canada seldom falls below 34 pounds per bushel under normal conditions chiefly because of the use of high quality varieties and the natural adaptation of the crop.

Percentage hull is a definite varietal characteristic, some varieties running as low as 20 per cent while others run as high as 35 per cent or even more. Both soil and season influence hull percentage, and it is not uncommon to find a normally good quality variety producing a relatively high percentage of hull when grown under adverse conditions. Since each variety is capable of producing a normal crop only under a specific set of conditions, any variation from these conditions, in the nature of longer or shorter growing season or periods of drought or wet weather at critical times in the growth of the plants, will tend to influence the percentage of hull. For this reason the quality of oats varies widely from year to year even when good seed of the same variety is used.

Percentage hull is usually lower in the earlier maturing varieties, but this is not always the case. In Canada, however, all the commonly grown early varieties are reasonably low in hull percentage and are, therefore, of high quality. Since early varieties normally yield less than later maturing ones, it becomes necessary to balance the higher quality of the former against the better yield of the latter in deciding which type to grow for feed purposes. Quite apart from quality, however, soil or climatic conditions are often the deciding factors in the choice of early or late varieties.

Weight per measured bushel is not always an indication of good quality in oats, since the weight of a sample depends not only on the proportion of kernel to hull, but also on the shape of the grain, presence of awns, hull tips and trash that tend to prevent the grains from packing closely together. Many varieties, low in hull percentage and possessing other desirable characters, have long, rather slim grains with an extended hull tip. The grain of such varieties does not pack well and a low weight per bushel is the result. If, however, the awns and hull tips are removed by clipping or scutching, the weight and general quality of the sample can be materially increased. It is clear, therefore, that low weight per bushel does not necessarily mean poor quality, since the low weight may be the result of lack of preparation of the sample. If a crop of oats produces a good weight per bushel, it is a strong indication that the variety used is adapted to the soil type and other growth conditions under which it has been grown.

As with other plant characters oat varieties may differ also in percentage protein and other chemical constituents. For example, from an analysis made by the Chemistry Division, the grain of the variety Mabel carried 2 to 3 per cent more protein than Banner based on a 3-year average.

Quality in oat straw is also a varietal characteristic. Analyses based on protein and fibre content have shown that there is not always an association between high quality grain and high quality straw. Seasonal influences play a large part in determining the quality of oat straw and although the feeding value may be low at all times, palatability may be greatly affected by growing conditions and methods of handling.

Thus, the first consideration in improving the feeding quality of oats is to use a well-adapted variety possessing a reasonably low percentage of hull and known to be a good yielder. Thorough cleaning of the grain with modern machinery will reduce the amount of fibre in oats considerably not only by removing light grains and chaff but also by breaking off hull tips which help to lower the weight per bushel.

Drought

As stated previously the oat crop requires a plentiful supply of moisture throughout its growing period for maximum development. Some areas in Canada normally suffer from too little moisture and a high degree of evaporation which tend to increase the hazards of growing this crop. In these areas, which include large acreages in both Saskatchewan and Alberta and to a limited extent in Manitoba, drought periods may occur at various times during the growing season to an extent where crop failures are frequent.

Insufficient moisture for normal germination results in poor stands. Drought conditions during the early period of growth tend to produce weakened plants and sparse tillering. The effect of drought in the latter part of the growing season results in reduced filling and yield. Early seeding as well as the use of early maturing varieties often enables the crop to escape drought damage during the later stages of growth.

In Canada, efforts are being made to locate varieties from foreign sources which have shown resistance to drought in different parts of the world. With some of these it is hoped that drought resistance may be incorporated into the better Canadian varieties.

Frost

Frost damage, either in the spring or fall, becomes a hazard to oat production in certain areas in Canada. This is particularly important where the frost-free growing period is short. Usually oats are able to make a better recovery from spring frost injury than some of the other cereals. Early fall frost damage is particularly detrimental when the crop is to be used for seed. A study of varietal resistance to fall frosts has shown that some oat varieties are more resistant than others during the maturity stages of the kernel.

Shattering

Losses resulting from shattering are common in the drier oat growing areas, particularly when the crop is left standing until over-ripe for straight combining or because of bad weather at harvest time.

While comparatively little investigational work has been done on the cause of shattering in oats, there is evidence which shows that some varietes shatter more than others when grown under a common environment and that this difference is associated with the basal attachment of the grain to the peduncle. Varieties having an angle of attachment similar to wild oats are more susceptible to conditions favoring shattering. A greater total area of grain attachment also appears to be related to shattering resistance.

False Wild Oats

False wild oats have been a topic of much scientific interest during the past two decades, particularly with regard to their origin. These forms resemble wild oats in that they possess strong, bent awns, darkened at the base, and a horse-shoe-shaped depression, often referred to as a suckermouth, at the base of the grain, partially surrounded by a conspicuous tuft of fine hairs. False wild oats are usually characterized further by possessing the same grain color and shape as that of the variety in which they are found. Since the suckermouth at the attachment point or base of the grain is the same as in wild oats, the seeds drop off even before maturity. Fortunately, however, false wild oats do not possess the delayed germination characteristic of wild oats and few if any survive the average Canadian winter. Thus the problem of control in the case of false wild oats is not a cultural one.

Much controversy has arisen over the origin of these forms and even now there exists some difference of opinion in this regard. It appears from the work of many investigators that the so-called wild oat type originates directly from common oats as a result of certain changes in the carriers of the hereditary material or in some cases from natural crossing between wild oats and common oats. The evidence, however, appears to favor the theory that these forms occur most frequently as a result of hereditary changes, and further that some varieties are more susceptible to such changes than others.

Apart from the true false wild oat, carrying the wild oat characters of awns, base attachment and hairs, there are other forms possessing these characters in a reduced or intermediate condition. These intermediate forms originate in a similar manner to the true false wild oat but are unstable and segregate into normal oats, intermediate false wild, and pure breeding false wild. These intermediate forms are hard to detect in a sample of oats without close examination and are impossible to remove with grain cleaning equipment. The true false wild, while easily distinguished in the field, is also impossible to separate from common oats by machinery. The only hope of controlling these forms, however, lies in pulling the plants in the growing crop. Fortunately for the seed oat grower, these types of false wild oats are not classed among the noxious weeds and a liberal allowance is made for their presence even in the highest grades of registered seed. When seed stocks get badly polluted with false wild oats, it is best to secure new seed.

Weeds

Weeds constitute one of the worst enemies of the farmer. They rob the soil of fertility and moisture, increase the cost of handling, lower the market grade of the crop, and often smother new seedings of grass and clover. In Eastern Canada where the type of farming lends itself to longer rotations, weeds are more easily kept under control than is the case where land is cropped almost exclusively to grain as in large acreages of Western Canada.

Since oats are used extensively as a nurse crop for seeding down to grasses and clovers it is perhaps even more important that weeds be kept under control in this crop than in the case of other cereals. Seed surveys made from time to time in various parts of the country have shown that too many weedy grain fields are the direct result of insufficient attention being given to the sowing of weed-free seed.

The annual weeds most prevalent in the oat crop are mustard, stinkweed, lambs quarters, and pig weed. Among the perennials, the most common are couch grass, Canada thistle, sowthistle and chicory. There are other weeds both annual and perennial which may be important in certain localities. Most annual weeds and certain perennials can be controlled effectively by application

of the selective weed killer 2,4-D. Detailed information regarding weed control may be obtained from the Field Husbandry Division, Central Experimental Farm, Ottawa.

In many areas of the country, particularly in Western Canada, wild oats are a serious menace to the production of oats and other cereals. Wild oats lower the yield and value of both feed and seed crops. They shatter readily at maturity and furthermore have the characteristic of delayed germination lasting two or more years. After surface cultivation, many of the small cut or broken pieces of underground stems of the seedlings of wild oat plants will take root again and produce new plants. Such characteristics make this weed a difficult one to control, particularly in areas where continuous grain production is practised.

Wild oats are on the average higher in fibre and slightly lower in protein than cultivated oats. The lower grades of feed oats may contain percentages of wild oats ranging up to 49 per cent in the lowest grade. While the use of these grades of feed oats is considered fairly satisfactory from a nutritional standpoint, such a practice favors the spread of this weed. When oats are sold as groats, i.e., oats with the hulls removed, they usually contain a high percentage of dehulled wild oats. Oat groats are of particular value as a starter feed for poultry and young stock.

Figure 7.—Harvesting oats at the Central Experimental Farm, Ottawa.

With modern grain cleaning equipment wild oats can be separated from wheat almost completely. With oats and barley it is practically impossible to make a thorough separation. Special wild oat separators are on the market that are efficient, but separating devices must be used in conjunction with other control methods in coping with the problem of wild oat eradication. Efforts have been made by the plant breeder to develop larger seeded varieties in order that the slender seeded wild oats may be more easily separated by ordinary seed cleaning methods.

Cultural practices such as summerfallowing, shallow after-harvest cultivation, extra spring cultivation, rotations involving sod or smother crops and the sowing of clean seed, all constitute effective measures of control. Some progress has been made in the control of wild oats in growing crops of cereals, particularly barley, by the use of chemical sprays. More specific information regarding the control of wild oats may be obtained from the Field Husbandry Division, Cereal Experimental Farm, Ottawa, or from the nearest Dominion Experimental Station.

Profitable oat production depends upon the elimination of as many of the above-mentioned hazards as possible. To accomplish this there must be the closest co-operation between the plant breeder and the grower. Successful utilization of the varieties that the plant breeder creates is greatly dependent on the practices followed by the grower. While the plant breeder may develop varieties having combined resistance to many diseases it may still be necessary for the grower to use the latest seed treatment recommendations and to follow suitable rotations as a precaution in eliminating other diseases. Again, the breeder may create new varieties that have resistance to lodging but the grower in the use of such varieties must guard against excessive fertility and heavy rates of seeding to aid in overcoming this hazard. Similarly the grower must follow good farm management practices such as maintenance of fertility and the control of weeds to obtain maximum yields, conservation of moisture to limit the effects of drought, and early seeding to avoid late frost. Lack of soil fertility is one of the main reasons for low yields in any crop. The plant breeder can do little to overcome this hazard. It must be met largely by the grower himself.

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