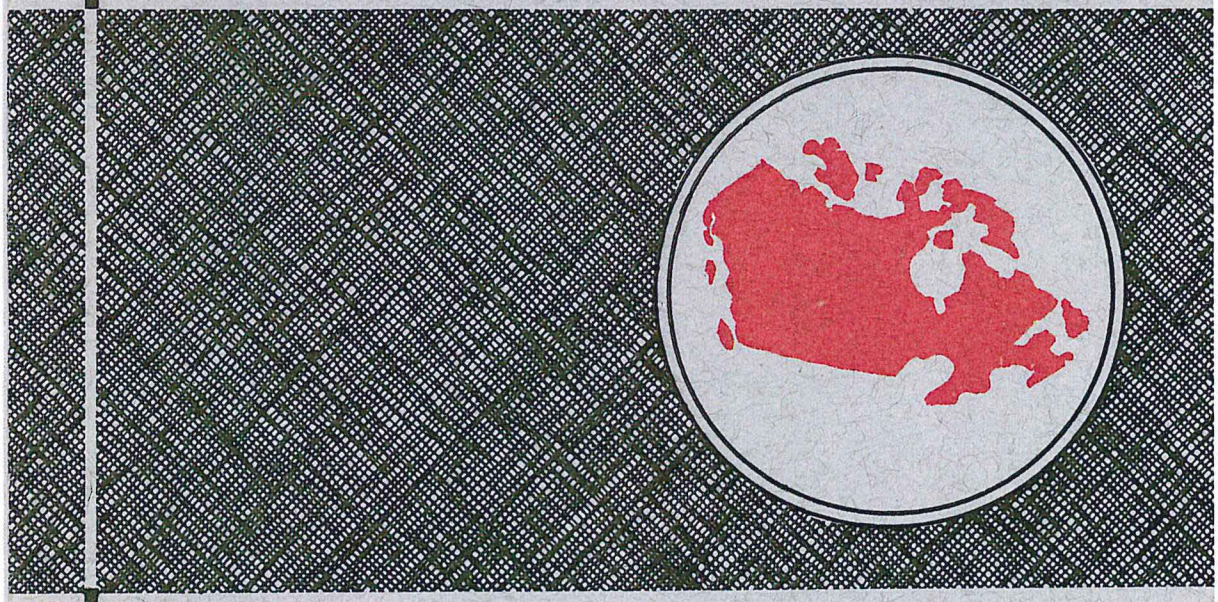
RESEARCH REPORT

1965-1966



Research Station
BEAVERLODGE, ALBERTA

RESEARCH BRANCH - CANADA DEPARTMENT OF AGRICULTURE

Research Report

1965-1966

Research Station

Beaverlodge, Alberta

and

Experimental Farms

Prince George, British Columbia
Fort Vermilion, Alberta
Fort Simpson, Northwest Territories
Mile 1019, Alaska Highway,
Yukon Territory

RESEARCH BRANCH
CANADA DEPARTMENT OF AGRICULTURE

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1556—1¼

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W. A. Russell, B.S.A. (Saskatchewan), to Experimental Farm, Scott, Sask., August 1965.

CONTENTS

HIGHLIGHTS

Climatic extremes at Beaverlodge during the past 50 years were determined and related to the potential for crop production. Climates at the Research Station, Beaverlodge, Alta., and the experimental farms at Smithers and Prince George, B.C.; Fort Vermilion, Alta.; Fort Simpson, N.W.T.; and Mile 1019, Alaska Hwy., Y.T., were compared.

The flax variety Noralta was licensed in 1965. It is early maturing, rust resistant, and high yielding throughout Western Canada.

Further study of the soil nutrient requirements for the production of cereal and oilseed crops in the Peace River region and central British Columbia indicated the need for higher rates of supplementation with N and P and, in certain localities, the need for K and S.

A number of vegetables were grown successfully on permafrost at Inuvik, N.W.T. The general adaptability to the north of a number of vegetables, small fruits, tree fruits, and ornamentals was established. The advantage in the north of the use of polyethylene mulches and portable shelters for the production of horticultural crops was demonstrated.

Boreal, a new variety of creeping red fescue, was licensed in 1966. On the average, it produces 6% more seed and herbage and is more uniform in plant and seed production characteristics than the variety Olds.

Final studies with a standardless mutant indicated that tripping by honey bees was not appreciably greater than for normal alfalfa. Because of this the characteristic has no practical value in a commercial variety.

Further studies of the soil nutrient requirements for the production of forages in central British Columbia indicated a general need for supplementation with N, P, and S.

The temperature and photoperiod requirements were determined for the induction and initiation phases of flowering in creeping red fescue, intermediate wheatgrass, and bromegrass.

It was demonstrated that phyllody virus of alsike clover is not transmitted by seed, pollen, or pollinating insects.

The potential of the Fort Nelson area of British Columbia for the production of cereal, oilseed, grass, and legume crops was shown to be similar to that of the Peace River region with regard to both crop development and fertilizer requirements. Because of the distance from markets and high land development costs, present development of this area for agriculture is not considered economically feasible.

Soil acidity and lack of available S were found to seriously restrict the development and yield of cereal crops, particularly barley, on certain soils in the Peace River region.

The yield of seven consecutive wheat crops was greater after early than after late breaking from bushland. The largest differences in yield were obtained with the first and second crops following breaking. Without nutrient supplementation yields after breaking declined in the sixth year to approximately one-half of the first year yield.

Nitrogen fixed by alfalfa on a Gray Wooded soil was found to benefit the first to the fifth consecutive wheat crop after breaking of the alfalfa or bromegrass–alfalfa mixture.

The average yield of barley on four Gray Wooded soils was increased from 55 to over 90 bu/acre by the application of 60 tons/acre of barnyard manure or ample quantities of N, P, K, S, and micronutrients. Applying both manure and chemical nutrients did not further increase yield.

Field-scale infestations of couchgrass were eradicated in 1 year by repeated tillage with a toolbar cultivator followed by a cableweeder. Similar infestations were controlled by TCA plus tillage, and isolated patches were controlled chemically by a mixture of bromacil and paraquat.

Honey bees overwintered in southern British Columbia produced from 4.4 to 5.9 two-lb packages of bees per colony. Colonies established from these packages were as productive as those established from package bees from California.

Both American and European foulbrood diseases were carried from southern British Columbia to Beaverlodge by package bees from infected colonies.

FOREWORD

27

Agricultural research for central and northern British Columbia, northern Alberta, the western part of the Northwest Territories, and the Yukon Territory was consolidated in 1965 under the direction of the Research Station at Beaverlodge, Alta. The Station was established as the center for northern research and the experimental farms at Smithers and Prince George, B.C.; Fort Vermilion, Alta.; Fort Simpson, N.W.T.; and Mile 1019, Alaska Hwy., Y.T., as associated field research locations. Smithers is operated as a substation of Prince George. Most of the research and administrative staff is now located at Beaverlodge. This centralization makes possible the coordination of the whole program conducted in the north by the Research Branch and also the initiation at the Station of an intensified research program for the north.

The coordination of activities and centralization of staff and facilities at Beaverlodge has not changed the purpose of the six northern locations. Beaverlodge is vitally concerned with agricultural problems in the whole of the north, of which the Peace River region is a part. The research staff at Beaverlodge and Prince George are concentrating on production problems in central British Columbia. Problems unique to the lower Peace River region are being studied at Beaverlodge and Fort Vermilion. The staff at Beaverlodge is directly responsible for research at Fort Simpson and Mile 1019 and, with the assistance of resident technicians, is continuing to assess the potential for agriculture of the Northwest and Yukon Territories.

This report summarizes the main research activities of the northern research group for 1965 and 1966. For Prince George, research conducted back to 1963 is also included. Studies are concerned mainly with the problems encountered in producing cereals, oilseeds, and forage crops for herbage and seed on the approximately 4 million acres now in production and with estimating the potential of about 20 million acres that are thought to be arable. Production problems are caused mainly by low temperatures and insufficient moisture during the growing season, and by degraded soil. The numbers below the headings in the text refer to relevant publications listed at the end of the report. Reprints may be obtained from the authors.

April 1967

A. A. Guitard
Director

AGROMETEOROLOGY

Climate and soil determine the crop production potential of any region and the combination of species and management required for economical production. In the north, growing season, temperature, and precipitation are particularly critical, but are compensated for, to a considerable extent, by increase in daylength with increase in latitude. Because of the critical production–climate relationship and the complex relationship with daylength, detailed evaluation and comparisons of climate, and research in crop–climate relationships are emphasized in the north.

Climate

Beaverlodge 1965-66

Meteorological data have been recorded daily at Beaverlodge since 1916 and for the years prior to 1965 were presented in earlier Research Reports. Precipitation during 1965 and 1966 was much heavier than normal, particularly during the summer months (Table 1). The summer of 1965 was warm, but that of 1966 was one of the coolest recorded. Evaporation, wind velocity, and hours of bright sunshine were above normal.

Extremes in the Peace River Region

23

Average weather data give a measure of the climate of a region, but extremes may decide what crops can be grown and what farm practices are used. For example, during 50 years yields of small grains at Beaverlodge have been severely curtailed by drought six times and damaged by excessive moisture three times. Droughty conditions are much more frequent than excess moisture since in 2 out of every 3 years crops experience drought during some stage of their development. Damaging frosts, especially those in late summer, have cut yields drastically. Five such frosts were recorded prior to 1950 but none since that time. Hail storms are rare, only causing damage at a given location during 1 year in 20. Dust storms, once common, are now practically nonexistent because of present farming methods.

Comparison of Northern Experimental Farms

22

Climate is compared on the basis of 1947-66, since records were not obtained at Fort Simpson before then. Beaverlodge, Fort Vermilion, and Fort Simpson are situated in the Great Plains area east of the Rocky Mountains, whereas Prince George, Smithers, and Mile 1019 are located in mountain valleys to the west. East of the Rocky Mountains, temperatures are more favorable (Table 2). Although winter temperatures at the eastern locations are extremely low, summer temperatures are higher than west of the Rocky Mountains. North of Beaverlodge summer temperatures increase. Fort Simpson has the highest June to August average temperature. This pattern does not hold for the western locations, where Prince George has the warmest summer and Mile 1019 the coldest. As

1556—2

Table 1. Meteorological conditions at the Research Station, Beaverlodge, 1965 and 1966, and long-term means

Month	Precipitation, inches			Mean air temperature, F			Evaporation,[1] inches mean monthly	Wind velocity, mph mean daily	Sunshine, hours mean daily	Mean soil temperature, F
	1965	1966	1916-66 mean	1965	1966	1916-66 mean				
January	1.90	1.93	1.33	5.0	−11.7	7.3	—	6.3	1.5	28.3
February	1.61	1.32	1.06	7.0	15.1	13.0	—	7.1	3.3	27.3
March	0.20	1.11	1.03	19.0	22.9	21.6	—	7.3	6.8	28.0
April	1.80	1.73	0.86	35.6	30.9	36.9	—	8.3	6.5	33.2
May	1.31	0.81	1.58	47.3	49.6	49.1	5.39	11.1	8.9	45.4
June	5.16	1.22	2.25	55.2	52.4	55.6	4.71	8.7	9.9	54.4
July	3.43	3.28	2.55	60.6	57.5	60.0	4.43	6.8	9.3	60.3
August	5.44	3.97	2.06	60.9	56.4	57.7	3.56	6.2	8.3	59.9
September	1.30	0.72	1.58	43.4	51.6	49.6	2.13	6.9	5.3	50.6
October	0.76	0.70	1.16	42.9	38.4	39.6	—	10.5	5.0	40.8
November	1.77	2.29	1.25	14.5	12.1	23.4	—	6.6	1.9	33.1
December	0.72	1.10	1.19	11.9	12.4	12.1	—	6.8	1.8	31.1
Annual										
1965-66	25.40	20.18	—	33.6	31.6	—	20.22	7.7	5.7	41.0
1947-66	—	—	17.90	—	—	35.5	20.99[2]	7.6	5.8	—

[1]Evaporation, wind velocity, sunshine, and soil temperature are for the years 1965 and 1966.
[2]1954-66.

1556—21

Table 2. Regional precipitation and temperature comparisons in northwestern Canada, 1947-66

Month	Precipitation, inches						Temperature, F					
	Beaver-lodge	Ft. Vermilion	Ft. Simpson	Prince George	Smithers	Mile 1019	Beaver-lodge	Ft. Vermilion	Ft. Simpson	Prince George	Smithers	Mile 1019
January	1.35	0.88	0.70	2.43	1.90	0.72	4.1	−11.6	−17.4	14.7	12.1	−10.6
February	1.29	0.80	0.55	1.90	1.12	0.46	12.3	2.5	−11.3	19.8	20.7	1.7
March	0.87	0.66	0.66	1.21	0.94	0.40	20.2	12.1	4.5	27.6	28.5	13.3
April	0.97	0.77	0.76	1.16	0.75	0.36	35.6	33.1	24.9	38.7	38.5	29.0
May	1.62	1.25	0.94	1.71	1.41	0.55	49.1	49.2	46.3	48.9	47.3	39.3
June	2.52	1.86	1.63	2.54	1.73	1.17	55.8	56.9	58.0	55.0	53.0	49.8
July	3.08	2.48	2.16	2.42	1.91	1.23	59.7	61.6	62.8	58.9	57.3	53.5
August	2.51	2.11	2.07	3.21	1.91	1.04	57.3	58.0	58.2	56.4	56.0	50.0
September	1.25	1.22	1.34	2.20	1.48	1.26	49.5	47.5	45.9	45.9	49.2	42.1
October	1.16	0.95	1.12	2.33	2.31	1.38	39.7	34.4	29.2	40.2	39.3	28.4
November	1.16	0.89	0.91	2.11	2.26	1.29	23.4	11.8	5.6	26.8	26.7	9.0
December	1.17	0.99	0.82	2.31	2.26	1.33	12.2	−3.4	−10.4	18.6	16.6	−4.4
Annual	18.95	14.92	13.66	25.53	19.98	11.19	34.9	29.3	24.7	37.6	37.1	25.1

Table 3. Precipitation extremes in northwestern Canada, 1947-66

Month	Beaverlodge		Ft. Vermilion		Ft. Simpson		Prince George		Smithers		Mile 1019	
	Extreme wet	Extreme dry	Extreme wet	Extreme dry	Extreme wet	Extreme dry	Extreme wet	Extreme dry	Extreme wet	Extreme dry	Extreme wet	Extreme dry
January	3.43	0.27	2.10	0.10	1.79	0.20	4.45	1.06	4.56	0.33	1.73	0.22
February	2.54	0.38	1.75	0.12	1.26	0.07	3.46	1.02	1.78	0.21	1.26	0.05
March	1.54	0.19	1.61	0.13	1.32	0.06	2.63	0.38	1.86	0.13	0.84	0.00
April	2.28	0.11	3.58	0.10	4.29	0.00	2.26	0.57	1.93	0.24	2.50	0.00
May	4.77	0.34	3.81	0.26	2.96	0.04	4.16	0.25	7.32	0.00	1.56	0.02
June	6.62	0.42	5.56	0.21	4.60	0.34	4.57	0.41	3.59	0.29	3.05	0.30
July	8.23	0.35	5.53	0.79	4.88	0.26	4.21	0.03	3.78	0.42	3.27	0.16
August	5.44	0.17	3.98	0.84	4.59	0.08	5.82	1.42	3.87	0.64	2.40	0.05
September	2.59	0.24	2.60	0.19	2.68	0.47	4.73	0.53	3.60	0.26	3.44	0.15
October	4.71	0.40	2.86	0.07	2.53	0.24	3.07	1.07	4.98	0.77	3.59	0.15
November	2.29	0.15	1.65	0.32	1.74	0.22	3.17	1.01	3.58	0.73	7.39	0.23
December	2.12	0.07	1.90	0.14	1.65	0.23	4.98	0.43	5.09	0.95	4.36	0.32
Annual	28.76	13.22	20.42	10.04	18.37	9.18	33.22	19.95	24.95	13.87	16.68	6.36

may be expected from their favorable temperature regimes, locations east of the Rocky Mountains have comparatively long frost-free periods with little reduction from south to north (Table 4). However, none of the intermountain locations have long frost-free periods and the northern stations are seriously limited in this respect.

The distribution of precipitation for the eastern stations is quite similar. All have very dry springs followed by maximum precipitation in the summer and reduction of precipitation in the fall and winter (Table 2). The annual distribution of moisture is not so favorable for the three experimental farms located west of the Rocky Mountains. The trend is again for dry springs but with maximum precipitation occurring in late summer or fall. Summer drought and wet harvest weather are common occurrences. For both groups, aridity increases with latitude, but the increase is more rapid west of the Rocky Mountains. Great differences in extremes of precipitation occur at all locations (Table 3). Those east of the Rocky Mountains have their maximum differences in midsummer, whereas those west have their greatest variability in late summer or fall. Smithers is an exception with May precipitation ranging from 0 to 7.32 inches. All locations are subject to destructive drought. The variation in precipitation is greatest at Beaverlodge and least at Prince George. At Beaverlodge, July rainfall has varied from 0.35 to 8.23 inches.

Counterbalancing limited precipitation in the north is the trend for reduced evaporation, probably because of less wind (Table 4). Prince George is the exception because evaporation is curtailed by recurrent showers and cool temperatures. Daily hours of sunshine tend to diminish to the north, presumably because the long summer daylength does not compensate for the short days of winter. Smithers belies the rule by having summer sunshine reduced by overcast.

Table 4. Evaporation, wind, sunshine, and length of frost-free periods in northwestern Canada, 1947-66

Establishment	Evaporation,[1] inches	Wind velocity, mph mean daily	Sunshine, hours mean daily	Frost-free period, days	Killing-frost-free period, days
Beaverlodge	20.99	7.6	5.8	107	133
Fort Vermilion	16.59	5.8	5.7	92	117
Fort Simpson	—	5.0	5.1	92	120
Prince George	11.43	7.5	5.2	81	132
Smithers	17.28	2.5	3.6	53	102
Mile 1019	16.15	3.8	4.8	23	53

[1] Total for 5 summer months from free-water surface. Data based on at least 10 years.

Crop–Climate Relationships

Variations in Moisture Use in the Peace River Region

A study conducted over a 10-year period at Beaverlodge, McLennan, and Baldonnel, each located about 100 miles apart, showed that although these communities receive approximately the same amount of precipitation, a crop of spring wheat at Beaverlodge uses 1.5 inches more water than at McLennan and 2 inches more than at Baldonnel. This relationship is caused by the high rate of evaporation at Beaverlodge, which receives more sunshine than the

other locations and, being located in less-wooded country, is exposed more to wind. In 1965 the rate of evaporation at Beaverlodge and McLennan differed only by 1% despite significantly less wind, lower temperature, and 6.8 inches more rain at Beaverlodge. Also, despite the higher precipitation at Beaverlodge the hours of bright sunshine differed by only 0.2%.

Crop–Temperature Relationships in the North

Studies conducted by Beaverlodge showed that the growth and development of cool-season crops in northwestern Canada require 80 killing-frost-free days, basis 28 F; a 110-day growing season or vegetative period, basis 42 F; and 1,000 degree days or heat units, basis 42 F. Crop growth at Inuvik is of interest because in the normal season these requirements are approached but not met. Although there were only 73, 90, and 900 killing-frost-free, growing season, and degree days, respectively, in 1966, Olli barley matured and produced a fair sample of feed grain. It went through early phenological stages at an incredible rate, but kernel ripening was very slow.

Instrument Testing

Rain Gauges

The standard rain gauge used by the Meteorological Branch of the Department of Transport, the Nipher shield gauge, and the United States Weather Bureau's official gauge have been compared for 7 years. The diameter of the catchment openings are 3.57, 5, and 8 inches, respectively. Comparison of 434 daily sets of records showed that on the average the Nipher gauge caught 0.09% less and the United States Weather Bureau's gauge 0.15% more precipitation than the standard gauge. The greatest differences occurred during very intense storms when the standard gauge gave definite undercatches. During a storm in June 1965, the standard, Nipher, and United States Bureau gauges recorded 2.32, 3.00, and 2.87 inches of rain and during a storm in August 1965, 1.41, 2.67, and 2.45 inches, respectively. The June storm consisted of heavy rain accompanied by light wind, but the August storm was intense for both rain and wind. Over 0.5 inch of rain fell in a 5-min period as measured by a rain intensity gauge and wind speed averaged 60 mph during this period.

Snow Measuring Devices

During six winters, the snowboard and ruler, the Nipher shield precipitation gauge, and the United States Weather Bureau's snow gauge with Alter shield were compared for measuring snowfall. Based on 361 daily comparisons the Nipher shield gauge measured 1.77% more and the gauge with the Alter shield 17.48% less snow than the snowboard. These results indicated the superior ability of the inverted, bell-shaped shield of the Nipher gauge to entrap snow compared with the metal slats of the Alter shield.

Atmometers for Measuring Evaporation

5

Since 1956 various types of atmometers have been compared for measuring evaporation. During this time, substantial progress has been made in removing the remaining shortcomings of these instruments such as difficulty of priming, vulnerability to frost, and undue loss of liquid in times of high wind. The shielded Bellani plate burette mount is the easiest to operate, but is very vulnerable to

damage by frost. The black porous disc atmometer will stand freezing to 25 F, but is unreliable in high wind. However, modified forms of this atmometer have been developed to operate correctly under this condition. An atmometer using a carborundum plug and a solution of water and methanol has functioned perfectly down to 10 F.

CEREAL AND OILSEED CROPS

Adaptation

26

The production of cereals and oilseeds is concentrated in the Peace River region, but these crops can be grown in central and northern British Columbia, northern Alberta, the Yukon Territory, and the Northwest Territories wherever there is suitable soil. Early maturity is the prime requirement for stable production. Late-maturing varieties produce well during some years, but are too often damaged by fall frost or inclement weather during late harvest. The need for early maturity usually becomes greater with increase in latitude. Barley is the preferred crop because it matures the earliest and produces the greatest amount of food energy per acre. Of the spring cereals, oats are second in suitability. Wheat is grown extensively in the Peace River region but, because of late maturity, is not suitable elsewhere in the north. Winter wheat and fall rye can be grown in all areas, but are not recommended because of frequent winter killing. Flax and rapeseed grow well in the Peace River region, but are seldom grown elsewhere in the north.

Breeding and Selection

Crossing, selection, and early generation testing are conducted at Beaverlodge. Advanced testing of promising hybrids from Beaverlodge and other breeding locations in Canada is conducted at Beaverlodge and Fort Vermilion. New, early-maturing varieties that are licensed for production in Canada are tested at a number of locations throughout the north.

Barley

25

Several early-maturing lines tested at Beaverlodge in 1966 in the F_9 generation were 20% higher yielding than Olli. These were derived from early-maturing plants selected in the F_2 generation from six crosses that had Olli as the common parent. These lines were multiplied in the F_3 generation and yield tested without further selection during the F_4 to F_6 generations. Single plants were selected at random from the highest-yielding lines in the F_7 generation and multiplied in southern California.

A program was initiated to backcross the daylength nonsensitivity and earliness characteristics of Olli into Conquest. This program was undertaken to improve the yield of Conquest, which appears to be low yielding in the north because of sensitivity to long daylength. The material is in the fourth backcross generation. No difficulty has been encountered in carrying the early floral initiation of Olli.

Bulk populations from the world barley collection, Ethiopian collection, Alaska composite cross, University of Alberta diallel cross, and Beaverlodge diallel cross were grown at Beaverlodge. A composite sample, prepared by mixing equal quantities of these five populations, was also grown at the northern

experimental farms in 1966. Each location will grow its own bulk population for at least 10 years before single plant selections are made. It is expected that natural selection within this broad genetic base will cause a concentration of plant types best suited to each location.

Oats

A limited program to improve the yield, kernel size, and lodging resistance of Abegweit was continued with further evaluation of segregating material from four crosses with Abegweit as the common parent. To broaden the genetic base of the oat-breeding program, bulk populations consisting of a diallel cross from Beaverlodge, an *Avena strigosa* – *A. sativa* cross from Ottawa and the world oat collection treated to induce male sterility obtained from Davis, Calif., were grown at Beaverlodge. These populations have been bulked in the manner used for the barley and will be grown for a number of successive generations at each of the northern experimental farms.

Wheat

Wheat acreage in the area is considerable, but it is difficult to constantly produce a high-quality product. Limited examination is being made of white wheat varieties and selections in an attempt to obtain a high-yielding, early-maturing type suitable for feed. Also, a bulk population has been prepared, from a composite of the world wheat collection from Davis, Calif., and a diallel cross from Beaverlodge, for growing through a number of successive generations at each of the northern experimental farms.

Flax

12

A very significant advance was made in the flax-breeding program with the licensing of the variety Noralta in 1965. Noralta is early maturing, rust resistant, and high yielding throughout Western Canada. The program is being continued in order to incorporate into Noralta more frost resistance, determinate ripening, and additional earliness. Sixty crosses and backcrosses are being carried out using the pedigree, mass pedigree, modified bulk, and bulk population methods of selection. Beaverlodge and Fort Vermilion are being used as the selection locations.

Management

Nutrient Requirements of Fall Rye on Acid Soil in the Peace River Region

Field tests were conducted with N, P, K, and S applied to barley and oats on stubble at more than 25 locations during 1965 and 1966. Most of the soils were Gray Wooded, but a few were Gleysolic and some Black. The most practical rate of application of N on most soils was between 40 and 80 lb/acre. The response to P varied greatly with the soil. K gave little or no increase in yield. S increased yield greatly on a few soils, but had little effect on most.

Approximately one-half of the tests were on Gray Wooded soils that had produced very poor crops the preceding year despite adequate moisture. On these soils, the average yield of oats was increased from 36 to 77 bu/acre by the addition of from 40 to 80 lb of N/acre and in some cases small applications of P. On five tests on Gleysolic soils, the addition of 80 lb of N/acre increased

yield of oats by an average of 140%. On four Gray Wooded soils, S deficiency seriously limited the yield of oats. The average yield of the oats was 30 bu/acre with no fertilizer, 32 bu with the addition of S, 48 bu with the addition of N, P, and K, and 79 bu with the addition of N, P, K, and S.

Nutrient Requirements of Fall Rye on Acid Soil in the Peace River Region

Sixty pounds per acre of $NH_4H_2PO_4$, 11-48-0, drilled with the seed of Sangaste and Antelope fall rye seeded on partially summerfallowed rapeseed stubble on acid Gray Wooded soil of the Boundary series increased the yield from 21 to 29 bu/acre. Increasing the N to 60 lb/acre by additional topdressing in the fall increased the yield a further 11 bu/acre. Topdressing with N in the spring or split between spring and fall gave about the same yields as topdressing in the fall.

Moisture Use on Summerfallow and Stubble in the Peace River Region

Thirty determinations made over 8 years at three locations showed that 10.7 inches of water were used to produce 30 bu/acre of wheat on summerfallow, whereas 10.2 inches were used to produce 25 bu/acre on stubble. Thus, wheat on summerfallow withdrew only 0.5 inch more moisture than on stubble, yet produced 5 bu/acre greater yield. This increase in yield on summerfallow was not altogether due to the wheat having more water available to it. In 1965 at Baldonnel, wheat on summerfallow yielded 47.5 bu/acre, 20 bu more than a crop on stubble with practically the same moisture uptake.

Nutrient Requirements of Barley and Oats in Central British Columbia

Olli barley seeded on Driftwood loam on the Experimental Farm at Smithers responded strongly to fertilizers containing P. N fertilizer alone did not increase yield, but, with increasing levels of P fertilizer, yields were further improved by adding N. Yields were increased by K when adequate levels of N and P were used. The addition of 20 lb/acre of N, 10 lb of P, and 15 lb of K increased yields from 63 to 74 bu/acre. The protein content of barley was increased by increasing rates of N, the highest level being obtained from an 80 lb/acre application. Ajax oats, seeded at the same location, required N, P, and K for maximum yields. When these elements were applied at 80, 10, and 15 lb/acre respectively, the yield increased from 85 to 112 bu/acre over a 3-year period. Of this increase, 5 bu was attributed to K fertilizer.

FORAGE CROPS

Adaptation

A number of species of grasses and legumes are adapted to northwestern Canada. The production of winter-hardy varieties in pure stands for seed and in mixtures for forage is an integral part of the agriculture of the Peace River region. The production of forage is the basis of agriculture in central British Columbia and is expected to be the backbone of initial agricultural development in the Yukon and Northwest Territories.

Species Adaptability to the North

Several new varieties of grasses and legumes were seeded in 1966 at five locations. This program will establish the performance of these varieties for

forage production at Prince George, B.C.; Beaverlodge and Fort Vermilion, Alta.; Fort Simpson, N.W.T.; and Mile 1019, Alaska Highway, Y.T., and will determine the reasons for differences in potential forage production among locations.

Testing European Varieties

In 1966 Beaverlodge was designated as the western location in Canada at which varieties of grasses and legumes licensed in Europe will be assessed for the production of seed and forage.

Breeding and Selection

Creeping Red Fescue

Boreal, a new variety of creeping red fescue developed at Beaverlodge, was licensed in 1966. It produces about 6% more seed and herbage than Olds, although in certain locations it has produced up to 24% more seed and 18% more herbage. Of particular importance to the seed grower is the fact that individual plants mature within a range of 3 to 5 days compared with 5 to 7 days for Olds, height of seed heads ranges from 20 to 24 inches compared with 15 to 27 inches for Olds, and crown width varies from 4 to 6 inches compared with 3 to 8 inches for Olds. The tendency of the roots to creep is about equal. Foundation seed will be available for seeding an estimated 5,000 acres in 1968.

Selection for types most suited to the production of turf and pasture was continued. Turf selections are being screened at the Experimental Farm, Saanichton, B.C., for resistance to red thread disease, a fungus that attacks fescue in west coast areas.

Reed Canarygrass

2, 3, 4

The purpose of this program is to produce a variety equal or superior to Frontier in forage production but with a high seed yield. Approximately 200 clones selected at Prince George in 1964 for low shattering and high seed weight per panicle were placed in 11 polycross nurseries at Beaverlodge in 1965. Synthetic varieties from 1966 seed of these polycrosses will be compared with Frontier for forage and seed production during 1967. In this program electronic data processing facilities have been used extensively. In 1964 numerical data on seven different characteristics for each of some 5,800 spaced plants were processed. Highly critical selection of specific plants was made possible in time for relocation of the selected material in 1965.

In conjunction with this breeding program, the Station is coordinating the testing of new varieties of reed canarygrass. Based on performance over 2 years in 10 tests for forage and seven tests for seed in British Columbia, Alberta, and Saskatchewan, none of the seven experimental synthetics produced elsewhere have been superior to Frontier or Ioreed in forage production. Two synthetics were superior to Frontier in seed production but inferior in forage production. This testing program has also been completely computerized since 1965. By doing this, analysis of data on several characteristics of each variety at all locations has become a routine operation. Analyses are conducted in cooperation with the Data Processing Service in Ottawa.

Alfalfa

13, 15

Field tests indicated that tripping of the standardless mutant by honey bees was not sufficiently greater than for normal alfalfa to be of any practical value in seed production. On the standardless mutant the honey bees were disoriented by the absence of the standard petal and attempted to obtain the nectar by inserting their mouthparts between the keel and wing petal. The standard appears to act as a nectar guide for pollinating insects. Further work will not be undertaken with this characteristic.

Alsike Clover

Alsike clover is important as a special legume for areas too acid or too wet for other legumes. Sixty-nine lines with good herbage and seed yields were selected from plants that survived five winters and were placed in a polycross nursery in 1965. Seed produced in 1966 and 1967 will be bulked to form a composite for comparative tests throughout northern Canada. When grown as spaced plants, the growth habit of these selections varies from strongly upright to prostrate. The advantages of the upright type as a legume component for hay mixtures is being studied. Sixteen of the most upright plants were grown in the greenhouse in a controlled diallel crossing program.

Management for Forage Production

Forage Rotations in Central British Columbia

The average yield of oats grown continuously for forage during 1960-66 on Pineview clay at Prince George was 2,207 lb of dry matter per acre. A 3-year rotation consisting of oats with 2 years of a timothy-alsike-red clover mixture yielded 3,205 lb of dry matter per acre. Yields of dry matter from rotations of longer duration or from those that included additional crops of oats together with perennial forage were lower.

Nitrogen Requirements of Cultivated Grasses in Central British Columbia

Up to 200 lb/acre of N as NH_4NO_3 continued to increase yields of timothy and reed canarygrass at Prince George during 1963-65. However, at Smithers applications of N in excess of 100 lb/acre to bromegrass did not cause further increases in yield. Dry matter production of timothy and bromegrass increased up to the seed-set stage, but that of reed canarygrass declined after anthesis. For optimum digestible dry matter and crude protein content, timothy and bromegrass had to be cut not later than the anthesis stage, whereas reed canarygrass had to be cut not later than the heading stage.

Nutrient Requirements for Native Grass Pasture in Central British Columbia

Application of 60 lb/acre of N to native *Poa* species growing on a predominantly Driftwood loam in the Grassy Plains area increased yields by from 37 to 130%. The addition of P, S, and K did not increase yields over those obtained from N applied alone. The variation in response to N fertilizer appeared to be caused primarily by differences in rainfall. Because of low rainfall and the short growing season the increases in hay yield from N fertilizer are often not economical.

Nutrient Requirements for Red Clover in Central British Columbia

First-year stands of red clover grown on Vanderhoof silty clay loam were fertilized with N, P, K, and S singly and in combination each year for 5 years. The average dry matter yield from unfertilized plots was 1.0 ton/acre. Plots fertilized with N, P, and K yielded 1.3 tons of dry matter per acre, whereas those fertilized with these three elements plus S yielded 2.1 tons of dry matter. Gypsum as a source of S was superior to equivalent amounts of elemental S. There was only a small residual effect from S the year following application.

Grass–Legume Mixtures for Central British Columbia

During 1962-66, forage mixtures containing red clover outyielded mixtures containing alfalfa at the Experimental Farm, Smithers. Commercial bromegrass with Altaswede red clover yielded 2.1 tons of dry matter per acre, whereas bromegrass with Grimm alfalfa yielded 1.4 tons. Commercial timothy, alsike clover, and Altaswede red clover produced the highest yield of 2.4 tons of dry matter per acre. In practically all mixtures the legume component increased with age of stand. Stands were usually the highest yielding in the third year of cutting and the lowest in the fifth.

Inoculation Requirements of Alfalfa on Newly Broken Land in the Lower Peace River Region

On a Gray Wooded well-drained silty clay loam broken from virgin land in 1962, cropped to oats in 1963, and seeded to alfalfa and a bromegrass–alfalfa mixture in 1964, the alfalfa did not respond to inoculation. However, on a Gray Wooded gleyed silty clay broken at the same time and cropped in a similar manner alfalfa responded to inoculation. Where inoculation was applied there was a tall, dense stand of dark-green alfalfa, but without inoculum the stand was thin, low growing, and pale green. In 1966 the pure stand of alfalfa yielded 2.0 tons/acre where no inoculum was used and 2.6 tons where the alfalfa was inoculated. Yields from the bromegrass–alfalfa mixture were 1.4 tons without inoculation and 2.7 tons with inoculation.

Breaking Recently Cleared Bushland for Seeding to Hay in the Lower Peace River Region

Several methods of establishing forage mixtures on newly cleared bushland were compared, particularly as they relate to subsequent hay yields and control of woody regrowth. In 1961, the land was cleared of aspen poplar ranging in diameter from 4 to 6 inches and a heavy undergrowth of prickly rose and saskatoon. The land was broken early in 1962 and during June and July seeded to a mixture of bromegrass, creeping red fescue, and crested wheatgrass. The production of hay was measured from 1963 to 1966. Establishment and subsequent growth were satisfactory on land that was broken with a moldboard plow followed by one pass with a double disc harrow or broken by two passes with a heavy serrated disc plow. A moderate stand was obtained on seedbeds prepared by two passes with a double disc harrow. Drilling grass into untilled virgin land resulted in poor establishment. Regrowth of woody plants was controlled by breaking with the moldboard plow or by breaking with the heavy serrated disc plow and a year later applying 3 lb/acre of an equal mixture of 2,4-D and 2,4,5-T esters in 15 gal of water.

Establishing Russian Wild Ryegrass in Mixed Stands in the Lower Peace River Region

Russian wild ryegrass, *Elymus junceus* Fisch., is an excellent pasture grass for the region, but its lack of seedling vigor seriously hinders establishment, especially when it is seeded with other forage species. At Fort Vermilion this disadvantage was overcome by seeding the Russian wild ryegrass alone in rows and seeding at right angles with bromegrass or alfalfa after the seedlings were in the 3- to 4-leaf stage.

Management for Seed Production

24

Induction and Initiation in Grasses

The induction and initiation phases of flowering in creeping red fescue, intermediate wheatgrass, and bromegrass were studied in natural and controlled environments to determine how grasses might be managed better for the production of seed. Under field conditions at Beaverlodge, bromegrass plants were induced by late September, whereas creeping red fescue and intermediate wheatgrass were not induced until early November. Under controlled environments creeping red fescue could not be induced to flower. Ten-week-old intermediate wheatgrass and 12-week-old bromegrass plants were induced after 4 weeks using 8-hr photoperiods and 50 F temperatures. Intermediate wheatgrass was also induced to flower by vernalizing the seed. The naturally induced state in creeping red fescue was acquired only by well-developed vegetative tillers, formed early in the season. Both vegetative tillers and tiller initials became induced in the other two grasses.

Overwintered field plants of the three grasses completed floral initiation within a few days of each other in early May. Bromegrass also initiated inflorescences during summer and autumn, but these primordia did not survive the winter. Artificially induced tillers of bromegrass initiated floral parts most rapidly under long photoperiods at high temperatures. Initiation also occurred with long photoperiods and low temperatures. High temperatures with short photoperiods delayed initiation. Initiation in both creeping red fescue and intermediate wheatgrass was promoted by long photoperiods and low temperatures and, unlike bromegrass, high temperatures with long photoperiods suppressed initiation in these two species through devernalization. Complete devernalization occurred at 60 F in creeping red fescue and at 70 F in intermediate wheatgrass. Intermediate wheatgrass plants from vernalized seed were not devernalized by high temperatures. Blind tillers frequently formed in bromegrass because the environmental requirements for stem elongation were separate from floral formation. Stem elongation was invariably followed by heading in the other two grasses. Gibberellin did not promote flowering in any of the three species.

Alfalfa Pollination by the Alfalfa Leaf-cutter Bee

Placing a plastic tent over domiciles of the alfalfa leaf-cutter bee, *Megachile rotundata* (F.), provided a more favorable environment for hatching, mating, and foraging. However, low temperatures prevailing outside of the tent reduced the foraging range to a maximum of 40 yards and most of the activity to a 20-yard range.

Moisture Content of Birdsfoot Trefoil at Harvest

Leo birdsfoot trefoil seed, harvested at a moisture content of 50% or less and allowed to dry in the pod, had over 80% germination and less than 10% shrunken seeds. Correlations between pod color and moisture content of the seed indicated that medium to dark green pods had a moisture content of over 60%, light green 50 to 60%, pale green to medium brown 30 to 50%, and medium to dark brown less than 30% moisture.

Phyllody Virus in Alsike Clover

Fourteen-month-old plants grown from seed of phyllody-infected plants and 12-month-old plants from seed of healthy plants fertilized by pollen from infected plants showed no symptoms of the disease. This indicated that the disease is not transmitted by seed, pollen, or pollinating insects.

HORTICULTURAL CROPS

It has long been known that a wide range of horticultural crops can be grown throughout northwestern Canada and that with many of them excellent production can be obtained in the river valleys, where water is readily available for irrigation and soil and temperature are generally more favorable than on the uplands. Most of the adapted crops are grown by home gardeners throughout the north with varying degrees of success, but only in the Peace River region and central British Columbia is there a nucleus of commercial production. Even here production is limited, but with growing markets there is increasing interest in the commercial production of many crops. Horticultural research for the north is directed towards determining the relative potential of the several regions for commercial production and developing new varieties and production methods.

Adaptation

Vegetables on Permafrost

At Inuvik on permafrost, Comet and Cherrybell radishes, Paris Island Cos lettuce, and Purple Top Milan turnips produced well from direct field seedings. Copenhagen Market Early and Viking cabbages, Italian Sprouting and Waltham 29 broccoli, Super Snowball cauliflower, Green Curled Scotch kale, and Lucullus swiss chard produced well if started inside and transplanted to the field. Little Marvel peas, Ruby Queen beets, and Jade Cross and Warba potatoes produced well only if planted on ridges covered with clear polyethylene.

Vegetables for Central British Columbia

Butter King lettuce, which is slow bolting and has firm compact heads, has proved to be the preferred variety for the Prince George area. Garden Treat (CH-9) corn ripens in late August and has produced a satisfactory yield of good-quality cobs in the Quesnel area of British Columbia.

Small Fruits for the North

9, 17

Red raspberry varieties that terminate growth early in the fall have been found to be hardier than the late-growing varieties at Prince George. Honeyking has been the hardiest, but the quality has not been as good as the slightly

less hardy varieties Chief, Trent, Boyne, and Muskoka. At Fort Vermilion, Honeyking, Rideau, Boyne, and Killarney have been the most reliable varieties, whereas at Mile 1019, in the Yukon Territory, only the native wild selections have matured early enough to avoid severe winter injury. The mildew-resistant Willoughby variety has been the most reliable black currant at all northern locations. A mildew-resistant selection of *Ribes floridum* L'Her. from the Northwest Territories ripens its fruit uniformly about 2 weeks earlier than cultivated varieties and should make a good parent for breeding.

The Protem strawberry was released for home garden production in 1964 and is now replacing Senator Dunlap in pick-yourself commercial fields. It is hardy enough not to require covering, and the fruit is large and attractive enough to overcome the long picking season and small yield at each picking. It is susceptible to Botrytis rot at Prince George where Redcoat and Guardsman are performing satisfactorily.

Tree Fruits for Central British Columbia

33

In the Bulkley Valley and McBride areas of central British Columbia, Battleford, Manitoba, Dolgo, Renown, Rescue, and Robin apples and crabapples are now recommended. On the light-textured soils in the Prince George area, Rescue, Osman, and Kerr have been the most reliable varieties.

Ornamentals for the North

18, 19, 20

Twenty-eight trees, shrubs, and perennials native to central British Columbia have been found satisfactory for ornamental purposes in the Prince George area. *Populus argenti*, *P. tristis*, and the varieties Brooke and Wheeler are the most attractive poplars for ornamental purposes on Pineview heavy clay soils near Prince George. For the far northern conditions at Inuvik, *Matthiola bicornis*, *Eschscholtzia*, *Dianthus* var. Gaity, *Dimorphotheca*, *Lobularia*, *Gypsophila*, *Tagetes* var. Petite, and single petunias are the most reliable annuals.

Breeding and Selection

Strawberries

9

At Beaverlodge, Protem and three seedlings have shown good combining ability among themselves and with Ottawa varieties and seedlings. At Mile 1019, 10% of the second backcross seedlings between Senator Dunlap × Wild and Pixie × Wild survived the winters and have been replanted for further evaluation.

Saskatoons

Selecting from hybrids between a wide range of species and from colchicine-treated material has not produced general improvement over Smoky or Pembina. However, seedlings have been obtained that have larger fruit and smaller seeds than these varieties and that vary in acidity, sugar content, flavor, and other components of quality. The advantage of having a range in these characteristics is that blending the juice from highly acid and mild-flavored fruit resulted in better flavor retention in processed fruit.

Potatoes

Two years of testing has indicated that the breeding of potatoes for the north does not have to be conducted in the north. The different environments at Beaverlodge, Alta.; Scott, Sask.; and Fredericton, N.B., have had little effect on the relative expression of such characteristics as tuber type, maturity, stolon length, general evaluation, or number of tubers. Less than 0.5% of the seedlings that might be adapted to the north were discarded at Fredericton in the first 2 years of selection from seed. In another test there was good association for yield among seven northern locations but poor association for tuber type and general evaluation.

On the basis of results at Prince George, the Fredericton seedling F5561 was advanced to the British Columbia replicated trials. This is the only one of over 300 seedlings grown in adaptation trials at Fort Vermilion, Prince George, and Mile 1019 that was recommended for advancement. Norgold Russet performed well in regional trials at Beaverlodge, Prince George, and Quesnel. It is about 10 days earlier, produces a higher marketable yield, and has better average quality than Netted Gem.

Apples and Crabapples

8

All but 36 of the 9,000 seedlings planted at the University of Alberta and 256 of the 6,000 seedlings at Beaverlodge have fruited. At the University of Alberta 88 selections have been made and at Beaverlodge 16. Only one selection has been chosen for the second test program.

Tomatoes

Three cool, wet summers have provided excellent environment to permit selection for fruit setting under cool conditions. Forty-six selections with fruit weighing 25 to 125 g and ripening in 45 to 75 days have been retained. All have Fireball as the large-fruited parent and 27 also have Beaverlodge selection 56-1 as the early parent. The remaining 19 have Swift, Red Cloud, or one of three Beaverlodge selections as the other parent.

Diallel correlations have shown that the relative yield of varieties has been similar at Beaverlodge, Fort Simpson, Anzac, and Fort Vermilion with the weakest association being between Fort Vermilion and Fort Simpson. However, there were generally poor locational associations for weight and number of days to first three ripe fruit, weight, and number of ripe fruit and number of green fruit.

Management

Use of Soil Mulches in the North

10

Clear polyethylene mulches increased soil temperature by up to 15 F and resulted in early maturity at Inuvik, Fort Simpson, Fort Vermilion, Beaverlodge, and Mile 1019. The liquid spray mulches O.E.D.[7] and Aqua-gro[8] increased soil temperatures and earliness at Inuvik and Fort Simpson, but were inferior to polyethylene. Ridging the soil into 8-inch-high ridges increased soil temperature at 4 inches below the surface by as much as 4 F and advanced maturity

[7]oxyethylene higher fatty acid; Nikken Chemicals Co. Ltd., Tokyo, Japan, distr. by Sumitomo Shoji Canada Ltd., Vancouver, B.C.

[8]non-ionic wetting agent; Aquatrols Corp of America, Campden, N.J.

at Inuvik and Fort Simpson. Ridges covered with clear polyethylene gave the highest soil temperature and earliest maturity.

Use of Portable Shelters in the North

At the Experimental Farm at Mile 1019 Quebec No. 5, Gardener, Early Chatham, and Stokes Early Hybrid tomatoes; and Mandarin and Marketer cucumbers produced good crops in unheated plastic-covered field shelters. Sugar hybrid watermelon and Samson hybrid cantaloupe matured and yielded well under similar shelters at Fort Simpson.

Trifluralin for Weed Control in Central British Columbia

At Prince George trifluralin did not show any phytotoxicity to rutabaga or cabbage and was an effective alternative to EPTC[9] for the control of annual weeds in these crops.

SOILS

Soils throughout the north vary widely in both nutrient status and structure. Proper management from the time that they are cleared of trees and brought into cultivation is essential for economical production. Much of the soil now farmed and most of the soil that will be brought into production in the future is Gray Wooded. Because of this, research is devoted primarily to assessing the potential of these soils and to devising management practices that will give maximum production.

The Agricultural Potential of the Fort Nelson Area of British Columbia

In 1943 Dr. A. Leahey estimated that there were 500,000 acres of potentially arable land in the Fort Nelson area. Most of this was in the river flats and flood plains bordering the Profit, Muskwa, and Fort Nelson rivers. As the upland areas became more readily accessible it was realized that to the east and southeast of Fort Nelson there are extensive meadow areas and numerous bogs that could increase the potential to 1.5 million acres. Several cereal, oilseed, grass, and legume crops were tested for their adaptability and response to fertilizers on a fine-textured Gray Wooded till upland soil at Mile 319 on the Alaska Highway during 1964-66. The following estimate of the potential of the area is based on these tests, weather records, and general observations in the area.

Records during 1964-66 at the airport at Fort Nelson indicated that the climate compares favorably with that at Beaverlodge and is suitable for the production of a wide variety of field and garden crops. A high mean summer temperature (60.3 F for June, July, and August), a 128-day frost-free period, 10.5 inches of precipitation during the growing season, and long hours of sunshine resulted in excellent crop growth. The cereal crops matured 7 to 15 days earlier than in the southern portion of the Peace River region, presumably because of longer hours of daylight and higher summer temperatures. Yield and quality compared well with that in the Peace River region.

The nutrients in short supply are mainly N and P and the general recommendations for the Peace River region should apply in the Fort Nelson area. Cereal and oilseed crops responded to both N and P, grasses responded to N only, and legumes responded mainly to P.

[9]ethyl di-*n*-propylthiolcarbamate; Stauffer Chemical Co. of Canada Ltd., Vancouver, B.C.

Despite this potential, there is no commercial production in the area. Because of distance from market and limited local market it is doubtful if development is imminent. High clearing costs that are generally associated with heavy tree cover, particularly on the rich river-flat soils, will further restrict development.

Nutrient Availability

Acid Soils in the Peace River Region

Large areas of soil in the Peace River region are sufficiently acid to seriously reduce the growth of some crops. In a greenhouse experiment on 40 acid soils, liming increased the yields of barley, rapeseed, and alfalfa on most of the soils, but it did not increase the yield of oats. These crops and soils are now being analyzed for Fe, Al, and Mn in an attempt to relate crop damage by soil acidity to the content of these heavy metals in the soil.

On four acid soils liming in the field gave large yield increases of barley and small increases of oats. Apparently liming greatly hastened mineralization of soil N in the first season for when N fertilizers were not used liming produced very large increases in the yields of both crops. The yield of oats was also increased by the application of N and P fertilizers. For example, on a soil with a pH of 4.4 the application of N and P increased the yield of oats from 38 to 107 bu/acre.

The Sulfur Status of Some Gray Wooded Soils in the Peace River Region

The 0-6 inch layer of 34 cultivated Gray Wooded soils, representing some 15 soil series, was potted in the greenhouse and seeded to oats after being fertilized with N, P, and K, and these three elements together with S. On 27 samples the average yield without S was only 58% of the yield when S was applied. Seven samples did not respond. Although S deficiencies may be exaggerated in the greenhouse as compared with the field, these results showed that many Gray Wooded soils in the Peace River region are apparently deficient in S.

Management

Comparison of Crop Sequences following Breaking in the Peace River Region

Shallow breaking in June by moldboard plowing resulted in a total yield of 135 bu/acre for seven consecutive Saunders wheat crops, compared with 122 bu from breaking in September. Breaking in June with a disc gave a total yield of 128 bu/acre, whereas breaking in September gave only 111 bu. The differences between early and late breaking were greatest for the first crop after breaking and usually disappeared by the third crop. Although all crop residues were returned to the soil and the plots were fall tilled after harvest, the mean yields after breaking decreased from 21 to 12 bu/acre from the first to the sixth crop, and the seventh crop, which was on backset breaking, yielded 16 bu/acre.

Summerfallowing after breaking reduced the yield differences between early and late breaking and between moldboard and disc breaking. The mean yield on the September breaking was increased by 17 bu/acre by summerfallowing, making the yield for this crop nearly equal to the combined yields of the two crops obtained when the breaking was not summerfallowed. The yield of the

second crop after summerfallow, however, was low and subsequent summerfallowing did not greatly increase the yield of even the first crop after summerfallow. Thus the total production after 7 years was in all cases higher in the continuous wheat sequence than in the summerfallow–wheat–wheat rotation.

Effect of Preceding Forage on the Yield of a Fifth Successive Wheat Crop in the Peace River Region

Different forage crops were each grown for 2 to 6 years on a Gray Wooded Nampa clay loam and then followed by five consecutive crops of wheat. The fifth consecutive wheat crop was grown both with and without N fertilizer and with a basal application of P. Without N fertilizer yields were higher after alfalfa (26 bu/acre) and bromegrass–alfalfa (23) than after bromegrass (19), fescue (18), or the summerfallow–wheat rotation used as the check (16). However, when 50 lb/acre of N were applied, yields were similar after all forage crops (38 to 41 bu/acre) and higher than after the summerfallow–wheat rotation (33). These results showed that the N fixed by alfalfa benefited a wheat crop grown 5 years after the alfalfa was broken. The results also showed that, apart from the N fixed by alfalfa, all forage crops increased the yield of the wheat crop.

Comparison of Manure and Heavy Applications of Fertilizers on Gray Wooded Soils in the Peace River Region

Field tests with barnyard manure and fertilizers were conducted with barley after summerfallow or legumes on four Gray Wooded soils. With no fertilizer the average yield on the four soils was 55 bu/acre and with 60 lb/acre of $NH_4H_2PO_4$, 11-48-0, it was 63 bu. With the application of 60 tons/acre of barnyard manure the yield was 94 bu/acre and with an application of 80 lb of N, 100 lb of P, and 100 lb of K, plus S and micronutrients, the yield was 97 bu/acre. Combining the manure and fertilizer did not cause further yield increases. These results demonstrated that high yields can be obtained on Gray Wooded soils when plant nutrients are in good supply.

Response to Organic Matter Additives in Central British Columbia

Organic matter in the form of mature dry oat straw, green oat straw, spruce sawdust, sphagnum peat, green clover, and green grass was added to Pineview clay at Prince George at rates of 2, 4, and 8 tons of dry matter per acre. Yields of oats for grain were generally low for all treatments the year following application. However, for six successive crops green clover provided an average yield increase of 32%, green grass 23%, and green oat straw 10% when compared with the yields from untreated plots. Usually, the yield of oats increased with increasing levels of applied clover and green grass. The addition of sphagnum peat suppressed the yield by 3%, ripe straw by 45%, and sawdust by 54%.

WEED CONTROL

Couchgrass

Eradication by Tillage

[21]

Field-scale infestations of couchgrass were eradicated in 1 year by tillage alone, but the procedure is very exacting. The satisfactory machines were found to be: (i) toolbar cultivator with a cableweeder attached behind, (ii) the rotovator, (iii) the one-way disc, and (iv) the heavy-duty tandem disc harrow. Eight or

nine workings were required, regardless of the implement used. The first working was done just before freeze-up and the others in the subsequent year. Tillage was required when 2 inches of couchgrass regrowth showed, and a 1-week delay, particularly early in the season, has caused failure. The success of the method has depended on farm management, as well as on the weather. In wet summers the shredding action given by the rotovator or a disc implement worked best, but in dry summers the toolbar cultivator – cableweeder combination was most effective. In extremely wet summers we found that any method may fail. Unfortunately, eradication of all couchgrass growth did not mean that a field was free of the weed. Dormant seed germinated and seedlings had to be disposed of by follow-up tillage worked into a standard cropping procedure.

Evaluation of a Rotary Cultivator

A rotary cultivator invented by an Alberta farmer specifically for the control of couchgrass was tested. The cultivator tears out the running rootstocks of the grass and lays them on the surface of the soil to desiccate. It accomplishes this by banks of chisel teeth rotating on oblong tracks in such a manner that at any given time about one-half of the teeth are in the ground. The teeth rotate slowly backward while in the ground and they have a forward motion slower than the ground speed of the implement. Each tooth is curved and when it is pulled from the soil it drags out the couchgrass rootstocks, which slide from the tooth and lie on the soil surface. The principle of this machine is sound, but in the Peace River region it proved no better than the toolbar cultivator – cableweeder combination, which is better than any other conventional farm implement for the control of couchgrass by the dragging-out, drying-out method.

Control with TCA

21

Control with TCA was found to depend on correct timing of the application and effective incorporation. Before application, the couchgrass had to be rejuvenated by thorough tillage to the depth of the mass of rhizomes by using a disc implement or rotovator. Complete shredding of the rhizomes was essential to activate their dormant buds. When the buds had sprouted and shoots were about an eighth of an inch long, the TCA had to be sprayed on the surface using 80 gal of water to insure uniform application, and incorporated by disc or rotovator to the depth of the initial tillage. By this procedure, 95% or more of the couchgrass was killed with as little as 20 lb/acre active ingredient of TCA. With this low rate of application of TCA, rapeseed, a tolerant crop, was grown the following year without injury from chemical residue.

Spot Eradication by Chemical

21

A mixture of paraquat and bromacil has been found suitable for spot control of couchgrass. Best results were obtained by mixing the bromacil with water at the rate of 1.5 oz of active ingredient per gal of water, then adding 3 tablespoons of active paraquat, stirring well, and spraying the foliage until wetted to the point of drip. When the mixture was allowed to stand the paraquat broke down and became ineffective.

Scentless Mayweed

Control with Picloram

29

Of over 30 herbicides tested, including bromoxynil, Chlorflurazole,[10] and Morfamquat,[11] picloram was the only one effective for the control of scentless mayweed, or false chamomile, *Matricaria maritima* L. var. *agrestis* (Knaf) Wilmott. In repeated tests with pure stands of mayweed 6 oz active ingredient per acre of picloram gave a high degree of control, and 8 oz eradicated it. When the weed was under strong competition, as by an established grass, 4 to 6 oz/acre was sufficient. These rates were too heavy to be used selectively with cereals, but they were satisfactory with bromegrass and creeping red fescue, providing their sods were not broken and sown to a sensitive cereal crop for 2 years. The grass was not suitable for grazing for several weeks after spraying. The hay or pasture yield was cut slightly, and seed yield was reduced drastically. Picloram proved to be somewhat more than twice as effective as dicamba, which in turn was about four times as lethal as mecoprop on mayweed.

Green Smartweed

At Fort Vermilion good control of green smartweed, *Polygonum scabrum* Moench., was obtained with a mixture of dicamba at 1.5 to 2 oz active ingredient per acre plus 2,4-D amine or MCPA at 4 to 6 oz/acre. These mixtures did not reduce yields of cereals when applied at the two- to four-leaf stage. Flax, on the other hand, was severly scorched by dicamba. Plants that were 2 to 3 inches tall died back to ground level. However, under droughty conditions flax recovered rapidly and the only adverse effect was a 3-day delay in maturity. In dry years dicamba appeared to increase yields of flax by increasing the number of bolls per plant.

Bromoxynil, Chlorflurazole, and Morfamquat were tested on flax in 1966 only. Morfamquat reduced yield and delayed maturity. Flax was more tolerant of the other herbicides.

APICULTURE

There were 55,000 colonies of honey bees in the Peace River region in 1966. This is an increase of 15,000 colonies since 1964 and is indicative of the increase that is expected to be associated with continued expansion of the production of legume and rapeseed crops. There is no commercial production elsewhere in northwestern Canada.

Wintering in Controlled–Temperature Rooms

Wintering at 40 F in controlled-temperature rooms gave an equivalent of 2.0 package bee colonies for each colony wintered during 1964-65 and 1.25 package bee colonies for each colony wintered during 1965-66. This increase is not economical.

Wintering in Southern British Columbia

32

Colonies were also taken from Beaverlodge to Agassiz, B.C., for wintering. In late April or early May surplus bees were shaken from these colonies into

[10] 4,5-dichloro-2-trifluoromethyl-benzimidazole; Fisons (Canada) Ltd., Toronto, Ont.
[11] 1,1'bis-(3,5-dimethylmorpholino-carbonylmethyl) 4'4'bipyridylium dichloride; Chipman Chemicals, Hamilton, Ont.

2-lb packages. In 1964-65 an equivalent of 5.9 packages per colony were obtained and in 1965-66 an equivalent of 4.4 packages. The colonies were supplied with ample stores of honey and pollen supplement. The antibiotic fumagillin was given in late September and again in early March for nosema control. Colonies infected with two million or more nosema spores per bee by early March produced fewer bees than noninfected colonies, even though they were given further treatments of fumagillin to control the disease. Brood rearing and honey production of package bee colonies from southern British Columbia were similar to those from California. Both groups were headed by queens from California.

Restriction of Daylength

Egg laying of package bee colonies hived in late April or early May was reduced by 35 and 60% when kept in darkness for 10 and 21 days, respectively. After colonies were placed outside in normal daylight, egg laying became normal within 3 weeks indicating that honey bees adapt rapidly to changes in environment.

Transmission of American and European Foulbrood Diseases by Package Bees

14, 16, 30, 31

Package bees shaken from American foulbrood infected colonies and installed 80 hr after shaking into sterile equipment showed symptoms of American foulbrood within 6 weeks indicating that this disease can be spread by package bees. These results are similar to those reported previously for transmission of European foulbrood. Package bees shaken from colonies infected with European foulbrood and installed 48 hr later into sterile equipment showed symptoms of the disease 5 weeks after hiving.

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