SOIL AND AGRICULTURAL PROBLEMS IN SUBARCTIC AND ARCTIC CANADA

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RESEARCH on soils and agriculture in the Canadian north has so far been confined almost entirely to government work in the subarctic regions of the northwest.

Soil investigations, although only preliminary, have been sufficient to provide useful information on the nature and development of soils in the Subarctic. During the past eleven years the morphology of the soils, the approximate distribution of the different types, and their possible use for agriculture have been studied on traverses along the Alaska, Haines, Whitehorse–Mayo, and Mackenzie highways and along the Yukon River as far north as Dawson, and the lower Liard, Slave, and Mackenzie rivers. The observations made on these trips and the chemical analyses of the samples collected from representative soils have been published by Leahey (1943, 1944, 1947, 1953, 1954 a,b).

Our knowledge of the soils of the arctic and eastern subarctic regions is meagre. Apart from an investigation in the Chimo district of Ungava Bay in the summer of 1954, the only direct information has come from the observations made and samples brought back by travellers whose primary interest was not in the soils. Special mention should be made of the useful paper by Feustel, Dutilly and Anderson (1939), which records the analyses of a number of samples collected by Dutilly.

At present the Department of Agriculture maintains two small experimental substations north of 60°N., one in the Yukon and one in the Mackenzie Valley. The Yukon station, which is located along the Alaska Highway at Mile 1019, about one hundred miles west of Whitehorse, was established in the fall of 1944 on a virgin site, and experimental work was started in 1946. The Mackenzie Valley station, at Fort Simpson, was established in 1946 on cultivated land, and experimental work could therefore be started the following year.

Although systematic experimental studies on agriculture in the Yukon and the Mackenzie Valley really commenced with the work of these stations, some valuable information had previously been obtained from cooperative tests with local residents. These tests, first started in 1917, were however only intermittent, and for the most part lacked direct technical supervision. Hence it was difficult to estimate the value of the results.

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The technical staff at each of the stations consists of a resident officer in charge, and two or three students from agricultural colleges during the open season. The first progress reports of these stations (Abbott, 1954; Gilbey, 1954) have now been published and show that experimental work has concentrated on field testing of the comparative adaptability of different field and horticultural crops, of winter hardiness of biennial and perennial crops, and of methods of crop production. Studies on livestock, including poultry, have been limited to observations on feeding and winter care. In addition to these investigations at the stations, some cooperative tests have been continued with local residents.

These experimental stations are reasonably well located for studying agricultural problems in areas without permafrost in the southern Subarctic. Probably some of the findings, especially those concerning kinds and varieties of crops, will also apply to the northern Subarctic. These stations, however, were not primarily established to carry out experimental work in the Subarctic, but rather to study agricultural problems in those specific parts of the Yukon and the Northwest Territories where commercial agriculture appeared most feasible.

Many other problems of northern agriculture, particularly the breeding, selection, and development of hardy varieties of cereal, forage, and horticultural crops, and studies on the control of biting flies are being investigated by scientists of the Department of Agriculture both elsewhere in the north and in the south.

Future research needed

Before our knowledge of the soils and agricultural possibilities of the north can be considered adequate, much research will have to be done on the nature of the soils, on the effect of the soil-climatic environment on agriculture, and on factors governing the success of different types of agriculture under various environmental conditions. We cannot at present appreciate all the problems which must exist, but the lines of investigation mentioned below appear to be of major importance.

Soils

Exploratory soil surveys: Information on the nature of the soils is required from most northern areas, and could be obtained by widely spaced traverses or by spot examinations in selected areas. Studies on the morphology of soils in widespread areas, coupled with chemical and physical analyses of representative soils, would provide basic information for the classification of arctic and subarctic soils, as well as on their development, and on their possible use by man. Furthermore, such examinations would serve as controls for information taken from air photographs and from geological and botanical sources. In this way general soil maps of northern Canada could be prepared.

Systematic soil surveys: The systematic mapping, description, and classification of soil types in selected areas would provide valuable type sections of the soils in the various physiographic and climatic regions. Such surveys are

Fig. 1. Buildings on the Yukon Experimental Substation at Mile 1019 on the Alaska Highway. The buildings are scattered as a fire protection measure.

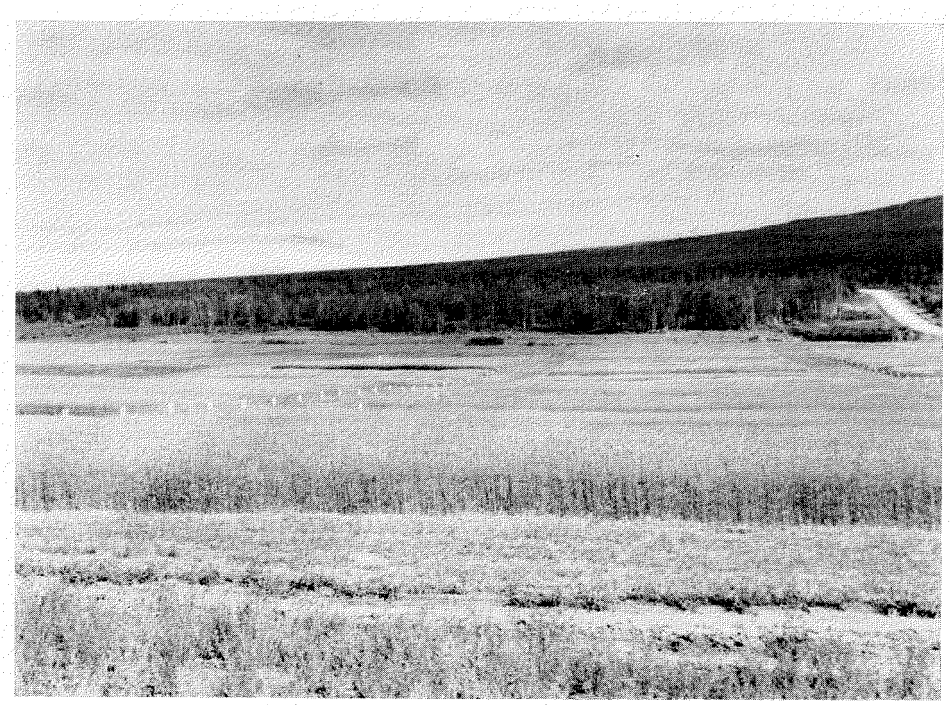

Fig. 2. Plot field for cereals at the Yukon Experimental Substation.

Fig. 3. Vegetable testing field at the Fort Simpson Experimental Substation, Northwest Territories.

particularly important for areas which are known to have agricultural possibilities, since they would show the extent and nature of the land suitable for agricultural development, and would provide basic information on proper land use.

Permafrost: The effect of permanently frozen subsoils on soil development, crop production, and soil management is not well understood. Information is needed on the effect of permafrost on soil temperatures, moisture relationships in soils, recession of permafrost under different climatic conditions when land is cultivated, and means of controlling the level of permafrost. The conditions under which ice blocks occur in soils requires investigation since pitting causes serious damage to some soils when the land is cleared and the ice melts. The effects of permafrost on the construction of roads, fences, and buildings must also be studied.

Micro-organisms: Very little information exists on the kinds, number, and activity of micro-organisms in the soils of northern Canada. In addition to such studies information is needed on the decomposition of organic matter, nitrification, the activity of nitrogen-fixing bacteria, and methods of promoting a desirable microflora in cultivated northern soils.

Soil formation: Very little is known on the processes of soil development in the arctic and subarctic regions. Among the investigations needed to provide information on this matter are studies of the nature and extent of the weathering of minerals in the mineral soils, the effect of permafrost on soil disturbance and on temperature and moisture relationships, the comparative effects of forest and tundra on soil development, and the accumulation or loss of organic matter in the mineral horizons. In connection with the organic soils, investigations are needed on their relative rate of formation under

different climatic environments, the decomposition of peat, and the nitrogen-fixing properties of the plants, the remains of which form organic soils.

Soil fertility: The chemical, physical, and biological environments which these northern soils provide for the growth of native and cultivated crops are not well understood. Some of the desirable investigations mentioned elsewhere in this paper will provide information on the factors affecting the fertility of the soils, but direct investigations, particularly where the soil environment can be changed, would be even more useful. Although the nature of such investigations would be governed by the particular problem under consideration, in general they might well include studies of effective root-feeding zones, plant nutrients, bulk density, available moisture-holding capacity and other moisture relationships, heat absorptive power, specific heat, thermal conductivity, and soil aeration.

Agro-meteorology: To predict the possibilities of crop production in any specified area, it is essential to have adequate meteorological data, as well as a knowledge of the response of crops to given climatic environments. This may appear to be a simple thesis but it involves many problems. From recent investigations it appears that five meteorological observations are essential: temperature in exposed site, wind speed in exposed site, total daily solar energy (direct and diffused), vapour pressure in exposed site, and rain and snowfall. These observations should reflect conditions existing in the air moving over a region, and should not reflect the influence of local characteristics of soil and plant cover. The modifying influence on the climate of such local characteristics is often of great practical importance, but measurement of their effect throughout a region is impracticable because of the numerous combinations of conditions which may exist.

To make full use of meteorological data, studies must be made on the heat and energy requirements of plants, their moisture requirements, and their photoperiodism. The integration of these measurements with meteorological factors in order to solve the main problem may in itself be difficult but not impossible.

Agriculture

Methods of crop production: In some parts of the Subarctic, crops are grown successfully by the intelligent use of common methods. Undoubtedly crops could be grown in some other parts if studies were made of special methods to be used where common methods fail. In the areas already being examined further work is needed on the value of summer fallow for moisture conservation, on suitable irrigation practices, on fertilizers for soils low in fertility, on the fertilizing value of local sources of organic matter, on tillage practices, and on methods of protecting vegetable crops from summer frosts.

Plant selection and breeding: The selection, breeding, and testing of crops adapted to far northern conditions require continuous research which is of utmost importance in extending agriculture northwards.

Quality of crops: The quality of crops which have been grown in the north for human and livestock consumption appears to be satisfactory although

precise information is lacking. Information on the quality of indigenous fodders for livestock is also needed.

Livestock: Horses, cattle, poultry, and swine have been raised and maintained in a number of places in the Subarctic. However, investigations on their response to different environments and their feeding and care under varying conditions are necessary.

Research on soils and agriculture in as vast a region as arctic and subarctic Canada is costly, laborious, and slow. The federal Department of Agriculture is carrying out certain investigations in these fields in the north, but there is room and need for other research organizations and for individual scientists to become actively interested in studying these important problems.

In conclusion, it should be remembered that valuable information on soils and the agricultural possibilities of a region may also be obtained from the experience of resident gardeners and farmers, and from meteorological, geological, botanical, and other scientific data on the region. In fact, our present knowledge of the Arctic and the Subarctic is based largely on such indirect sources of information. The validity of inferences which can be made from this information depends largely on the number and variety of places where direct investigations on soils and agriculture serve as control points.

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