in which are trained to pursue such studies as the one described above.

Extensive use of the radioactive by-products of a pile is also made in the field of technical physics. The subject is less interesting to the layman and hence will not be discussed here. Only preliminary investigations have been undertaken as yet and the full range of the possibilities has yet to be disclosed.

If man can be persuaded to act sensibly in his use of the atomic bomb, there is reason to believe that the discovery of the means of releasing atomic energy is merely the prelude to a host of new discoveries which will be put to creative uses. We may expect new mastery over disease, we may be able to do old tasks more easily and effectively, and we may arrive at a more profound and satisfying insight into some of nature's secrets.

Research in Agriculture

By Frank Shefrin

SCIENTIFIC agriculture is replacing rule-of-thumb farming in Canada. Not all farmers have accepted the new way. Oxen as beasts of burden are more than a tourist curio in some sections. But where new techniques and methods are used, the increase in productive capacity is most marked.

Much of this scientific research development, and extension work is undertaken in the laboratories and on experimental farms operated by the Dominion and Provincial Governments. Through this publicly supported program, the position of the family farm in the Canadian economy has been strengthened.

This article deals briefly with the activities of the Dominion Government research agencies in the physical sciences. Reference will be made to provincial activities. A short statement will also be included on economic and social research in agriculture.

Canadian agriculture, through its human and natural resources, aided by research, has shown remarkable growth during the past sixty-five years. The extent of this expansion of agriculture in space is shown by the fact that during the sixty years between 1881 and 1941 the amount of land used for farming, as reported by the Census, increased from a total of 45 million acres to 175 million acres. Farmland was improved. In 1881, 22 million acres of farmland were classified as improved. By 1941, improved land had reached a total of 92 million acres, well over four times the total of 1881. Land sown to grains, such as wheat, oats and barley occupied 15 million acres in 1881. By 1941 grains sprouted on 57 million acres.

The extension of Canadian wheat production has made us one of the biggest breadbaskets in the world. In 1881 only 2.4 million acres were planted to wheat yielding 32 million bushels. By 1940 28.7 million acres were sown to wheat, giving a yield of 540 million bushels. This yield was exceeded only in 1942. Other grains have shown similar though less steep climbs in production.

The livestock industry expanded. In 1881 there were 1.6 million milk cows on Canadian farms. By 1947 the total was 3.7 million. For other cattle, numbers increased from 1.9 million in 1881 to 6.0 million in 1947. Total milk production amounted to 6.9 billion pounds in 1901 and was around 17 billion pounds in 1947.

The average size of the Canadian farm has also expanded. In 1881, the average size was 97.7 acres and by 1941 it was 238.5 acres. The 1946 Prairie Census shows that in Saskatchewan the

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average size of the farm was 473 acres. To-day, with the use of machines and science, the average Canadian farmer can work about 85 acres of improved land; in 1911, he was able to cultivate only 52 acres.

Means of Improvement

Contributing to this advance in efficiency have been improved varieties of crops and breeds of livestock, better control over plant and animal diseases and insects, improved facilities and methods of marketing, use of better fertilizers, more effective feeding methods, adaptation of more efficient farm equipment, and better internal organization of farms. To-day, the farmer can get about 60 bushels of hybrid corn per acre, where previously he got only 50 bushels from standard varieties. Cows yielding 5,000 pounds of milk annually are average cows, as compared with less than 3,000-pound producers at the turn of the century. Proper balancing of rations, the provision of mineral foods, and the use of vitamins, give more meat per steer, more milk per cow and more eggs per hen for each pound of feed. The farmer to-day is able to use breeding methods to produce an animal that is more efficient as a meat producer or a milker. Virginia leaf-tobacco is grown in Southern Ontario where formerly sand had drifted on abandoned farmers. Farmers who have been handicapped by short growing seasons, dry weather, rust, smut and other hazards, have been given another chance by the introduction of new plants, such as hybrid corn, Saunders, Garnet, Thatcher, Renown, Rescue and Cascade wheat, crested wheat grass, rust- and smut-resistant oats, such as Ajax, Vanguard and Beaver. In the battle against insect pests, the former methods of hand picking and the sprinkling of insecticides with a wisp of hay have given way to high-powered sprayers that reach the tallest trees, and spraying by aeroplanes is used. Powerful new weapons of weed eradication, such as the "2, 4-D" killer, are being developed by chemists, the efficient application of which may be expected to reduce losses in crop yields from weeds.

Drainage and irrigation have brought much additional land under cultivation. High powered equipment has reduced the cost of land clearing. Dyke lands in the Maritimes have been reclaimed from the ocean. In every province evidence may be found of wind and water erosion and techniques have been developed to conserve land resources. In the Prairie Provinces, the Prairie Farm Rehabilitation program has given aid in the conservation of water supply and in the development of "community pastures." In those sections of Alberta and British Columbia where little rain falls, irrigation has made possible the production of intensively cultivated fruit and vegetable crops. In some areas it has enabled feed supplies to be built up. New information on fertilizers and fertility practices has contributed to increased output on available land.

But the proportion of Canadians living in agricultural Canada has decreased markedly. Eighty per cent of Canada's population lived on farms or in small communities in farm districts in 1871. By 1941, the figure was 45 per cent. The actual proportion living on farms was about 27 per cent.

The reduction in the proportion of workers engaged in primary food production, while the output of food is increasing, has been an important factor in establishing Canada as an industrial nation and has been a strong force in advancing the level of living for all of her people. Each advance in the science and technique of agricultural production and marketing, which leads either to a larger output per worker or to a lower cost per unit of product, benefits society by releasing more workers for other employment and by providing food for the consumer at a more reasonable cost. Since levels of living are determined, to a large extent, by the amount of economic goods available per person, increased efficiency in agriculture benefits all people.

Research Agencies

In the Dominion Department of Agriculture, activities are grouped on a functional basis in what are known as Services. The Experimental Farms represent a service in themselves and all research activities in the natural sciences are grouped under a Science Service. There is also a service combining all activities relating to production, and another under which activities relating to marketing, including the grading and inspection of products, are centered.

Research activities in the natural sciences, as conducted by provincial institutions, vary widely in scope and quality. Much of the work done relates to testing of the effect of fertilizers, comparing yields of different varieties of grains, and the effect on animal growth of different feed mixtures. Most of the research work in the provinces is done at the agricultural colleges but some research relating to agriculture is done in other university faculties, especially in biology and chemistry. In Ontario, a considerable amount of research on agricultural matters is conducted by the Ontario Research Foundation.

The Dominion Experimental Farms Service comprises the Central Experimental Farm, Ottawa, twenty-four Branch Farms or Stations, two Forest Nursery Stations, thirteen Substations and eight Branch Laboratories. Many of the Branch Stations are engaged in some specialized fields of agriculture such as horticulture, grain production, livestock, fox farming, range improvement, forestry, irrigation and agricultural engineering.

As a connecting link between the Dominion Experimental Farms and the farmers of Canada, there has been established a system of Illustration Stations and District Experiment Substations. There are 219 of these stations located in various agricultural regions throughout Canada. At the Central Experimental Farms in Ottawa, there are ten Divisions actively engaged in a special phase of agricultural research. These Divisions include: Animal Husbandry, Bee, Cereals, Economic Fibre Production, Field Husbandry, Forage Plants, Horticulture, Poultry, Tobacco and Illustration Stations.

The work of the Experimental Farms Service may be divided into four main categories, namely, research, development, investigation, and demonstration. Reference will be made only to the first.

Experimental Farm Research

The type of research conducted by the Experimental Farms Service ranges from continuous routine records of the various phenomena of agriculture, weather records, crop yields, records of performance of livestock, etc., to enquiries into the scientific principles underlying the technique of farming. The guiding principle in undertaking research is that it will possess practical application by, or for, farmers, and that it can be best conducted in connection with the facilities of a network of farms.

Some indication of the extent of this work is that in one year as many as 1,500 projects were in force. A single project may represent the full-time work of a large group of specialists, as with soil surveys, or be only the part-time responsibility of an individual.

Many Experimental Farm research projects result in the production of new varieties of plants or improved strains of live stock. In some such cases, it becomes desirable or even necessary to develop the supply of new product to the point where it becomes available to farmers in general. Further, where these introductions come into general use, degeneration may result in a few generations from cross-breeding, so that a continuous new supply of true-bred stock is necessary. Such activities constitute a type of development work which is a direct service to farmers.

Science and Production Service

The Science Service has forty laboratories in the provinces, and headquarters

laboratories at Ottawa and Hull. It includes research Divisions of Animal Pathology, Bacteriology and Dairy Research, Botany and Plant Pathology, Chemistry and Entomology, and the Division of Plant Protection. The work of this Service is directed toward the solution of practical problems of agriculture through scientific investigation. It deals with problems relating to ravages of insect pests and diseases affecting plants and animals, the deterioration of plant and animal products through the invasion of fungi and bacteria, the nutritional requirements of plants and animals, and the chemistry and microbiology of soils, foods and dairy products.

It is important to add that much of the work done by the Division of Applied Biology of the National Research Council is of interest to the farmer and benefits Canadian agriculture directly. Research in this Division includes projects concerned with the biological, chemical and engineering aspects of food preservation, and of industrial utilization of agricultural wastes and surpluses, with oils and fats, and with plant science.

The Production Service of the Department of Agriculture, although basically not a research agency, has the important function of giving national leadership in organizing agricultural production. Through it, the work of the Dominion and Provincial field staffs is coordinated in interpretating to farmers ways to profitable production derived from activities of the Experimental Farms and Science Services, and from the intimate association of the Marketing Service with agricultural commerce.

Economic Research

The Agricultural Economics Division of the Marketing Service serves as a fact-finding body in matters relating to production and marketing. The work undertaken includes studies of national policies relating to agriculture and research relating to farm business, land settlement land tenure, farm credit and indebtedness, assessment and taxation, land use and classification, levels of living, consumption, marketing, co-operation, and other subjects. Projects recently undertaken have been concerned with post-war irrigation possibilities, probable farm requirements for buildings and equipment, and economic considerations associated with the expansion of rural electrification.

The Economics staff works in close co-operation with the agricultural colleges, universities, Provincial Departments of Agriculture, Departments of Municipal Affairs, public utility bodies, and other agencies.

The main responsibility for agricultural statistics is centred in the Dominion Bureau of Statistics of the Department of Trade and Commerce. The Agricultural Division makes annual and monthly estimates, while the Agricultural Census Division is responsible for the compilation of the agricultural census.

Expenditures

Expenditures by the Dominion Government for research and development, excluding economic research relating to agricultural resources, rose from $2.6 million in 1939 to $4.4 million in 1946, an increase of 72 per cent.[1] This was proportionately less than the increase in expenditures for fisheries, mining and forestry; well below the 406 per cent increase for other non-military expenditures, and the 170 increase for total non-military expenditures in the same period.

Federal expenditures for research and development in agriculture were 0.24 per cent of the net value of production of agriculture in 1945. However, Provincial Governments also spend considerable sums for research and development in this field, which should be included in the above calculation.

These expenditures in research may loom large to the taxpayer and to the legislator, but the dividends from such

1. Research and Scientific Activity, Canadian Federal Expenditures, 1938-1946. Dominion Department of Reconstruction and Supply, Ottawa. April 1947.

activities repay the total cost of investment many times over. In the field of agriculture, the United States Department of Agriculture, in its 1946 Report of the Administrator of Agricultural Research, cites examples of benefits derived from scientific activity. Some of these are given below:

Hybrid corn research, covering a period of 30 years, has cost the United States Government about 5 million dollars. During this period, the States have spent about the same amount on this work. From this investment of 10 million dollars, that nation in 1946 collected a dividend of at least three-fourths of a billion dollars.

Wheat, oats and other cereal crops in the United States have also been greatly improved by research. Stem rust and other diseases took an enormous toll until improved varieties, developed through co-operation with state agricultural experiment stations, came into general use. The report estimates that research on small grain is responsible for adding half a billion dollars to the national wealth each year. We have no similar estimates for Canada but the results should be comparable.

Economic Significance of Research

Research, the search for new knowledge in an organized manner, has become a *must* or essential function of nations that want to do new things or improve the old way of doing things. It has directly contributed to the increased farm productive capacity of Canada.

New techniques and new methods have also transformed agriculture from a simple to a complex society. The introduction of technological changes has been an incentive for adjustment in the use and allocation of resources. The shift to tractors for farm work, to trucks for hauling, and to automobiles for travel, has speeded up the rate with which work is done and has increased the capacity of the farm labour force. The application of mechanical power has resulted in an increase in the size of the business unit and reduction in the use of extra labour on the family farm.

The influence of scientific research on the volume of output of the farm is made through replacing work stock with machinery, reducing insect and disease losses, increasing yields, and thus adding to the total of salable crops or livestock products. The end-products of scientific research have made agriculture a dynamic industry, and have, as a result, created or intensified many economic problems in land use, tenure, finance, and marketing.

Much still needs to be done. Agricultural progress in a developing economy is dependent upon increasing production per worker. New and more profitable uses of manpower, mechanical power, soils, water, plant and animal resources, have to be developed. New and improved market outlets have to be found for farm products. Losses through insects, diseases, and spoilage, have to be reduced. Human nutrition must be improved,and food use for farm products must be extended. And another major task is to make use of the results of scientific research, to introduce them into the economy with a minimum of disturbance, and to pass on the gains to all.