permits us to find whatever information has been accumulated about it. Once a species is classified, we have a basis for making deductions regarding its general biology or behavior.

Work in insect taxonomy has been in progress for nearly 200 years. Some 700 thousand kinds of insects have been named so far.

Yet reliable estimates of the total number of insect species in the world indicate that less than half have been named so far. Of the thousands that have been named, only a relatively small percentage has been described in a satisfactory manner.

To complete this task of describing, naming, and classifying insects, we need more workers, more facilities, new techniques of study, and more efficient methods for organizing, storing, and retrieving the enormous amounts of information we do have.

Even though many agricultural organizations and museums throughout the world maintain insect collections and employ taxonomists, the demand for identifications far exceeds what can be supplied by personnel concerned with this task. For example, each year the insect identification unit of the United States Department of Agriculture makes some 85 thousand to 100 thousand identifications as a service to scientists, farmers, and others. This work may require the analysis of 500 thousand individual insects. Many of the requests for assistance come from foreign countries.

It is to be expected that as new methods and new crops are introduced into developing countries and as agriculture expands into new regions, new or little known insects will appear as crop pests. More and more attention therefore will have to be devoted to the methods and means of identifying insects.

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Cooperation in Crops

by JOHN H. MARTIN

NO CROP is perfect. Every cultivated crop is amenable to improvement by breeding and better cultural practices. All varieties of every crop have certain weaknesses or characteristics that often limit their usefulness. All crop varieties are subject to injury by several insects, diseases, and unfavorable weather and soil conditions.

Average world yields of most crops are only one-tenth to one-half of those attainable when all conditions are favorable. Future world food shortages must be met by better crop production.

Crop yields in many underdeveloped and autocratic countries are now far below the levels that could be obtained by the application of modern crop science. The rapid rise in advanced countries since 1950 in acre yields of some of the major crops demonstrates the possibilities of improvement.

The development of corn and sorghum hybrids adapted to local conditions has increased potential crop yields in the United States and some other countries by 20 to 30 percent. Better cultural practices, such as heavy application of fertilizer and supplemental irrigation, permit thicker planting. These practices and better control of disease, insects, and weeds raise the basic yield level. Then a 25-percent increase in yield resulting from hybrids means more bushels per acre than from mediocre basic yields.

Crop yields may well be doubled by the combined improvements.

Uniform quality may be unimportant for food crops that are processed and consumed on the home farm, but is essential for industrial, market, and export commodities. Subsistence farms often grow mixed, local varieties of crops. Nearby communities may be producing different mixed varieties. These crops can be standardized by collecting, purifying, and testing the local varieties. Pure seed of the better varieties of good quality can then be increased and distributed to growers.

In many countries of Asia and Africa, the collection and evaluation of local grain varieties on a national scale was not even attempted until after the Second World War. In many instances, the general production of the better varieties is scarcely started.

THE GREATEST opportunities in crop research are in breeding, disease control, and mineral nutrition.

The development of disease- and insect-resistant varieties is most urgent. Some diseases, like the rusts and smuts of the cereals, are prevalent wherever grain is grown. Certain soil-infesting fungi that cause plant diseases are damaging most crops throughout the world. The insidious nematodes occur widely. Destructive insects are always present. Pesticides often prevent crop losses from these pests, but the cheapest control comes from the breeding of resistant varieties.

Sometimes resistance to a particular pest or disease can be found in adapted cultivated varieties. Usually, however, the best source of resistance is in exotic varieties or related wild species that are unsuitable for domestic culture.

In such instances, 10 to 20 years of intensive breeding are needed to develop a resistant variety that also is satisfactory to the grower and the consumer.

But resistance to the most important disease does not protect the variety from other losses. Thus, to insure a healthy crop, breeders must incorporate resistance to all of the damaging prevalent diseases. That requires many more years of effort during the initial stages of the project.

Later, when breeders over the world have developed lines that are resistant to several diseases, the hereditary factors may be combined to produce varieties with multiple resistance. This can best be realized by the free interchange of materials and knowledge among the research workers over the world.

Breeding crops for resistance to insects and nematodes will follow a similar pattern and must eventually be combined with disease resistance.

VARIETIES DIFFER in their content of vitamins and proteins and of certain of the amino acids that are essential in human and animal nutrition. The nutritive quality of many food crops could be improved by selection and breeding for those characteristics.

Likewise, many grain, fiber, and oil crops could be improved by breeding for better industrial or processing qualities.

Some examples: New industrial uses have been established in corn by breeding hybrids with an endosperm that is waxy or that is high in amylose content. Fibers can be lengthened, strengthened, or improved in spinning qualities by breeding. Oilseed crops can be improved in oil content, oil composition or protein content, and protein quality.

Fertilizers are used only sparingly for growing the major food crops in underdeveloped countries. Often the leading varieties grown in those places are the ones that have become adapted to soils of low productivity through a process of natural or manual selection. Often their response to heavy applications of fertilizer is limited.

When it is desired to increase crop yields by the use of ample fertilizer, it may be necessary to choose or breed other varieties so as to realize the maximum benefits.

Rice, sorghum, and pearl millet are

among the crops that will require modification to fit higher productivity levels in certain countries.

Improved farming technology, particularly in shifting to mechanized operations, also may make it necessary to breed varieties that are suited to changing methods. The grain sorghum varieties that grow 12 to 15 feet tall in tropical Africa cannot be harvested with a combine. The tall weak-stalked rice varieties grown in much of southeastern Asia often lodge so that they must be harvested by hand.

Grain sorghum, cotton, castor beans, sesame, rice, soybeans, and snap beans are among the crops in which varieties have been bred to meet the requirements for efficient mechanical harvesting and handling in the United States.

BASIC RESEARCH is essential to an understanding of the behavior, adaptation, and hereditary characteristics of each crop.

Extensive scientific facts, accumulated by research workers over the world, have been helpful to workers who are attempting to solve practical problems. Much of the crop improvement in past centuries was accomplished with little scientific knowledge to serve as a guide.

But progress is greatly accelerated if the research worker has sufficient basic information to enable him to formulate practical plans and to predict the probable outcome. The plant breeder may develop quickly a new variety with a desired characteristic when he knows the hereditary behavior of those characters in crosses.

Basic research often points the way to practical improvements. The concept of hybrid corn is an example. G. H. Shull, of the Carnegie Institution of Washington, was studying the genetics of corn characters at Cold Spring Harbor in New York. He was not engaged in the breeding of better corn varieties. It was necessary to inbreed the corn in order to obtain uniform lines for investigation. Inbreeding resulted in small plants with little vigor. When he intercrossed certain of the runty inbred lines, he obtained vigorous and productive hybrid plants.

From this observation, in 1909, he proposed the breeding of corn hybrids to obtain higher yields.

The success of hybrid corn engendered an interest in developing other hybrids. Hybrids of most other crops, however, cannot be produced by a simple operation, such as the detasseling of corn plants to eliminate pollen shedding in the seed-parent rows of the hybrid seed field.

Another corn geneticist, Dr. M. M. Rhoades, reported a cytoplasmic male-sterile character in some of his progenies. This led to a search by others for this character. It since was found in a number of crops. The removal of anthers—the pollen-bearing flower organs—is avoided in producing hybrid seed on cytoplasmic male-sterile plants, because the anthers bear no pollen. Hybrid seed is produced merely by interplanting a pollinator line with a male-sterile seed parent line.

Hybrid onions, hybrid sorghum, hybrid sugarbeets, and hybrid castor beans now are grown on a big scale. Hybrids of wheat and several other crops merely await further developments. Many countries are reaping the benefits from hybrid seed by applying the knowledge obtained by research workers in the United States.

MANY COUNTRIES have established experiment stations to test crops, varieties, and cultural methods. Most have several such stations, and the larger countries have field stations, where the answers to local or national crop problems are sought. The better equipped stations provide laboratory facilities for plant pathologists, chemists, engineers, and entomologists to supplement the research of the crop scientists.

In the United States, research on crops, crop protection, and crop utilization is being conducted by the 50 State agricultural experiment stations at nearly 300 branch stations and laboratories and at perhaps 100 additional experiment fields. The United States Department of Agriculture maintains cooperation at many of these locations and also conducts research with crops at a number of independent locations.

THE INTERNATIONAL CEREAL RUST NURSERIES exemplify the cooperation among research scientists of different nations. This project involves about 150 scientists, who test more than a thousand varieties of wheat, oats, and barley for resistance to rust and other diseases in 176 nurseries at 85 experiment stations in 40 countries.

International research on rust began in 1919, when uniform wheat nurseries were planted at several experiment stations in the United States and Canada. Cooperative research was started with Mexico after 1940 and with several countries in South America in 1950.

The planting of rust nurseries in foreign countries is voluntary, and the cooperation is informal. Correspondence, reports, instructions, and seed shipments are routed directly between the scientific leader in the United States and the scientists overseas.

Each participating country provides seed of any of their lines that appear to be resistant to rust. These then are tested in all cooperating countries.

Copies of the data from all countries are sent to all cooperators. The information from other countries enables a scientist to evaluate his material quickly. Several more years of testing might be required if the tests were limited to his own country. Because natural rust epidemics are erratic, no useful data are obtained in years in which abundant rust is lacking at a particular station.

The international rust nurseries are particularly valuable because varieties of grain can be tested for reaction to the prevalent world races of the fungus organism without the hazard of introducing exotic races into countries where they do not yet occur.

Good will among countries has been fostered by the international rust nursery program. Breeders formerly were reluctant to supply their selected lines to workers in other countries before their release to their own growers, because of the possibility of competitive exploitation. Now they recognize the advantages of an international exchange that permits any country to utilize varieties from any cooperating nation. Seed of several new wheat varieties from other countries has been increased and distributed in a cooperating country after tests in the rust nursery.

THE BASIC FEATURES of the uniform rust nurseries and of other uniform crop nurseries conducted in the United States have been helpful in improving agriculture in many countries.

The United States Department of Agriculture coordinates the uniform testing of many crops. Workers at any interested State experiment station may participate. Many of the State experiment stations conduct the tests on an informal basis without Federal subsidy for the project.

The national potato improvement program involves about 40 States. A free exchange of materials and information speeds up recommendations and releases of new varieties by shortening the testing period. Usually tests continue about 5 years before new materials are recommended or released when the testing is confined to a single State. When tests in surrounding States confirm the local results, sound conclusions may be drawn after 2 or 3 years of testing. Similar progress can be expected from international testing.

SCIENCE RECOGNIZES no political or racial boundaries. Communication among scientists in different countries has gone on for more than a century.

The United States Department of Agriculture has been collecting seed and plant materials from all over the world on an organized basis since about 1890. The world wheat collection maintained by the Crops Research Division numbers some 16 thousand lots. These and other crop collections are available for use in any country where they are needed.

The late Russian scientist, N. I. Vavilov, assembled large world seed collections between 1920 and 1940. Limited numbers of the crop varieties in this collection occasionally are supplied to other countries.

INTERNATIONAL scientific societies conduct meetings at intervals of about 3 years. They are concerned with a specific scientific field, such as botany, genetics, seeds, or horticulture. Plant scientists employed by the Federal or State Governments of the United States frequently travel to other countries to participate in these meetings. These contacts are mutually beneficial in promoting international relations as well as in diffusing knowledge.

It is obvious that research accomplishments often are greatly accelerated when undertaken by teams of scientists with different types of training. Free interchange of information and materials among nations is equally important.

In 1908 the first president of the American Society of Agronomy stated that wheat varieties had been tested for 100 years previously and that new varieties would be undergoing tests 100 years hence. Now, after 55 years more of productive research on wheat, many other achievements still appear to be 100 years in the future. One should not be discouraged by the long task ahead.

JOHN H. MARTIN *retired on July 1, 1963, after working nearly 49 years as research agronomist in the Agricultural Research Service. His research in crops covered many States and several countries in Europe, Asia, and Africa. He is the joint author of two textbooks dealing with crops. He contributed chapters to eight previous Yearbooks of Agriculture.*

Problems in Human Nutrition

by HAZEL K. STIEBELING and RUTH M. LEVERTON

MUCH OF OUR PRESENT insight into the functions of nutrients and our nutritional requirements has come from studies of food habits of people who differ in health and physique.

The studies reveal great differences in the amounts of food customarily eaten by persons in different parts of the world and in the proportions of the different kinds of food.

The kinds of food we can put in three broad groups: (1) Seeds of grasses and of leguminous plants; nuts; and the flesh of beast, fishes, and fowl. (2) Starchy roots, tubers, and the fruits; sugars; and the separated fats and oils. (3) Milk, eggs, and the succulent vegetables and fruits.

The groups differ widely in nutritional value, but several similarities exist within each group.

THE SEEDS and cereals, pulses (peas, beans, lentils), nuts, and meat provide much the same assortment of nutrients—proteins, B-vitamins, and minerals, especially iron and phosphorus—as well as calories.

The contribution the cereal products make to the mineral and vitamin content of diets depends largely on the extent to which these nutrients are retained or restored when food is processed. Generally, though, the cereal grains contain less protein,