WHEAT IMPROVEMENT IN MEXICO

The value of wheat as a food crop in Mexico and its importance in National economy is a matter of historical record. This cereal has gradually assumed greater importance as a food crop of the country until it ranks third. With the increasing demand for wheat without compensating available agricultural acreage it is apparent that one of the most important agricultural problems in Mexico is that of increased wheat production through improved agricultural techniques; increased soil fertility; improved, higher yielding varieties; and disease and pest control.

During 1938-1944 wheat production in Mexico averaged approximately 400,000 tons on about 550,000 hectares of land with an average production of 720 kilos per hectare. To supply the total demand an average of 115,300 tons of wheat were imported from the United States and elsewhere during this period.

The foregoing figures may be interpreted in either of two ways: (1) that Mexico is not a wheat country and should not attempt to become self sufficient in wheat production but rather should import wheat and utilize the acreage now sown to wheat for other crops; (2) that Mexico should utilize its wheat lands to better advantage and should increase production through modern techniques;

soil improvement; better seed; and disease and pest control, tending to reach self sufficiency in wheat production.

Because of numerous factors in Mexico the first hypothesis appears unsound at the present time and for many years to come. In many areas of the country only wheat or other small grains can be grown successfully under existing conditions. Wheat is cold resistant, drought resistant, a good competitor, and well adapted to established rotation systems. It is granted that both wheat-corn rotation and mono-culture are undesirable and agriculturally unsound unless a high fertility level can be maintained through the application of chemical fertilizers and/or green manures. It is further admitted that much wheat in Mexico is sown on sub-marginal land and that irrigation water is often inadequate and seeding rates variable. However, from a practical aspect it is evident that certain agricultural systems exist which can not be easily nor immediately changed; that wheat-corn rotations will continue in many parts of Mexico for a long time to come; that wheat can not be readily replaced by another crop of similar value with similar resistance to unfavorable conditions and that greater yields of wheat can be produced in this country on the same or less land now under culture.

On the promise that one great agricultural need in Mexico is that of wheat improvement the following data are given to present the problem of

wheat production and suggestions for their solutions. Also included is a plan for future work for wheat improvement in Mexico.

DISEASE FACTORS LIMITING WHEAT PRODUCTION IN MEXICO

Rust. - It has long been recognized that black stem rust, caused by Puccinia graminis tritici, is the most important cause of wheat losses in this country. This disease is probably responsible for more loss than all other wheat troubles combined. Many varieties which are well adapted and high yielding under optimum conditions are of little value because of their susceptibility to stem rust and the frequent crop losses encountered when such varieties are grown. The production of wheat during the spring and summer months is relatively unknown in Mexico not only because of competition with corn but also because of the danger of stem rust epidemics which occur during the rainy season. Wheat is usually sown during the fall and harvested in late spring before the rains begin. Water is supplied primarily through irrigation. If a summer crop of small grain is to be grown, barley is selected because of its relative resistance to stem rust.

The rust fungi are among the most complex parasites known. Puccinia graminis comprises a number of varieties, the most important of which is P. graminis tritici. This variety is further divided into more than 200 physiologic races which are morphologically indistinguishable but which vary

widely in factors for pathogenicity. These races are variously distributed throughout the world and their individual and collective occurrence largely determine the varieties of wheat which can be grown in a given area. Conversely, the problem of the wheat specialist is to determine the races which occur in a given area and to introduce or develop high quality, high yielding, rust resistant varieties, in that region.

In Mexico the rust problem is complicated by the 3 distinct geographical regions which are the most important wheat producing areas. These are: the southern area including the Bajío, the northern region represented by the states of Coahuila and Chihuahua, and the northwest represented by Sonora and Baja California. Rust surveys over a period of years have revealed that the most important races of Puccinia graminis tritici which occur in southern Mexico are distinct from those which occur in the north and northwest. The races found in each region listed in order of importance are as follows:

Northeast Mexico - 56, 38, 59, 17, 49.
Northwest Mexico - 56, 49, 38.
Central Mexico - 59, 38, 59A, 56, 19.

A number of other races occur in each of the three zones but are not as yet widely distributed.

Since the reaction of these races differs with the variety of wheat, it is apparent that attempt must be made to introduce or develop varieties which

would be successful in southern Mexico would not necessarily be of value in the other important wheat growing areas, therefore, the wheat rust problem of Mexico is a multiple one and work must be carried out on a regional basis. Eventually it is probable that the predominant races will be distributed throughout the country.

The origin of physiologic races of rust is either by mutation or through hybridization of two races It is generally accepted that the latter is the more important source of new physiologic races. Heteroecism is well defined among the rusts and in the case of Puccinia graminis tritici the complete life cycle requires two hosts, namelt Triticum or other closely related genera, and members of the family Berberidaceae; the asexual stages being formed on the grass host and the sexual steges on the dicot host.

The role of the common barberrys, Berberis vulgaris and B. canadensis, in disseminating wheat rust and the formation of new physiologic races has long been recognized in the United States and a federal and state campaign which at one time affected 21 states has been in progress in attempt to eradicate the common barberry from important wheat growing areas. In Mexico it has been believed that the barberry problem is of no significance and that the organism repeats itself year after year by means of urediniospres.

According to this hypothesis teliospores are of no significance and basidiospores formed by germination of teliospores must necessarily die because of the absence of a susceptible host. It is well known that there is an exchange of rust spores between the United States and Mexico by means of air currents and definite evidence exists that spores from northern Mexico may often be carried to the southern limits of the United States wheat belt. Physiologic race distribution in Mexico has been attributed to these wind blown spores. It is quite correct to state that new infections arise from overliving urediniospores. Inestimable numbers do remain viable from one spring until the following fall. These initiate infection of new plantings and since wheat planting may begin in early October and continue through January, the successive generations of urediniospores which may form at 10 to 12 day intervals soon build up an immense mass of innoculum which cause epiphytotics when climatic conditions are favorable. However, recent studies conducted in Mexico have thrown new light on the question of physiologic races. It has long been known that the family Berberidaceae is well represented in Mexico by the genus Mahonia. Species of Mahonia are widely distributed throughout the country but have been thought to have no role in wheat rust epidemiology. It is now known that a number of the species do become rusted and in at least one instance a rust of Mahonia species has been

shown to be Puccinia graminis. An intensive study is in progress in an effort to determine the relationship of the several local species of Mahonia and the physiologic races of stem rust existing in Mexico. There is always the possibility that new races will be introduced into the country by wind or other races and if local Mahonia species are susceptible to the stem rust organism there is the added possibility that new races may be produced by hybridization of two distinct races inhabiting a Mahonia host.

From the foregoing statements it is evident that any program of wheat improvement must be of long duration. Efforts to introduce or develop new varieties of value to the country must be accompanied by annual studies of race distribution and the role of Mahonias must be determined if complete information is to be available. All of these data are essential to an intelligent program of improvement through introduction and breeding.

Two other rusts attack wheat in Mexico namely, Puccinia glumarum, or stripe rust, and P. rubigovera, or orange rust. Usually these species do relatively little damage but under very favorable conditions losses may result from their attack. Stripe rust is more common under conditions of low temperature and high humidity and while common in Mexico is usually mild in effect. The orange leaf rust of wheat attacks many spring wheat varieties but in this country is most damaging to winter wheats. Recently is has been found

that certain races of this rust which exist in Mexico are extremely parasitic to many of the Durum varieties and may on occasion be responsible for considerable loss. However, stem rust, which attacks Durum, spring wheats, winter wheats, grasses and to some extent barley causes many times greater losses than all other cereal diseases in Mexico combined.

Smuts.- Next to the rusts the smuts are most important in limiting wheat production in Mexico. The three smuts which occur here, listed in order of importance are: stinking smut caused by Tilletia tritici and T. levis respectively, loose smut caused by Ustilago tritici, and flag smut caused by Urocystis tritici.

Stinking smut or bunt is an externally seed borne disease in which the spores on the seed or in the soil germinate and infect seedling wheat plants. The fungus develops with the host and eventually replaces the developing seed with a mass of fungus hyphae and eventually chlamydospores. These spores escape when the grain is threshed and are carried by seed or fall to the ground and repeat the cycle with the next crop.

Fortunately stinking smut can be controlled with a minimum of effort and expense. Three effective seed protectant dusts have been developed, namely, ethyl mercury phosphate, copper carbonate, and basic copper sulphate. These

dusts are applied to dry seed and mixed and the seed may then be stored until planted. Any one of the three will give excellent results but the organic mercury dusts have proven most effective and economical. Annual treatment of seed wheat as described above should eventually reduce the incidence of bunt to a minimum, whereas, there are now in Mexico each year fields in which losses up to 40% from bunt are recorded. The disease is nation wide and is on the increase. While the cooperative wheat improvement program now in effect has the development of bunt resistant varieties as one of its objectives, the most important and immediate need is for a campaign of seed treatment for the control of this disease.

Loose smut of wheat is distributed throughout Mexico and causes some losses each year. However, it rarely reaches the severity attained by bunt. Many improved varieties are highly resistant while others are quite susceptible. Loose smut is always a problem unless precautions are taken to prevent its increase. The use of resistant varieties, sanitary control measures and seed treatment are indicated in the control of this disease. The most important control measure for loose smut is the sowing of disease free seed. This can readily be accomplished by producing and distributing certified seed. Since loose smut is an internally seed borne disease control through seed treatment

is difficult. The only successful method thus far developed is that of treatment with hot water by which differential protoplasmic resistance of the fungus and host is utilized to control the former. The host cells, with a higher heat resistance than the fungus are unaffected and the fungus hyphae are killed when the proper procedures are followed. Hot water treatments are clumsy and require considerable equipment as well as very careful temperature control. Excessively high temperatures will destroy seed viability while if they are too low the parasite is unaffected. After treatment the seed must be dried before it can be drilled or broadcast.

Flag smut may well become one of the most important troubles of wheat in Mexico if it escapes from the small area where it is known to exist and if it does not already exist in other parts of the country. Flag smut did not occur in Mexico prior to 1945. If it is not eliminated from the country it will be necessary to expand the wheat improvement project to include breeding for resistance and seed treatment for its control. Fortunately the same treatment which is effective for bunt is effective for flag smut.

Other Diseases.- A number of other wheat diseases have been reported from Mexico but none of these has ever reached sifnificant proportions. Among these noted have been powdery mildew, glume blotch, root rot, and scab. It

is conceivable that root rot is of greater importance than is now recognized and isolated fields have been found in which root rot damage reach 20%.

Agronomic Factors

In Mexico, spring wheats are by far the most important varieties grown. These are in order of importance, soft spring wheats, hard spring wheats, and the durums. Winter wheats are grown to some extent in the northern part of the Republic and some of the spring types have an admixture of winter wheat genes. In general, the spring types are better adapted to Mexico, more drought resistant, and mature earlier. In Mexico they are usually planted in October, November and December and are harvested in April and May.

This system of handling spring wheats results in phenological responses which are distinct from those in the United States and thus it is impossible to predict the behavior of United States or other new varieties introduced into Mexico. Frequently varieties which are early elsewhere are late maturing when grown in the Bajio and some which are late when grown in the United States wheat belt are early when grown in Mexico. Therefore, each introduced variety must be tested on a regional basis before its behavior can be known. The most essential characters which must be studied (aside from disease resistance) are:

Yield.- High yielding potentialities are of obvious importance and for that reason the yield factor must always be taken into consideration when making introductions or when breeding for the production of improved varieties. As stated above, performance elsewhere is not necessarily a criterion for success in Mexico and regional tests are essential to demonstrate yield potentialities locally.

Earliness.- Unfortunately there is no definite planting season for wheat in much of Mexico. Planting dates vary with weather, available water for irrigation, and other factors. Thus while some fields may be sown as early as late September others are being planted in mid-January. Where sowing can be accomplished in late October or November it is usually possible to recommend varieties which will be mature in April. Later planting means late harvest. It is therefore necessary to use varieties with factors for earliness in order to insure a wheat crop between corn harvest and the proximate corn planting.

Drought resistance.- Resistance to drought is often a determining factor in wheat production in Mexico since wheat is sown, grown, and harvested during the dry season and since adequate irrigation water is often lacking. Improved varieties should necessarily contain factors for drought resistance.

Resistance to lodging.- It is quite obvious that weak strawed wheat

results in management difficulties and low yields. Only stiff strawed varieties are acceptable for Mexico.

Resistance to shattering.- A number of improved selections which have been tested in Mexico have shown a tendency to shatter at maturity. This is a serious defect and often results in heavy losses, particularly when mechanical reapers are used. Recommended varieties must necessarily contain factors for non-shattering characteristics.

The aforementioned requirements for improved wheat varieties may satisfactorily be met through introduction, selection and breeding.

Cultural Techniques

It has been demosntrated that improved cultural techniques for wheat production may materially increase yields. Obviously in many instances there is a certain amount of dictation as to the techniques of wheat culture by existing local conditions. In some areas sub-soil irrigation is feasible and practical, in others, flooding is indicated, while in still others irrigation must be accomplished by ditching. Frequently wheat must be planted in dry soil and irrigated up while in others the common practice is to plant as soon after the first irrigation as possible. These several practices are dependent upon local conditions and must be studied individually

in attempt to develop efficient systems in keeping with the best principles of soil and water conservation. Culutural practices of general application are:

1.- Seed bed preparation.- While wheat is a good competitor and in general is able to establish itself under adverse conditions, best stands and consequently best yields are obtained when seed beds are well prepared. Additional advantages are: more efficient use of irrigation water and reduced rates of seeding.

A well prepared seed bed is one which is well cultivated to permit free movement of air and water; the surface should be free of clods stones and debries to permit efficient sowing and maximum germination and level to allow adequate and even distribution of water.

A satisfactory seed bed may be prepared with various combinations of farm tools. Among the most useful are the disk plow, disk harrow, cultipacker and spike toothed harrow.

2.- Method of sowing.- Whenever possible, wheat should be drilled instead of broadcast. Drilling insures better stands with less loss. Drilling is most successful when the land has been irrigated before sowing and the drill is most effective in well prepared seed beds. When the land is badly

prepared or when many stones or clods are present it is usually necessary to broadcast and cover.

3.- Rate of sowing.- The rate at which wheat should be sown is dependent upon viability of seed, preparation of seed bed, and system of sowing. When proper seed control is available and seed beds well prepared and planted with a drill, excellent stands may be obtained at the rate of 60 kilos per hectare. It is a serious error to sow lightly in order to secure thin stands as an aid in reducing rust damage. It is true that there is less rust when stands are thin but the resultant reduction in crop is usually greater than when stands are normal and rust present.

4.- Irrigation Practice.- The purpose of irrigation is to supply most effectively a supplementary quantity of water to soils not fully supplied by rainfall. Methods used depend upon soil type and texture, the quantity of water available, and the time at which it is available. In Mexico run-off and evaporation cause a considerable loss in the irrigation waters available. It is therefore impossible to make general recommendations. It can be said, however, that few thorough irrigations are most satisfactory and are to be recommended over numerous light applications. The practice of "castigating" wheat for rust control by withholding water while the

plants are young, is not to be recommended. This practice may effectively reduce yields as much or more than the degree of rust damage usually encountered.

Fertilizers

Much of the wheat land in Mexico is lacking in humus and is deficient in both Nitrogen and phosphorus. When possible it is highly desirable to add natural or green manures to the soil and to supply supplementary Nitrogen and Phosphorus as needed in the form of commercial fertilizers.

The use of natural manures is always dependent upon supply and price and frequently this form of soil enrichment cannot be applied economically. Green manure crops may be handled in one of several ways; (1) each year part (1/3) of the land usually sown to wheat could be planted to a green manure crop. Thus during each three year period all of the land will receive one application of green manure, (2) every third year a green manure crop might be substituted for wheat, (3) experiments are in progress to locate green manure crops which may be sown in corn fields immediately after the last cultivation. A successful crop of this sort could be burned under by fall plowing and thus furnish considerable organic matter to the soil each year.

Recent experiments in the Bajio have led to the following general conclusion. (1) Eighty percent of the wheat land in the Bajio will show a

response to the application of nitrogen, (2) 60% will respond to the application of phosphorus, (3) about 50% of the land requires both elements, (4) potassium is not deficient in soils of this area.

Results indicate that the best plan is to apply both nitrogen and phosphorus at the rates of 40 kilos of nitrogen (200 kilos of ammonium sulfate) and 80 kilos of phosphoric acid (500 kilos of 16% superphosphate) per hectare. The phosphorus and one half of the nitrogen can be applied at the time of planting and the remainder of the nitrogen about 6 weeks later. In soils deficient in these elements valuable yield increases should be secured provided that the wheat sown is well adapted to the region and that the land is suitable and adequately prepared and irrigated.

Varieties and Varietal Improvement

Wheat is an introduced crop in Mexico and innumerable introductions have occurred over a period of many years. Varieties from the United States, the Mediterranean region, Europe and South America have all been tried and certain of these varieties or selections from them comprised the bulk of the wheat currently produced in the Republic. Over a period of many years there has gradually been a selection on a more or less regional basis for varieties well adapted to a given area. The principle criteria used for

this selection have been yielding ability, earliness and drouth resistance. There has also been some selection for types which has resulted generally in the production of spring bread wheats and durums in Central Mexico and spring, semi-winter and winter types in the North.

It is difficult to analyse the origen of Mexican varieties as most of them have lost their original identity and are known by one or more local names. Numerous of these are recognizable as United States varieties. Others are fairly well established under the names Mentana, Marroqui, Pelón Colorado, etc.

Collections have been made of native wheats from many parts of the country and these have been grown in pure stands and their important characteristics noted. Selections have been made with promising results from varieties known as Candeal, Lagunero, Pelón Colorado, Colorado Obregón, Rojo, Mentana, Querétaro, Colorado, Marroqui, etc. (It is recognized that these names are of local value only and that the same name may be applied to distinctly different wheats). Selections from many other varieties have also been made and are beingstudied with a view to improvement.

A large number of U.S. and other varieties have been introduced into Mexico during the past several years. Some have proven to be unadapted

for one or more reasons and others have been put into production in some areas. The advantage of United States varieties is that their history and qualities are well known and they can be chosen for the purpose required. While the behavior of these varieties in Mexico is not always predictable their characters for disease resistance are well established and their quality is uniformly high. Some fairly recent introductions of future promise in an improvement program have been Regent, Newthatch, Hida, Pilot, Thatcher, Renown, Kenya, the trigo Supreme group, the Renacimiento group and a number of durum's notably Carleton and Stewart.

From the material available it is possible to increase the better varieties for immediate distribution. In addition, selections from varieties can be made and tested and increased. Meanwhile genetic recombinations can be made which will ultimately result in the production of improved varieties for Mexico.

Commercial Characteristics

While milling and baking requirements are not extremely rigid in Mexico there is definite need and desire for higher quality wheats in quantity. At present, blending is a common practice and commercial flours are derived from combinations of all types locally grown. Thus standards are poorly defined and highest quality flours are not available from local wheats.

In order to improve gluten content it might be possible to import gluten extract and incorporate it into bread flour. A better plan would be to gradually increase production of well adapted, high quality, high yielding, rust resistant varieties and to establish standards of quality which will force continual improvement. It would also be highly desirable to establish a pilot milling and baking laboratory to test and control wheat flour quality.