Lahore
November 11, 1966.

Report No. 7.

Accelerated Crop Improvement Series
West Pakistan

Maize:

Recommendations for Accelerated Maize Improvement in West Pakistan

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Introduction to the

Accelerated Crop Improvement Reports

West Pakistan

In 1965, after the first successful testing of Mexican dwarf wheat in West Pakistan, it was already evident that accelerated crop improvement would be possible during Pakistan's Third Five Year Plan, 1965-70, and that much higher yields of crops would require some shifts in land use.

The Government therefore inquired whether the necessary technology for accelerated crop improvement was being assembled in West Pakistan, and whether additional applied research would be needed in West Pakistan to prepare for the most rapid testing of new technology, and introduction of new crops, varieties, and cultural practices to farmers.

The present Accelerated Crop Improvement Reports grew out of this inquiry, and the series now covers:

No. 1: Dr. Norman Borlaug:
Accelerated Wheat Improvement in West Pakistan, and the Revolution in Agriculture.
April 1, 1965.

No. 2: Kenneth Brown
Private Tubewells in West Pakistan
July 1966.

No. 3: Reggie Laird, Ph.D.
Soil and Water Management Research in West Pakistan
October 1966.

No. 4: William M. Waddle, Ph.D.
Accelerated Cotton Improvement in West Pakistan
October 1966.

No. 5: Francisco Pacheco Mendivil, Ph.D.
Plant Protection Improvement in West Pakistan
October 1966.

No. 6: W.H. Odom
Accelerated Jowar (Sorghum) Improvement in West Pakistan.
October 1966.

No. 7: E.W. Sprague, Ph.D. and R.D. Osler, Ph.D.
Accelerated Maize, Jowar, and Bajra Improvement in West Pakistan.
November 1966.

No. 8: Robert F. Chandler, Jr., Ph.D.
Accelerated Rice Improvement in West Pakistan
November 1966.

Additional reports in this series are planned, and will cover when suitable consultants can visit Pakistan:

Accelerated Oil Seed and Pulse Improvement.

Accelerated Forage Crop Improvement.

Improvement of Farm Machinery and Equipment for Irrigated Agriculture in West Pakistan.

International Marketing of Potential Grain Surpluses.

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About the authors:

Ernest W. Sprague holds a Ph.D. degree in genetics from the University of Minnesota (1956). He served as geneticist for the U.S. Department of Agriculture 1956-58, and as a geneticist for the Rockefeller Foundation in India 1958-66, assisting with maize, jowar, and bajra improvement. Since September 1966 he has been Representative of the Rockefeller Foundation in Thailand, and is directing a regional maize improvement program for South Asia.

Robert D. Osler holds a Ph.D. degree in genetics from the University of Minnesota (1951). He served as a soyabean breeder for the U.S. Regional Soyabean Laboratory, Urban, Illinois, 1951-54; as head of the Rockefeller Foundation Corn Improvement Program in Mexico, 1954-60; as Associate Director of the Agricultural Sciences Division, Rockefeller Foundation, New York, 1964-66; and returned to Mexico in 1966 as Coordinator, Maize Improvement Program, International Center for Maize and Wheat Improvement.

Lahore
November 11, 1966.

To: Mr. Amir Ahmad Khan
Secretary of Agriculture
Government of West Pakistan
Lahore.

From: E.W. Sprague, Ph.D.
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Bangkok, Thailand

and

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Subject: Accelerated Maize, Jowar, and Bajra Improvement in West Pakistan

Sir, the Government of West Pakistan invited us to visit its research stations, during October 31 through November 11, 1966, and to offer our suggestions for accelerated improvement of maize, jowar, and bajra. We reported our findings orally to:

H.E. Mohammad Musa, Governor of West Pakistan.

Hon. Malik Khuda Bakhsh, Minister of Agriculture, West Pakistan.

Mr. B.A. Kuraishi, Additional Chief Secretary (Development), Government of West Pakistan, Planning and Development Department.

You asked us to put our comments in writing, which we

submit below:

On the basis of our short but very intensive visit to West Pakistan we are convinced there is an outstanding potential for increasing maize production in this country.

The present atmosphere of optimism surrounding agricultural development is opening the way to a new look at the many opportunities for increasing crop yields. During our visit we had an opportunity to review the present status of most aspects of maize production with government officials, research scientists, extension specialists, foreign experts, and farmers. We also had an opportunity to travel by car in the important maize areas of Montgomery and Lyallpur and in the vicinity of Peshawar.

According to the statistics made available to us the acreage and yields of maize have been relatively static during the past 15 years. The area planted to maize is approximately 1.4 million acres with an average yield of 11.8 maunds per acre. In contrast, we saw maize on experiment stations and in a number of progressive farmers' fields with yields of 70-80 maunds of dry shelled grain per acre.

A program for the development of high-yielding hybrids was initiated in West Pakistan in 1952 and good hybrids have been developed which under proper management have given yields of 70-80 maunds per acre. The obvious question then is why have average country yields remained static?

Our discussions have led us to the belief that the difficulty lies partially in the area of inadequate technology but primarily due to the difficulties inherent in large scale production of high quality hybrid seed and its distribution to the farmers in time for planting their crop. The use of hybrid maize requires that the farmer must purchase new seed each year. Since much of West Pakistan's maize production is on small farms, this makes the yearly distribution of new seed each year extremely difficult if not impossible.

In view of this, the senior maize botanists in West Pakistan have proceeded with the development of synthetic varieties which do not require new seed each year. We wholeheartedly endorse this trend not only on the basis of what we observed in farmers' fields in SCARP-I and near Mardan but also because of our observations in several other countries where, as in Pakistan, average yields are low but due to the world-wide need for more foodgrains must be dramatically improved. Farmers know from experience and research that the Desi varieties often do not give economic responses to the additional inputs (fertilizer, good cultural practices, weed and insect control, etc.) required to increase production substantially. To justify the expenditure for these additional inputs the farmer requires new varieties of maize which have the inherent potential to efficiently utilize them. We believe the hybrids and synthetics developed in West Pakistan have this potential. Due to problems of distribution and production the

farmer cannot get seed of the hybrids. The synthetic varieties now available in limited quantities in SCARP-I and in Mardan will not encounter this same problem because the farmer can save his own seed.

Good synthetic varieties are, however, only the beginning. To realize their full yield potential the farmer must apply as much fertilizer as they will utilize economically, control weeds and insects, manage his water efficiently, obtain a good plant population, etc.

From our limited discussions it is clear that farmers are enthusiastic about the new synthetics and recognize that they provide the vehicle whereby significant yield increases can be obtained. The farmers are beginning to look for and apply the additional inputs required for high economic returns.

During our discussions particularly in Lahore and with officials in the Central Region concern was expressed over West Pakistan's need for a large scale increase in maize production. As pointed out above we feel that there is a great potential for large increases in production of maize, jowar and bajra. If West Pakistan obtains the potential increase in these grains they will need to consider ways of utilization and marketing. We suggest that the Planners watch closely the yearly increases in production and the utilization, and as needed incorporate into their planning possibilities for industrial uses, increased use in livestock feed, and foreign markets for any surplus that could be produced in the near future.

The remainder of this report will outline our recommendations for the short- and long-run programs designed to increase significantly maize production in West Pakistan.

RESEARCH NEEDS

Breeding

The potential of maize in West Pakistan has been discussed earlier in this report. In order to realize the full potential as it was described, a substantial amount of integrated research must be planned and carried out.

Research in temperate and tropical climates during the past ten years has developed new methods of maize improvement. Except in areas where mechanical harvesting demands the ultimate in uniformity in the crop synthetic varieties rather than hybrids should be the goal of the maize botanists.

The maize botanists in West Pakistan are aware of the relative merits of synthetics vs. hybrids and they have several good synthetics the best of which should be promoted as rapidly as possible. The possibilities of rapid expansion of the use of synthetics and acceptance by farmers is well illustrated in SCARP-I.

The maize breeding program should involve materials which have a wider genetic basis than has been done in the past. Fortunately, the germ plasm (breeding materials) are now available with the maize botanists. Their breeding programs should be conducted under cultural practices which allow the fullest possible expression of the genetic potential of the selections. It would seem that under West Pakistan conditions the testing programs should be

conducted with a minimum of 150 lbs of Nitrogen per acre (6½ bags) balanced with P_2O_5, K_2O, and possibly zinc.

The best germ plasm with a high degree of genetic diversity should be identified immediately and subjected to a population improvement program. There are several breeding methods which are now known to be very effective in improving populations for release to farmers as open pollinated varieties (synthetics). Perhaps the cheapest and most effective method is the system known as modified mass selection coupled with ear to row testing. This procedure has given substantial yield gains per cycle and can be released immediately to the advantage of the farmers.

In our opinion, commercial seed production should not be the responsibility of the plant breeder but should be in the hands of the farmers and private seed companies.

Since it is now known that proper manipulation of appropriate breeding procedures will produce synthetics with as high a yield potential as that of hybrids, the farmer will naturally assume most of the seed production responsibilities presently carried by the maize botanists. We support such a trend since we believe the maize botanists will have a full time job in developing the new high-yielding materials vital to continued improvement of maize in West Pakistan. The breeder must, however, continue to conduct large scale yield plots on farmers' fields as his final evaluation prior to release to farmers. In order to conduct such trials, sizeable quantities of seed of promising synthetics will be required. The maize botanists should be responsible for seed production to the extent necessary to produce the seed for such trials.

Agronomy

It is evident that there is an immediate need to determine the maximum yield potential of the new synthetics and optimum fertilizer practices on farmers' land if they are to attain maximum economic returns. As new synthetics become available there will be a continuing need for research on cultural practices, that is, seeding rate, fertility levels, date of sowing, etc. In general, there seems to be little or no concern about potassium and zinc, although we observed apparent potassium deficiency symptoms in maize and zinc deficiency symptoms in citrus-an indication that there may be zinc deficiencies at the seedling stage in maize. New varieties which will respond to much higher levels of fertilizer require that the agronomists and soil scientists investigate the possibilities of economic returns from the use of potassium and zinc in combination with nitrogen and phosphorus.

It is generally accepted that the greatest economic responses to fertility will be obtained with good varieties under conditions of optimum control of insects, weeds and water. Therefore, agronomic research must be based on well defined objectives and include such variables as plant population, and soil and water management. Such investigations should be carried out using the best available varieties and the best known insect control. As newer synthetics and other technologies become available they should be immediately employed by the agronomist in order that he is always working towards systems of culture that will keep farm yields and farm income improving. The economics, that is, price-cost relationship, will greatly

influence recommendations made by agronomists. The research agronomist should never, however, assume that farmers will not change or cannot afford a practice that he (the researcher) can show to be economical under farm conditions.

Entomology

Pest control is a very important and continuing need. For example, it is evident that adequate control of the stem-borer is one of the most important production factors in West Pakistan. The best and most efficient insect control will ultimately be resistant varieties. Such varieties, however, are not now available. From experience in West Pakistan and other countries it is apparent that the stem-borer can be effectively controlled by the appropriate use of granulated insecticides. About 10 pounds of 2% granulated endrin applied when the maize seedlings have 5 to 7 leaves has proven successful in India. This material was applied by dropping 4 to 5 granules in the whorl of each plant. One man can treat one acre a day. Such materials should be made available directly to the farmer.

In general, maize sowing is delayed on the assumption there is less borer damage than with early plantings. This may be necessary but it does limit the growing season, hence reducing maximum yield potentials. Research should be initiated immediately to study the relationship of the borer to the maize plant. This research should be designed to determine when and where egg masses are laid on the maize plant and when the larvae begin to migrate to the whorl of the plant. Since maize is planted at different times, ranging

from April to August in different regions and from June to August in the same region, it would be desirable to conduct such studies in a series of plantings covering the entire season. This type of information must be available in order to formulate appropriate recommendations as to the best time of insecticide application.

Adequate research on the insect and breeding for resistance to the insect and for varieties adapted to earlier planting dates should be initiated as soon as possible. Facilities and personnel should be made available for mass rearing of the insect to permit the evaluation of breeding materials under conditions of controlled artificial infestation. It is well known that such a procedure is the only known method which is effective in breeding resistant varieties.

There are sources of germ plasm which appear to carry resistance to this insect and there are new techniques which make it possible to mass rear the insect. These materials and methods should be incorporated into the program immediately.

Although the borer seems to be the only insect of widespread importance on maize in West Pakistan entomologists should be on the alert for new problem areas.

Pathology

Diseases are considered of less importance than insects and this is, for the present, no doubt true. There are, however, leaf blights and rust prevalent in the country and it is probable they, at times, are causing considerable reduction of yield. Sources of resistance are available and the breeding programs must attempt to

incorporate them into their new synthetics. Pathological investigations should be initiated to determine what diseases are prevalent as well as their present and potential importance.

Integration of Research

Research disciplines important to improve maize production have been treated as individual units for convenience. In practice, the research necessary for any crop improvement program should be so integrated that each member of the team is taking advantage of the knowledge and findings of all important disciplines.

An example of the necessity of the team approach relates to cropping patterns. Maize must be considered in relation to the other crops which are now or will be of future importance within any given region. Varieties must be developed which will fit the longest possible growing period available in any crop rotation which is now or could become important in West Pakistan. The development of such varieties will only be possible and worthwhile if all the specialists representing the important disciplines are working together. New varieties and new cropping patterns will most certainly require new information on agronomic practices, insect and weed control, diseases, etc. In fact, maize-wheat in the Central and Northern Regions and maize-sugarbeets in the Northern Region are important cropping patterns used by the farmers. There is not, however, adequate information on the production factors of these crops to determine definitely the best management to assume the maximum potential of total production within any 12-month period.

A good maize improvement team should consist of qualified scientists who are trained specialists in breeding, agronomy and soil science, entomology and pathology. This group should then work as a team with each member supporting the other. Likewise, teams at different locations should be cooperating very closely by exchanging material, ideas and results. This can perhaps best be done by organizing maize research units involving specialists representing each discipline taking the necessary steps to assure that the different units are mobile. All the scientists involved in West Pakistan's maize research programs should meet together at least once a year for discussions on objectives, accomplishments and new ideas. Every effort should be made to make it possible for all people working on maize to be in close contact with each other. Furthermore, the individuals involved should consider themselves as members of a team and not individual entities. If this framework can be developed the resulting organized cooperation can be extrmely effective in the improvement of maize and in reaching Pakistan's objective of rapidly becoming self-sufficient in food production and of continuing to develop the new technology vital to the continued long range progress in agricultural production.

TRAINING

Potentials of maize and research needs have been discussed. It seems imperative that if these objectives are to be attained a vigorous training program must be undertaken at all levels beginning with the top research scientist through to the farmers.

They key research people should be given an opportunity to spend six months to a year in in-service training working with vigorous, fast moving maize improvement programs in countries where conditions are somewhat similar to West Pakistan. The junior research people should also be expected to undergo six months to a year of training in programs that would direct their training towards a better grasp of improved plot techniques, greater knowledge of germ plasm, genetics, breeding procedures and improved cultural practices. Effective training programs must also be implemented for class III people, field assistants, and farmers. Some of the training could best be done outside Pakistan and other portions could best be done within the country. The type and place of training should be given careful consideration. The type of training should be tailored, to the extent possible, to meet the needs of West Pakistan's agricultural production objectives.

Research training at the present time could, without a doubt, be done more effectively in Mexico and Thailand but extension people could, by and large, be better trained within Pakistan.

Within the research cadre several young and promising researchers should be sent for intense in-service training in their area of research interests and then return to function effectively in the maize improvement program. It must, however, be recognized that the best of these young scientists must have an opportunity to work towards advanced degrees after demonstrating their merit. This implies that a young man may go out for a year of in-service training, return for two years of productive service to the program and

go abroad again for advanced degree training. If this approach can be implemented, people can be phased in and out with a minimum of interruption to the research program and at the same time, over a period of several years, a very strong research cadre can be developed which will be capable of developing the new technology vital if West Pakistan is to meet its increasing requirements of the basic cereal crops.

It is hoped that during this period education and research expertise would develop to the extent that the country would be more or less self-sufficient and would not need to rely on outside training and education.

People receiving training and advanced degrees would, in time, provide the necessary training for agricultural- and field-assistants who are working in extension-oriented programs. Training for extension people should be more and more crop production oriented. It would be advisable to give intensive training to certain agricultural assistants in maize and wheat production so that they truly become maize and wheat production specialists with a responsibility so defined that they devote their entire effort toward increasing maize and wheat production. The maize and wheat production specialists must keep in close touch with the research teams so that they are well versed in the latest technology and at the same time keep the research cadre aware of production problems that should be investigated. They should also be charged with the responsibility of taking researchers to the farmers' fields as an aid in the identification and solving of new problems that arise.

LOGISTICS OF PRODUCTION

To put to work the continual flow of new technology farmers must have readily available to them the necessary commodity inputs.

From discussions with government administrators, research and extension people, and farmers it is apparent that the distribution of the required commodity inputs, that is, seed, fertilizer and pest control chemicals, is not as efficient as it must be if a significant percentage of farmers are to improve their production. This, perhaps, is true because most of the distribution goes through various groups or agencies which are manned by civil servants who must operate within government regulations. When this is the case, there is no profit incentive for the individual who does the actual distribution. With a situation of this kind he is not likely to be enthusiastic about the extra effort required for an effective sales program. Furthermore, he usually has several other duties which make it impossible for him to properly attend to the farmers' needs.

If sales and distribution could be given to the private sector it would allow dealers to be involved in the distribution of agricultural commodities as a profession in which their efficiency would determine their livelihood. It is recognized there is a fear of overpricing and perhaps adulteration where such activities are managed by the private sector. This is, however, over-emphasized in that the farm community will not pay prices beyond what is economically realistic for the inputs as they relate to his production potential. This will force the dealers to provide the necessary inputs at fair prices. Furthermore, industries that sell their

commodities through private dealers usually provide a considerable amount of farm advisory service assisting greatly in solving the difficult problem of disseminating technological information.

Farmers by nature are inclined to wait until they need a commodity before making a purchase. Therefore, the farmer is always in a hurry and will not take the necessary time to collect what he needs. If,however, dealers had these materials available in the villages he would purchase and use larger quantities. It, of course, can be argued that seed, fertilizer and insecticides cannot be brought down to the village level for distribution. In this context, it should be pointed out that many commodities of luxury type articles such as cigarettes, biscuits, etc., are readily available in very remote villages. These items may be considered insignificant but they are not when one considers the tonnage of such commodities brought into the villages and sold each year. If such arrangements were made, agricultural commodity inputs would almost surely come into the villages and be used if there were a profit for the dealer and for the farmer.

November 11, 1966.

Ernest W. Sprague
Robert D. Osler

APPENDIX A

Jowar and Bajra

Jowar (sorghum) and Bajra (millet) are very important crops in West Pakistan. Jowar covers a land area nearly equal to maize, and Bajra is grown on nearly twice as many acres. It is recognized that these crops are often grown for fodder and are usually grown on barani land. The average yield figures of 5.3 and 5.4 mds/acre are extremely low, however, and these crops should receive immediate research attention directed towards improvement in production.

Apparently very little research has been done on these crops as grain producers and adequate diversity of germ plasm is not available in Pakistan.

It would seem logical to introduce a few of the key sources of germ plasm that are known to be well adapted under similar conditions as are prevailing in the Jowar and Bajra tracts of West Pakistan.

On the basis of our experience in other countries we believe that research on these two crops should probably be done within the framework of a coordinated and integrated research effort on maize, jowar and bajra. Although the range of ecological adaptation is somewhat different there are rather broad environments where all three crops may be grown. In addition, the methods of improvement, the cultural practices, and problems of production are similar in many important respects.

We are also convinced that the breeder working on any of the three crops should be responsible for both grain and fodder improvement.

As has already been discussed in the maize section of this report we believe that unless private seed companies can become established in West Pakistan the breeding programs for the improvement of either Jowar or Bajra should be directed towards the development and release of varieties and/or synthetics and not hybrids. We are convinced that germ plasm exists which properly manipulated can equal the best hybrids in yield and thereby circumvent the problems of seed production and distribution inherent with hybrids.

In support of our suggestion on the potential of these crops we know of varietal and synthetic materials that have in the case of Jowar given 70 mds/acre and 50 mds/acre in case of Bajra.