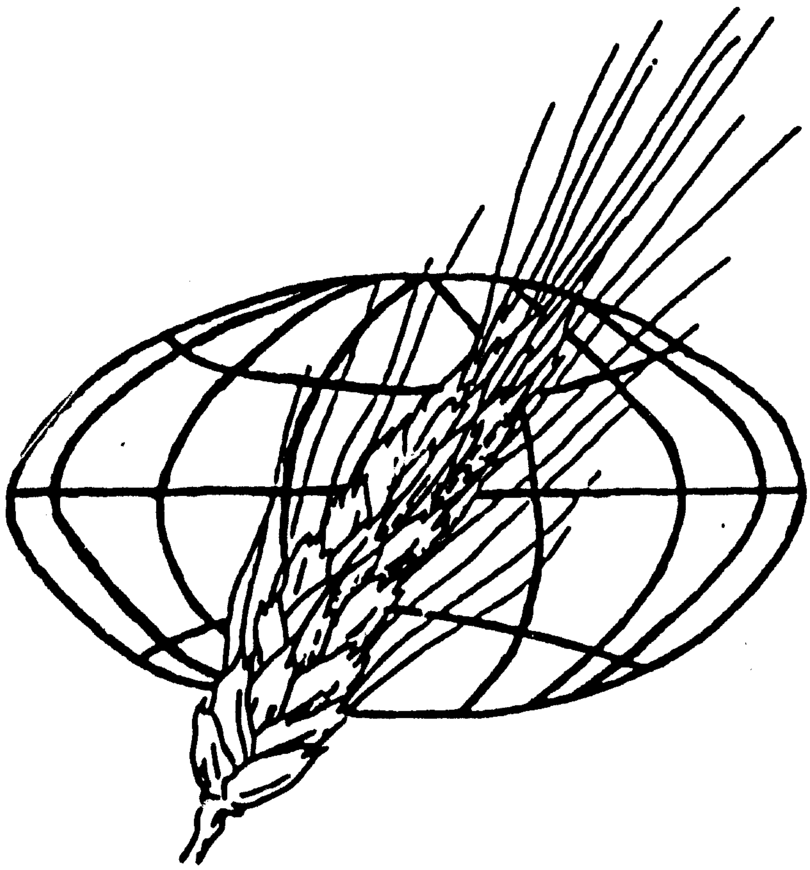
IMPROVEMENT OF WINTER WHEAT FOR DEVELOPING COUNTRIES BASED ON HYBRIDIZATION OF SPRING X WINTER FORMS

PROJECT REVIEW

June 20-23, 1978



OREGON STATE UNIVERSITY

Contract AID/ta-c-1352

P R O J E C T   R E V I E W

IMPROVEMENT OF WINTER WHEAT FOR DEVELOPING COUNTRIES,

BASED ON HYBRIDIZATION OF SPRING X WINTER FORMS.

Contract AID/ta-c-1352-Research

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CONTENTS

CONTENTS

(continued)

PROJECT STATEMENT

IMPROVEMENT OF WINTER WHEAT FOR DEVELOPING COUNTRIES, BASED ON HYBRIDIZATION OF SPRING X WINTER FORMS.

Statistical

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Duration: September 30, 1976 - September 30, 1979

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Funding by Fiscal Year:

FY 76	$324,000
FY 77	$305,000
FY 78	$314,000

Project Personnel:

		% Financial Contribution AID	OSU	SEA
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Summary of Problem

Among the major food crops, wheat is the most widely adapted and the most efficient source of both calories and protein. With the introduction of the semi-dwarf, day-length insensitive characters into agronomically desirable spring type wheats, progress made in wheat improvement has resulted in a substantial increase in the world food supply. Of particular significance is that as the result of day-length insensitivity, wheat is now a major food crop in many of the subtropical Less Developed Countries (LDCs) rather than remaining solely a crop restricted to the temperate zones. Furthermore, this technological breakthrough has been largely independent of farm size as increased yield levels have benefited both the large and small farmer. Unfortunately, improvements have been much less spectacular in winter type wheats which are generally grown under less productive environments. As a result, millions of hectares, particularly in the winter-rainfall, summer-drought areas of the Middle East, North Africa, Northern Asia and certain Latin and South American countries, are still devoted to a subsistence level of winter wheat culture. Due to the vastness of these areas, and the lack of stability in production, modest and consistent improvements in yield levels would result in substantial increases in food production. In order to improve the quality of life for the people inhabiting these now marginal areas, there is a pressing need for the development and dissemination of superior varieties and the improvement of production technology. This would lessen the gap in wheat production between the more favorable spring growing areas and the less favored sites growing winter wheat.

There is a concern that with the development of such outstanding semi-dwarf varieties as Gaines and Hyslop among the winter types and varieties from the 8156 cross (Siete Cerros) and Anza representing spring types, future yield and adaptation breakthroughs will be difficult utilizing existing germ plasm. Much of the success of the semi-dwarf varieties arose from the crosses made between diverse germ plasm sources. It is apparent that a much greater degree of genetic diversity must be created within both winter and spring type wheats if further major improvements are to be made. There is solid evidence that such diversity can be achieved by the intercrossing of winter and spring type wheats. Historically such crosses were only attempted when the plant breeder was desperate for a new source of disease resistance or some other attribute not found within the particular type he was developing. This reluctance was in part the result of difficulties in crossing due to the vernalization required by winter type wheats. As a consequence, spring and winter wheats have diverged from one another in an evolutionary fashion. It is noteworthy that several of the major breakthroughs in wheat breeding, such as the variety Thatcher, resulted from winter x spring crosses. Even the semi-dwarf spring wheats originally developed in Mexico obtain their short stature from the dwarfing source found in Norin 10-Brevor 14, a winter type wheat.

The results gained by the International Maize and Wheat Improvement Center (CIMMYT) and the winter wheat project conducted by Oregon State University (OSU) indicate that new genetic combinations resulting from the systematic crossing of winter x spring types are superior to either the winter or spring parent. In addition to greater vigor and wider adaptation, desirable characteristics lacking in one group can be transferred from the other. Such factors as good sources of stripe rust and drought resistance found in winter wheat can be transferred into spring types while spring varieties can contribute superior sources of stem rust resistance and early maturity (Table 1).

TABLE 1. SELECTED AGRONOMIC CHARACTERISTICS OF EACH WHEAT GROUP THOUGHT DESIRABLE FOR INTERCROSSING.

WINTER WHEATS	SPRING WHEATS
Winterhardiness	Early Maturity
Frost Tolerance	Agronomic Type
Dwarf Source	Dwarf Sources
Drought Resistance	Yield Potential
Yield Potential	Yield Stability
Yield Stability	Light Insensitivity
Shattering Resistance	Spike Fertility
Quality	Stem Rust Resistance
Stripe Rust Resistance	Yellow Dwarf Virus Resistance
Mildew Resistance	Septoria Resistance
Leaf Rust Resistance	Leaf Rust Resistance
Root Rot Resistance (Cercosporella, Ophiobolus, Fusarium, etc.)	
Yellow Dwarf Virus Resistance	

The cooperative program between CIMMYT and OSU is providing the necessary genetic diversity to substantially improve both winter and spring wheats and is currently making such germ plasm available to the scientists in the LDCs through international screening nurseries.

EXPANDED NARRATIVE STATEMENT

Project Background Description and Accomplishments

Oregon State University has been engaged in winter wheat improvement for nearly 75 years. Its association with CIMMYT originated nine years ago when scientists from OSU, working under a United States Agency for International Development (USAID) contract, introduced the semi-dwarf spring type wheats developed by CIMMYT in Mexico into the coastal areas of Turkey. With the subsequent development of the Wheat Research and Training Center in Turkey by the Rockefeller Foundation, a close association between CIMMYT and OSU scientists was established. The OSU team was supported by a USAID grant to develop a package of cultural practices to increase winter wheat production under dryland conditions. Further linkages between these three institutions have been developed through the identification of young, dedicated scientists from the LDCs for graduate training in cereal breeding at OSU. From these associations the various agencies became aware of the potential benefits each could derive from an integrated endeavor to achieve a degree of excellence in wheat improvement with emphasis on small farms which are marginally productive due to environmental stressed conditions.

The winter x spring concept of increasing genetic variability to improve both winter and spring wheats was developed by the late Dr. Rupert, a Rockefeller Foundation scientist assigned to CIMMYT. The initial program was based in Chile and subsequently moved to Davis, California. When it became apparent that the environmental conditions in Oregon were more similar to the winter wheat growing conditions observed in the LDCs and with the associations already established between CIMMYT and OSU, the program was transferred to Oregon in 1971. It was on the basis of similarities of climate that USAID supported the OSU involvement in the Turkish national program at an earlier date. It was hoped that CIMMYT in Mexico would handle the spring wheat improvement phase while the Turkish national program and OSU would concentrate on the winter dimension. Because of a number of factors, the Turkish program was not able to provide an international scope to the program. As a result, CIMMYT, lacking the sustained support from Turkey and realizing it could not conduct a full international winter wheat program from Mexico, sought a greater involvement by OSU, requesting that it become the center of operation for winter wheat improvement.

With this strengthening of the mutual research activities between CIMMYT and OSU coupled with the already existing linkages with the program at the University of Nebraska, a very positive and complementary total wheat improvement program has been created. As superior nutritional strains of wheat are identified and different genetic sources of high protein emerge from the Nebraska project, they are incorporated into the winter x spring program. The winter wheat germ plasm developed in Oregon has then the advantage of including superior nutritional properties in addition to the desired agronomic traits. A similar situation exists for spring type wheats developed through the CIMMYT program.

The current winter x spring program takes advantage of the vastly different environmental conditions and disease complexes observed between Oregon and Mexico. The first crosses are made in Toluca, Mexico in May where the vernalization and day-length requirements for winter wheat cultivars can be satisfied, thereby providing the opportunity to nick with spring type wheats. Thus the problem which has historically isolated winter and spring wheats is avoided. Resulting F1 seed is divided and planted in October at Obregon, Mexico and Corvallis, Oregon. The F1 material at Obregon is integrated into the spring wheat improvement program by top and double crossing to spring type material. Thus, the spring habit is retained while transferring only the desired attributes from the winter wheat parent. After subsequent evaluation and selection, the advanced lines are disseminated throughout the existing international nurseries coordinated by CIMMYT to the spring wheat growing LDC programs. The earlier maturity and different disease complexes enable scientists from OSU to collect valuable agronomic information from the plots in Mexico just prior to the crossing season in Oregon, thus providing an additional dimension in determining the most productive crosses to make.

In Oregon, the winter x spring F1 seed is top and double crossed back to winter type wheats. In conducting subsequent evaluations, three major testing sites are utilized for screening segregating populations. These include: The Hyslop Agronomy Farm near Corvallis (1000 mm rainfall), Pendleton Experimental Site (500 mm rainfall), and the Sherman Experiment Station (250 mm rainfall). These sites not only provide varying degrees of moisture stress, but also allow selection of winterhardy lines and those resistant to the major diseases observed in the winter wheat producing regions of the world.1/ In addition, the Sherman Experiment Station allows for selection under summer fallow management systems. This is very critical in dryland areas like the Anatolian Plateau in Turkey which typifies dryland wheat-producing areas in most LDCs. A significant input to the dryland wheat production effort is the recent awarding of a 211-D grant by USAID to OSU, thereby strengthening the expertise in dryland agriculture production. This will benefit the breeding program as well since the management system is so vital in developing suitable varieties or germ plasm. Further resources in the area of weed control in both dryland and high rainfall areas can be obtained through the cooperative effort between the breeding program and the International Plant Protection Center (IPPC) also funded by USAID and based at OSU.

When considering the three diverse testing sites, it should be noted that through the "material flow" system, the germ plasm in the course of development is alternated and/or simultaneously subjected to various environmental stresses. Thus, successful lines will have favorable responses to a full range of requirements. This approach has been the key to the wide adaptation of the materials developed in Mexico for spring wheat. Wheat breeders in Oregon are in a unique position to do the same thing for winter wheats. Nowhere else in the United States and few places in the world can such an ideal situation be found.

1/ To insure adequate levels of leaf and stem rust infection, all segregating populations are also grown in Toluca, Mexico where artifical inoculations are practiced to identify resistant genotypes.

Two hundred and fifty lines representing the F4, F5 and F6 generations are to be included in the International Winter X Spring Wheat Screening Nursery (IWSWSN) along with suitable check varieties. This nursery is currently sent from Oregon to 48 different countries representing 90 breeding programs. (Appendix Table, p. 44) Elite lines identified in Oregon through yearly visits by CIMMYT scientists, along with the screening nursery, are sent back to Mexico for recycling, thus providing additional germ plasm for the spring wheat improvement program. To some of the same LDCs, outstanding early generation populations are also sent, particularly where specific limiting factors have been identified such as aluminum toxicity in Brazil. (Appendix Table, p. 43)

Accomplishments have included: (1) The systematic crossing between winter and spring wheat cultivars has greatly increased the genetic potential for both winter and spring wheats. The most promising lines now emerging in the CIMMYT program for the improvement of spring wheats have resulted from winter x spring crosses. A similar situation exists for winter wheats in Oregon. (2) The growing conditions observed in Mexico at the Toluca site have permitted the extensive crossing of winter and spring wheat cultivars. (3) The different environmental conditions, disease complexes and growing season observed between Mexico and Oregon have permitted a very efficient program to be conducted for the improvement of both winter and spring wheats. (4) Research activity at the University of Nebraska has identified superior nutritional material and provided significant linkage to the winter x spring wheat improvement program. (5) Through the use of the computer and the development of a useful format for summarization of data at OSU, results of each IWSWSN have been returned to the cooperators prior to their crossing season. (6) The IWSWSN made up of superior lines is an excellent way to disseminate germ plasm which is being used effectively by the LDCs. (7) Results from the first four screening nurseries suggest that the germ plasm selected in Oregon retains the desired attributes when grown in the LDCs. (8) The positive response of cooperators and the overwhelming requests for the nurseries give a very strong indication of the value placed on the winter x spring program by the scientists in the LDCs. Not only is the nursery providing a mechanism for the exchange of germ plasm and information, but in concert with the University of Nebraska program and CIMMYT, it has opened up lines of communication between the winter and spring wheat breeders throughout the world.

Furthermore, the strong breeding program has provided an ideal milieu within which to train students from the LDCs at the graduate level. Currently 28 LDC students have been, or are now participating in this research program. Many have returned home after completing the M.S. or Ph.D. degree and are now the cooperators in the winter x spring program in their respective countries. It is apparent that without the program strength as background, the university's ability to train young, dedicated scientists from the developing countries would be only partially effective.

Relevance to AID Objectives

Wheat is the most widely cultivated of all cereal crops in the world, occupying about 17 percent of the total cultivated land. It is grown in most temperate and sub-tropical countries; however, approximately 90 percent of the world wheat acreage lies in the northern hemisphere.

The major thrust of the Green Revolution has been under the direction of CIMMYT on spring wheats, and therefore, confined to the sub-tropical zones. An important statistic that is often overlooked, however, is that winter wheats occupy 66 percent of the total world wheat acreage. Also of importance is the fact that 75 percent of the acreage is fall-sown. Both wheats with true spring habit and facultative types are fall-sown when possible to take advantage of a longer growing season.

The present local varieties being grown in the LDCs are generally tall, late and low yielding because they do not have the genetic potential to respond even under optimum growing conditions. Introduced varieties with higher yield potential often lack seed quality, disease and insect resistance, winter hardiness, or other adaptation to climatic conditions. A large acreage within each of th LDCs belongs to small farmers working in marginally productive areas where yearly yield levels are totally dependent on the environment. If the farmers are to benefit from improved technology, the institutions of selected LDCs with major responsibility for adaptive research and extension of wheat improvement to the rural populations must be strengthened. The training of dedicated young scientists in conjunction with providing them access to superior germ plasm is the most direct means of accomplishing this objective.

Through OSU's distribution of the IWSWSN, a worldwide network of cooperators has been formed which insures that the LDCs can obtain and effectively take advantage of the widely adapted materials developed through the combined efforts of OSU and CIMMYT.

The 5th IWSWSN is currently being evaluated in most of the major winter wheat growing areas of the world. Additionally, selected F2 populations have been sent to those countries with the scientific personnel necessary to use such materials. The close linkage of OSU with international and national research organizations will accelerate the efforts to produce and distribute new improved advanced lines and varieties for use in the LDCs.

Program Objectives

The major objectives of this project are as follows:

a) Develop and maintain a germ plasm bank of superior winter wheat cultivars for hybridization.

b) Create greater genetic diversity for the improvement of winter and spring type wheats.

c) Improve nutritional properties in winter wheat by making crosses to lines identified by the University of Nebraska.

d) Apply suitable selection pressures to identify superior winter wheat germ plasm with improved yield and adaptation.

e) Disseminate early generation breeding stocks to selected LDC cooperators for further selection under their local conditions.

f) Distribute superior agronomic lines and fixed varieties to all cooperators through the IWSWSN.

g) Determine those attributes necessary in winter wheat cultivars to insure maximum soil erosion control, productivity and stability in concert with improved dryland cultural practices.

h) Train dedicated young scientists who will have prime responsibility for adaptive research in their LDC institutions.

i) Establish new relationships and expand those already existing between LDC agencies and institutions, U.S. universities, USDA-SEA, USAID missions, the Rockefeller Foundation, CIMMYT, FAO and other international and regional plant breeding centers.

Plan of Work

a) Germ Plasm Bank 5%

In order to make crosses directed toward specific objectives, it is necessary to accumulate and maintain a working genetic pool made up of superior winter wheat cultivars which cover a wide range of adaptability. Through the network of cooperation that has already been formed between LDC agencies and institutions, U.S. universities, USDA-SEA, USAID missions, the Rockefeller Foundation, CIMMYT, FAO and other international and regional plant breeding centers, superior varieties and advanced lines will be exchanged. Information from the country of origin as well as local observations concerning combining ability, yield potential, adaptation resistance to various diseases, and responses to other limiting factors will be catalogued. Utilizing the computer to record and cross reference such information a data bank will be compiled to give the plant breeder ready access to the names of varieties or lines which can be effectively utilized in crosses directed toward a particular goal.

b) Genetic Diversity 25%

There is a concern that future improvement in yield levels and adaptability will be only minor if scientists are limited to the use of existing germ plasm and are restricted to intracrossing in the spring or winter types.

However, results have shown that a much greater genetic diversity can be achieved through the intercrossing of the two types. The CIMMYT field staff makes the initial winter x spring single crosses at Toluca, and Obregon, Mexico. Spring wheat parental sources are carefully chosen to incorporate important characters such as a wide maturity range, head fertility, agronomic type, new dwarf genes, and genes for disease resistance not available in the winter wheats. The winter wheat parents provide new genetic sources for winterhardiness, frost and drought tolerance, yield potential and stability, shattering resistance, bread making quality and different types of disease resistance not presently available in spring wheats. F1 seed of these single crosses is equally divided between CIMMYT and OSU. CIMMYT utilizes these F1 populations in subsequent top and double crosses with spring type wheats. Conversely, with emphasis on winter wheat improvement, OSU makes top and double crosses to superior winter types. Plants in the segregating populations have diverse genotypes capable of adapting to a range of environments and limiting factors. Annually, approximately 30 hectares of winter x spring material comprising over 30,000 different genetic combinations are evaluated across the state of Oregon.

Through mutual agreement with CIMMYT, OSU has become the base of operation for winter wheat improvement, however, both the spring and winter wheat improvement programs are closely correlated and a wealth of beneficial information can be obtained through close cooperation. Prior to the crossing season in Oregon, OSU scientists visit Obregon, Mexico where the F1 single crosses are being grown. They record information on each F1 population concerning agronomic type, fertility and disease reactions to be used in matching winter parents to the same F1's during the subsequent crossing season in Oregon. Scientists from CIMMYT annually visit OSU prior to harvest to select plants from segregating populations which have desirable characteristics needed to improve spring wheats. These populations are incorporated into CIMMYT's program and are utilized in generating new genetic combinations for spring wheat improvement.

c) Incorporation of superior nutritional properties 5%

Selected F1 populations resulting from spring x winter single crosses made in Mexico are top and double crossed in Oregon to high protein cultivars identified by the University of Nebraska. After preliminary screening at OSU superior F2 progeny are sent to the University of Nebraska for further testing. Lines with exceptional nutritional properties are identified and returned to

Oregon where diversified selection pressures are applied in subsequent generations to insure that lines with enriched nutritional properties will have wide adaptation. Prior to entry into the IWSWSN, selected lines are further evaluated by the University of Nebraska for improved nutritional properties. This information, along with the agronomic data obtained in Oregon, is provided to the scientists in the LDCs with the IWSWSN seed. With this background information, scientists in the LDCs can more effectively identify promising lines.

d) Selection Pressures 15%

Specific climatic conditions and those factors which limit winter wheat production in the LDCs can be found somewhere within the boundaries of the state of Oregon (Appendix 1). There are over 400 different soil types varying from strongly basic to strongly acidic in reaction. Winter temperatures in coastal areas are mild enough to accomodate the growing of fall-sown spring wheats; but in eastern Oregon are severe enough to require a high degree of winterhardiness. The rainfall pattern is predominantly a mediterranean type with annual amounts varying from less than 250 mm to over 1000 mm. In the dryland areas, drought resistance is an important consideration and the development of cultivars in relation to an exacting management system is required. Every major disease attacking winter wheat is present with the exception of stem rust. All early generation material is sent to Toluca, Mexico where it can be effectively screened for stem rust resistance. Data already obtained from the entries in the first four IWSWSNs also suggest that many of the physiological races of major diseases present in LDCs are found in Oregon.

To insure wide adaptation, superior progeny from segregating populations identified at one experimental site will be subsequently tested at the other two locations. Due to the large environmental differences observed between sites, the resulting germ plasm is exposed to many of the limiting factors common to winter wheat areas of the world. It should be noted that advanced lines which have been selected for their yield potential under Oregon conditions do in fact have wide adaptation as evidenced by their superior performance across locations in the LDCs.

e) Early Generation Breeding Stocks 10%

The F1 top and double populations are selected on an individual plant basis using the pedigree method. In addition, superior populations are bulked following plant selection and sufficient seed is available for further testing as F2's at a number of locations. Each F2 bulked population is planted at the three major Oregon experimental sites. The remaining seed is disseminated to selected LDCs where facilities and staff are available for further selection under local conditions.

Cooperators in areas with particular problems consistently limiting wheat production, such as special types of winter killing, late spring frosts, drought conditions, specific disease attacks, etc., will be asked to assist in screening additional genetic material for resistance to those limiting factors. Providing these early generation stocks is extremely important to the cooperator and can also benefit the OSU and CIMMYT programs as data are returned indicating the best populations under unique conditions. Programs in developed countries, particularly in eastern Europe, are not only providing useful agronomic data as a result of growing the IWSWSN, but are also providing valuable germ plasm for incorporation into the winter x spring program. As a consequence of this exchange, superior experimental lines are now finding their way into the LDCs.

When early generation quality screening is used along with agronomic and pathological selection, a higher percentage of the lines have desirable quality in the advanced generations. The wheat quality evaluation of lines starts with the F4 individual selections (seed from F3 selected plants) and is continued through the F5 and F6 generations.

In making winter x spring crosses tremendous variability in gluten strength results due to the wide variation in germ plasm. Following harvest, seed of all selected plants are first tested for grain type and only those with plump kernels are maintained. These individual plant samples are then evaluated for gluten strength using a mixograph. Only lines with acceptable gluten strength in keeping with hard or soft wheat types are retained for further evaluation.

f) Screening Nurseries 20%

Selections from preliminary yield trials at the three Oregon sites are advanced to the IWSWSN for evaluation in many winter wheat areas. In Table 2 is presented the number of entries, cooperators and countries receiving the six IWSWSNs that have been distributed to date. With the identification of additional nursery sites in the People's Republic of China, Northern India and the mountainous region of Bangladesh, all the major winter wheat growing areas are covered.

TABLE 2. TOTAL NUMBERS OF ENTRIES, COOPERATORS AND COUNTRIES RECEIVING THE SIX IWSWSN'S, 1973-1979.

IWSWSN NURS. NO.	NO. OF ENTRIES	NO. OF COOPERATORS	NO. OF COUNTRIES	CROP SEASON
1	360	38	24	1973-74
2	450	52	30	1974-75
3	448	63	33	1975-76
4	250	69	40	1976-77
5	250	80	46	1977-78
6	250	90	48	1978-79

Return of the experimental data following harvest is essential for proper evaluation of the material. Response from cooperators thus far has been very encouraging. Personal contact through visits to different cooperators will improve the quality and amount of data returned. Receipt of all data is requested prior to the end of the year in which the nursery is grown. The data are completely summarized by computer and superior lines identified. A printed copy of the results is returned to the cooperator by mid-February of the following year. This provides the cooperator with complete data prior to the crossing period allowing use of superior lines in new combinations. This summary is a valuable tool for OSU and CIMMYT in planning their crosses for new hybrid combinations.

Superior F5 and F6 lines with good general adaptation which have been screened through the IWSWSN will be placed in a new international winter x spring wheat yield trial to be distributed by OSU. Agronomic data will be accumulated on such lines covering several crop years and a wide range of environments. These data will then be used to select superior lines to be submitted to the International Winter Wheat Performance Nursery.

g) Variety X Management Interaction 10%

Since the majority of the winter wheat production in the LDCs is under limited rainfall conditions, a management system to conserve moisture must be employed if successful yield levels are to be obtained. The summer fallow system of the Pacific Northwest has been successfully introduced into Turkey and Jordan. Experience has shown that if maximum production is to be achieved, varieties must be developed in keeping with the particular system. Furthermore, such a variety x management interaction is even more critical in preventing or reducing soil erosion either by wind or water. With the awarding of the 211-D grant to OSU for strengthening dryland agriculture production technology, it is possible to utilize this resource in the breeding program in a complementary fashion.

One cultural practice which has been clearly identified as being significant in dryland management systems is that of seeding early in residual moisture. This not only results in higher yield levels, but is a major deterrent to soil erosion. However, if this practice is to be effective, cultivars must be developed which have certain attributes not found in existing varieties. These involve factors which influence stand establishment including rapid emergence in warm, relatively dry soils, semi-erect seedlings having a proper balance of tillers and leaves to lessen damage by wind, improved winterhardiness, varieties that efficiently use limited water supplies, greater ability to compete with weeds, emergence through compact, residue covered soil and greater resistance to pathogens.

In the winter wheat producing LDCs, the need for developing cultivars in keeping with management systems to reduce soil erosion either by wind or water cannot be overstated. These areas have already lost a substantial amount of an irreplaceable resource base which they can ill afford in terms of present food needs to say nothing of future requirements.

h) Training 5%

The ongoing cereal research program at OSU provides a faculty and staff concerned with extending scientific knowledge and dedicated to the training of young people.

The scope and size of the winter x spring hybridization is ideal for training qualified young scientists and technicians in cereal breeding and production. The program has been developed to provide an educational base for those young people who will be expected to assume leadership roles in their respective national programs. The students work directly in the winter x spring research receiving assigned responsibilities thus becoming familiar with all practical aspects of wheat breeding. They learn to disseminate information by being exposed to the philosophy and techniques employed in extension systems. That there is dignity in getting one's hands dirty is another important learning experience. The students are expected to assume leadership roles and discuss their phase of the program with visiting scientists and with farmers during field days.

Thesis problems for students from LDCs are selected in keeping with their personal interests and with regard to the type of research experience which will be most beneficial upon thier return home. Under certain circumstances, a student may complete his academic work at OSU and return home to conduct his thesis research. This is possible provided that a well-qualified scientists, approved by the OSU graduate faculty, is available to direct the student's thesis work in his home country. Examples of this arrangement presently exist in Turkey, Mexico and The Philippines.

A positive result of the program has been the lasting relationships which have developed between LDC students and the faculty and staff at OSU. Contacts are maintained through a quarterly newsletter and, in some instances, faculty members are able to visit programs in various countries and assist in developing objectives. Such visits not only reinforce the young scientists confidence in himself, but frequently road blocks can be removed by visiting with government officials in the particular country. Several graduates of the program are now cooperators in the winter x spring research effort in their respective countries.

The post doctorate position has proven to be a very positive asset to the total program. Individuals in this position not only assist students in their graduate studies, but also free the faculty for other responsibilties in the total international program. Such experience provides an excellent opportunity for young Ph.D.s to gain an understanding and an appreciation for international work.

i) Linkages 5%

Communication and cooperation between agencies and programs throughout the world forms the cornerstone of success in an international wheat improvement program.

Genetic stocks, experimental lines, and research information are exchanged with other organizations engaged in international activities, such as CIMMYT, FAO, the Rockefeller Foundation, the University of Nebraska and Michigan State University to insure rapid progress in the improvement of winter wheat.

Visits between institutions and cooperators are made to avoid duplication of effort and to coordinate the exchange of material and information. Personal contact through visits to countries where the IWSWSN is being grown will improve the quality and amount of data returned.

OSU will assist and participate in national and international workshops and conferences in cooperation with the above mentioned agencies. Furthermore, upon request and funding by USAID missions OSU scientists will provide inputs to LDCs to strengthen national cereal research programs.

Research results will be published in appropriate reports, bulletins, and scientific journals.

CURRENT STATUS

a) Germ Plasm Bank

Approximately 5000 winter wheat cultivars have been evaluated for their agronomic worth. These lines were obtained from every major winter wheat producing area in the world and represent mainly advanced materials from the more progressive breeding programs. Nearly 200 new entries are received each year and evaluated in the miscellaneous crossing block. The most promising genotypes are then advanced to the main crossing block the following year for hybridization in the top crossing program. Information is catalogued on such factors as yield potential, combining ability, disease reactions and other important agronomic properties. Those lines found to be superior for various desired traits are made available to the cooperators upon request. By 1979 an information sheet will be made available to all the cooperators identifying the attributes of each of the more promising lines.

A collection of 3500 cultivars was collected by the late Dr. Rupert at the time he initiated this program. Over the past four years these lines have been evaluated under local conditions and the most promising lines were distributed as a collection to 1) the USDA germ plasm collection at Beltsville, Maryland, 2) the seed depository at Fort Collins, Colorado, 3) for incorporation into the initial winter x spring crossing program at CIMMYT and are also being used as parental sources for top crossing at Oregon State.

Approximately 200 new entries are received each year from nearly all the major winter wheat breeding programs. For the past two years collections have also been received from the People's Republic of China. Since earliness is a major factor needed in many parts of the world, 75 of the very earliest maturing lines from the collection in Suwon, Korea are being sent for use by Oregon this year. Particularly promising lines for earliness and winterhardiness have been obtained from the USSR, Yugoslavia, Romania and Turkey. Sources for aluminum tolerance have been obtained from Brazil. Materials from Argentina and South Africa are being obtained as new sources of stem rust resistance. It should also be noted that the high protein and high lysine screening nursery from Nebraska is grown each year and utilized in the crossing program.

b) Genetic Diversity

Data from the 90 cooperators currently receiving the screening nursery suggest that the concept of creating greater genetic diversity through the systematic crossing of winter x spring wheat cultivars is valid. Thirty percent of the advanced lines currently being increased at CIMMYT originated from winter x spring crosses. These not only represent some of the best spring cultivars but when it is realized that the winter x spring program has only been underway since 1972, it is most impressive. Similar observations have been made in Oregon when progeny from the winter x spring program compared with strict winter x winter crosses.

c) Incorporation of Superior Nutritional Properties

The most promising lines in the high protein, high lysine screening nursery from the University of Nebraska have been used in top crosses. The nutritional information provided by the University of Nebraska and local agronomic evaluation is utilized in making the desired crosses. Selected progeny from such crosses was to be sent to Nebraska for subsequent screening; however, with the reduction in the Nebraska program this phase of the program is now in doubt.

d) Selection Pressures

The simultaneous selection within segregating populations across three diverse testing sites has been positive in developing lines with wide adaptation. Certainly the results returned from the screening nurseries substantiate that most limiting factors in developing countries can be found at the three testing sites in Oregon. Leaf and stem rust epidemics are an exception; therefore, in addition to the three sites in Oregon, all the winter segregating populations are also grown at Toluca, Mexico where they are artificially inoculated and meaningful selection can be carried out. In Appendix Table, p. 32 a detailed breakdown for each of the testing sites is provided including cropping practices, soil properties, rainfall and the selection criteria employed.

e) Early Generation Breeding Stocks

In addition to the IWSWSN, selected F2 and later generation populations which have special attributes are sent to selected developing countries. For example, populations where short stature has been combined with different sources of aluminum tolerance have been sent to Brazil for their evaluation or selection. Early generation materials exhibiting extreme earliness have been sent to Korea. Such materials can be effectively utilized in developing countries where positive breeding programs are being conducted. This has the benefit of providing elite materials much earlier to these programs rather than waiting until the F5 or F6 generation when such material might reach them through the screening nursery It should be noted that early generation materials selected in the various developing countries are then recycled through the winter x spring program.

f) Screening Nurseries

The 6th IWSWSN, made up of 250 lines from F4, F5, and F6 populations, has been distributed to 90 cooperators representing 48 different countries where winter wheat is being grown. Testing sites have now been identified in the People's Republic of China, Northern India and Bangladesh thus expanding coverage to all of the major winter wheat producing areas of the world. A list of the current cooperators is provided in Appendix Table, p. 44.

Lines in the screening nursery have been selected over a wide range of environments within the state of Oregon. Many are selected with strengths in certain problem areas known to exist in the LDCs such as specific disease resistance, earliness and drought tolerance. Some lines are useful to the cooperators as germ plasm to be incorporated in crosses with local adapted varieties. On the other hand, several countries including Iran, Jordan, Turkey and Afghanistan have indicated that they are increasing several lines from the screening nursery for direct varietal release.

In an effort to provide the most beneficial data summary, the IWSWSN is sent six months earlier to cooperators in the southern hemisphere so that all data on the current screening nursery can be returned in time for inclusion in the annual summary. Such a practice will provide a more complete picture of the performance of lines across a wide range of environments.

Testing sites have been divided into three rainfall zones: Low (<400 mm), intermediate (400-650 mm), and high (>650 mm and irrigated sites) in an effort to better summarize data and pinpoint lines which are most suitable to a specific area.

After harvest, cooperators return data to Oregon where it is coded and keypunched for analysis by computer. Data are accepted for inclusion in the current summary up until January 30. Data received after that time are included as an addendum in the following year's summary.

The computer facilitates the handling of thousands of bits of information on the 250 lines in the screening nursery. A complete catalog of all data received for each line is printed, enabling the cooperator to view the performance of a particular line across a wide range of environments and growing conditions. Utilizing weighted scores obtained by ranking all of the lines for nine agronomic traits, the best 25 lines are identified and printed for each location. Subsequently, the best 25 lines over all locations reporting are identified for yield potential, earliness, winter-hardiness, stripe rust, leaf rust, stem rust, septoria, and powdery mildew. Therefore, lines are identified with strengths in these areas so the cooperator can make use of them in his breeding program. Finally, based on weighted scores from all locations reporting in the low, intermediate, and high rainfall zones, a table is printed of the 25 lines in each rainfall zone which exhibited adaptation for particular areas and may be useful to the cooperator either for reselection or direct release.

By the first of March, the summarization is complete and printed in book form. It is in the hands of the cooperator prior to the subsequent crossing season so that he may make the most effective use of the information. Because of the timely return of the data, there has been an excellent response from the cooperators. Approximately 70 percent of all those who receive the nursery return data to be included in the summary. This is of extreme importance and serves to increase the value and usefulness of the summary. It should be noted that the summary books are available to those other than just cooperators who might be interested in specific germ plasm.

g) Variety X Management Interaction

Under dryland wheat production moisture conservation is a critical factor. Through the development of various management practices, successful winter wheat production has been accomplished with 200 mm of annual rainfall. It is very apparent that to maximize grain yield under such conditions, new cultivars must be developed in keeping with specific management systems. At the Sherman Branch Experiment Station germ plasm is being evaluated under such practices as mold board plowing, stubble mulching, minimum and no tillage. Important plant attributes such as germination and emergence under low moisture and high temperature conditions and other factors associated with stand establishment are being evaluated.

With the minimum and no tillage practices, erosion control is the main consideration. Wheat cultivars have been identified that germinate under lower moisture conditions and higher soil temperatures, emerge rapidly, and have a spreading growth habit and prolific root branching patterns for holding the soil. Adequate levels of winterhardiness and increased spring vigor have also been observed. Greater problems with pathogens and insects can be anticipated; therefore, more work must be completed to identify specific problems and find tolerance or resistance to these limiting factors. With the existing genetic variability it is possible to develop cultivars with the desired attributes to fit into management systems which can help to control wind and water erosion. This will be an important feature of the winter x spring program when making future crosses.

h) Training

An integral part of the winter x spring wheat research program at OSU is a graduate training program where young scientists can receive appropriate training leading to M.S. and Ph.D. degrees. The program has been developed to provide an educational base for those young people who will be expected to assume leadership roles in their respective national programs.

A student who first joins the program is assigned responsibility on the research project. As a result, students become familiar with the practical aspects of the research program through actual participation. He is expected to take the leadership and discuss phases of the program with visiting scientists and with farmers during field days. The importance of the team approach to research is stressed and the student has the opportunity to participate as a team member. As the individual progresses through the program, the research effort will turn toward the M.S. or Ph.D. thesis problem which often, by it very nature, is more specific than the work on the cereal research program. Thesis problems are selected in keeping with the student's interest and with regard to the type of research experience which will be most beneficial upon his return home. A program has been developed where, under certain circumstances a student may complete his academic work at OSU and conduct his thesis research at one of the international centers. Currently three Ph.D. students are doing their thesis research in Mexico with the assistance of CIMMYT scientists. Another student is working on a thesis project in rice at the International Rice Research Institute in the Philippines.

The scientific approach, integrity in reporting data and dedication are stressed. It is equally important that the student learn to disseminate information, therefore, he is exposed to the philosophy and techniques of extension systems. Furthermore, he comes to realize that there is dignity in getting his hands dirty as he work beside faculty members in the field.

A positive result of the program has been the lasting relationships which have developed between the former students and the faculty and staff. Contacts are maintained through a quarterly newsletter and, in some instances, faculty members are able to visit various countries and assist in developing programs. Such visits not only reinforce the young scientist's confidence in himself, but frequently road blocks can be removed by visiting with government officials either in the particular country or while the officials are touring the United States.

If a solution is to found to population-food supply problems, it will be only after there is a sufficient number of highly motivated young scientists with the desired level of training to make the necessary contributions. It will not be possible for any country or organization to provide enough support to the developing countries to solve the food problem. The goal should be the strengthening of the national programs which can only be achieved if there is enough expertise in a given country to get the job done. The need for strong training programs . the M.S. and Ph.D. levels to complement the training received the various centers such as CIMMYT must receive top priority for 's is the ground work upon which to build strong national programs can meet existing and future requirements for food. The graduate .ing program at OSU addresses itself to this need. A list of former and current graduate students is provided in appendix table, page 34.

i) <u>Linkages</u>

The winter wheat improvement program at OSU is closely aligned with the spring wheat program conducted by CIMMYT in Mexico and their various outreach activities. Both programs are production oriented and utilize the same breeding procedures. The unique geographic locations, easy travel between programs, and complementary environmental stresses maximize the progress achieved in the winter x spring program for the benefit of both winter and spring wheat production areas in the LDCs.

Currently as cultivars with superior nutritional value are identified by the University of Nebraska, they are utilized in top crosses in Oregon. If linkages are reinforced, segregating populations found to be agronomically outstanding in Oregon will be systematically screened for nutritional properties in Nebraska. This will insure that advanced lines in the IWSWSN will represent germ plasm which combines desirable agronomic characteristics and higher nutritional properties.

The International Center of Agricultural Research for Dry Areas (ICARDA) has also joined OSU and CIMMYT in the development and screening of germ plasm. The International Rice Research Institute (IRRI) is also participating by assisting in graduate training.

The two programs currently funded by USAID at OSU, which include a 211-D grant for development of expertise in dryland agriculture production and the IPPC for weed control, will be valuable assets to the winter x spring program. The combined thrusts of these three programs will be to develop improved varieties and a package of cultural practices to protect the existing natural resources while improving the quality of life by maximizing winter wheat production in the LDCs.

Linkages have also been established with several institutes in LDCs as follows:

1) The Government of Tunisia Accelerated Cereal Project - Tunis, Tunisia

2) The Turkey Wheat Research and Training Center - Ankara, Turkey

3) The Wheat Research Program at the University of Jordan - Amman, Jordan

4) IDGC - The Algerian Institute for Development of Cereal Production and Companion Crops - Algiers, Algeria

5) The Agricultural Research Council for the Government of Pakistan - Islamabad, Pakistan

6) The Ministry of Agriculture and Irrigation - Kabul, Afghanistan

7) The All-India Wheat Coordinated Program - New Delhi, India

8) Wheat and Barley Research Institute - Suweon, Korea

In the OSU winter x spring program the exact role and responsibilities that ICARDA will assume have not yet been fully determined. Director General Darling and Mr. Robert Havener, soon to be Director General of CIMMYT, recently were at OSU to review the program and interact with OSU scientists to develop stronger linkages.

In Appendix Table, p. 38, a complete flow diagram of the existing linkages is provided.

METHODOLOGY

The primary breeding method employed to handle the diversity in the segregating populations within the winter x spring program is the pedigree method. The superior phenotypes are selected in successive segregating generations with records being maintained for all parent-progeny relationships. The pedigree method is utilized to permit the early elimination of unpromising phenotypes and to provide maximum quantities of F2 seed and seed of later generation material for distribution to the international cooperators. The method also permits a careful evaluation of the breeding material over the diverse environments and therefore selection of genotypes with wide adaptation can be accomplished. To insure optimum expression of disease reactions, artificial inoculations of wheat pathogens; i.e. stripe rust, are applied to universally susceptible cultivars previously interspersed throughout the breeding nurseries.

The program is now completely mechanized to facilitate accurate and efficient handling of the large quantity of breeding material. The mechanization applies for the entire process from planting through harvest. New seed drills have been developed for accurate and rapid sowing of both segregating populations and yield trials. The harvest equipment includes a small two-row Suzi combine that cuts and bundles the plant rows, a stationary (Vogel) thresher, and several Hege experimental plot harvesters. This equipment saves time and labor and improves the flow of the harvest operation.

In the handling of approximately 60,000 plots, all of different genetic backgrounds, the computer has proved to be not only efficient but essential as a record keeping device to maintain pedigree history and print plot labels, field books and harvest bag labels. The accuracy of pedigree records has improved significantly over the manual process of rewriting pedigrees each year. Field books, tags, and bag labels can be printed for all test sites within six weeks after planting so that books are available before the time for data collection.

Within weeks after harvest, the new nurseries must be prepared and seeded at the dryland locations. Therefore, it is critical that yield and agronomic data be collected and analyzed immediately so that the breeders can make decisions as to the disposition of lines tested. In an effort to make this process as efficient and accurate as possible, an electronic weighing and data processing system has been devised for field use. An electronic balance is interfaced to a programmable calculator and powered by a small gasoline driven generator. As a nursery is harvested, sacks of grain are weighed on the balance and the weights are passed electronically from the balance to the calculator and recorded on magnetic tape. As soon as all sacks for a nursery have been weighed, an analysis of variance is performed by the calculator and a list of all entries exceeding a certain cut-off level is printed. Results are instantaneous, enabling the researcher to make decisions in the field. Only those lines selected are brought back to the main station for quality evaluation and further testing, thus reducing the number of grain sacks that must be transported and subsequently stored.

Once back on campus, the calculator is interfaced to a large computer and the data are transferred from the tape to large storage discs. The final computer summaries include disease reactions, yield results, other agronomic data and stored information from previous years. Annual yield summary books are then printed. By eliminating the need for manual transcription of data, speed and accuracy has increased significantly. It should also be noted that CIMMYT, based on the development and experience at OSU, is now using this system.

INFORMATION, GERM PLASM EXCHANGE, TECHNICAL ASSISTANCE

Publications

Oregon State University Cereal Team. 1976.
Results of the Third International Winter X Spring Wheat Screening Nursery.
OSU-CIMMYT

Oregon State University Cereal Team. 1977.
Results of the Fourth International Winter X Spring Wheat Screening Hursery.
OSU-CIMMYT

Kronstad, W. E., W. L. McCuistion, M. L. Swearingen and C. O. Qualset. 1977.
Crop Selection for specific residue management systems. ASA monograph
"In process of being published".

Scott, N. H., W. E. Kronstad and W. L. McCuistion. 1978. An electronic weighing and data processing system for field use in a small grain breeding program. "For publication in Crop Science - probably August, 1978."

Kronstad, W. E. 1977. Wheat breeding and genetics in the People's Republic of China. Wheat Delegation - National Academy of Science.

Oregon State University Cereal Team. 1978.
Wheat Cultivar Abbreviations (Winter and Spring)
Agricultural Experiment Station.

Vahabian, Mohammad. Factors influencing stand establishment of winter wheat under dryland conditions 1976. Ph.D. Thesis.

Cooway, Michael. The relationship between ATP and early germination in wheat. 1977. M. S. Thesis.

Yakar, Kamil. Earliness and winterhardiness in winter x spring crosses. 1977. M. S. Thesis.

Firat, Ertug. Inheritance and association of earliness and grain yield in four winter x spring wheat crosses (*Triticum aestivum* L. em Thell). 1977. M. S. Thesis.

Participation in Meetings

Technical Advisory Committee review of CIMMYT and all related international programs, Ciudad Obregon, Mexico. April, 1976. Presentations by Drs. W. E. Kronstad and W. L. McCuistion.

American Society of Agronomy meetings. November, 1976. Houston, Texas. Drs. W. E. Kronstad and W. L. McCuistion interviewed for new staff positions provided by the USAID grant.

India. The visit of Dr. W. L. McCuistion with Dr. M. V. Rao, Coordinator of the All-India Wheat Coordinated Program permitted time to develop a detailed outline of India's requirements for winter wheats in the northern Himalaya mountains.

Pakistan. An extensive field tour was arranged for Dr. McCuistion by Dr. M. Tahir, the newly appointed National Wheat Coordinator. The winter wheat nurseries will be grown in western and northern Pakistan.

Korea. The Korean Ministry of Agriculture invited Dr. W. E. Kronstad to participate as a team member in reviewing the National Wheat Research Program. The team members prepared a summary report providing suggested modifications and additions to the existing program.

Evaluation of Effectiveness of Program

The IWSWSN has served as an effective means of distributing useful germ plasm to all country programs. Data returned by over 70 percent of the cooperators indicate that scientists in developed as well as developing countries are making extensive use of the lines in the screening nurseries either through further hybridization or as direct varietal releases. A few specific examples are as follows:

Afghanistan. Approximately fifteen winter x spring breeding lines have been selected each year from the screening nurseries for advancement into yield trials. This germ plasm is especially well adapted to the regions of Kabul and similar high altitudes. The Afghan scientists are hopeful that one of these selections can be multiplied for release.

Algeria. The earlier winter x spring cultivars from OSU are well adapted to the high plateau regions of Setif, Tiaret and Siada in Algeria. The climatic conditions are very similar to those at the Sherman station in eastern Oregon. Selections are being advanced from segregating populations and the IWSWSN.

Argentina. Several selections from the winter x spring program have expressed good disease resistance and contain sufficient frost tolerance and/or winter hardiness for the region of Bordenave near Buenos Aires.

Brazil. Two different wheat research programs in southern Brazil are selecting the winter x spring germ plasm for resistance and tolerance to a number of important diseases and soil problems; i.e., aluminum toxicity caused by low soil pH similar to the conditions in western Oregon.

Chile. Dr. I. Ramirez (Santiago), Mr. J. Acevedo (Temuco) and Mrs. L. Aguayo (Chillan) each have several winter x spring wheat cultivars in yield trials. These cultivars exhibit good disease resistance and/or intermediate-to-high levels of winterhardiness.

An International Symposium on Rainfed Agriculture in Semi-Arid Regions. April, 1977. University of California, Riverside. Participant, Dr. W. L. McCuistion.

Regional Barley and Wheat Workshop. Amman, Jordan. April, 1977. Presentation on the OSU W X S Wheat Program by Dr. W. L. McCuistion. "The OSU International Nursery Program".

International Agricultural Development Service organizational meetings. Airlie House - Warrenton, Virginia. June, 1977. Presentation on Cereal Production in North Africa by Dr. W. L. McCuistion.

American Society of Agronomy Meetings. November, 1977. Los Angeles, California. Attendants, Drs. W. E. Kronstad and W. L. McCuistion.

The Fifth International Wheat Genetics Symposium. February-March, 1978. Presentation by Dr. W. L. McCuistion. "Development in the W X S Wheat Program during the Past Six Years."

Conferencia Regional de Cereales. CIMMYT-INIAP-CIDA. May, 1978. Quito, Ecuador. Presentation by Dr. W. E. Kronstad. "The International W X S Wheat Research and Graduate Training Programs at OSU."

Country Program Reviews

The People's Republic of China. Dr. W. E. Kronstad was a member of a Wheat Delegation reviewing the national wheat program during the months of May and June, 1976.

Jordan. The national wheat program of Jordan. Dr. W. L. McCuistion reviewed the national and university programs during and following the Regional Barley and Wheat Workshop during April, 1977.

Syria. Review of planned research sites and offices of ICARDA - Aleppo, Syria. Dr. W. L. McCuistion toured the research sites and interacted with new staff members to discuss future coordination of regional and international nurseries.

Iran. The wheat research team at the Karaj Plant Breeding Center spent four days with Dr. W. L. McCuistion reviewing the present field goals. They are relying on strong support from the new winter wheat station established by ICARDA at Tabriz, Iran.

Afghanistan. Representatives of the Ministry of Agriculture, the Agricultural University at Kabul and the Food and Agricultural officer of USAID provided complete support to Dr. W. L. McCuistion in reviewing their present wheat research. They also requested suggestions on future direction of the national research program. The overlapping visit of Dr. F. Zillinsky with Dr. McCuistion allowed additional discussions on coordination of international nurseries.

India. Dr. Sivaminathan, Director General - ICAR, and Dr. M. V. Rao, Coordinator, All-India Wheat Coordinated Program, have requested and received winter x spring wheat germ plasm for the major research centers in the Himalaya mountains. They are selecting facultative types with sufficient winterhardiness and earliness for the available moisture provided by the annual monsoon.

Iran. The scientists at the Karaj plant breeding center have selected three cultivars which are now in the second year of yield testing and under preliminary increase. Major emphasis for the winter and winter x spring wheat programs has now been moved to the Tabriz site in the mountains of northern Iran. The 5th IWSWSN was planted for the first time at this site in the fall of 1977.

Jordan. Over 50 advanced lines from the IWSWSN have been included in yield trials and five of these lines are also under preliminary multiplication at Amman, Jordan. These lines are of intermediate maturity and have expressed a sufficient level of frost tolerance.

Mexico. The CIMMYT program is using winter wheat varieties and advanced lines from the OSU winter x spring program as parents in the development of new Winter x Spring F1 single crosses at the Ciudad Obregon site and at Toluca in northern and southern Mexico, respectively. The diverse locations in Mexico provide ideal conditions to screen the gern plasm for resistance to stem rust, leaf rust, and stripe rust. Equally diverse sites in Oregon provide optimum conditions to identify resistance to stripe rust, septoria, powdery mildew, barley yellow dwarf, and the foot rots.

Nepal. Several selections from the IWSWSN have performed well in the Kathmandu regions and have been included in the national trials.

Pakistan. Promising IWSWSN lines are being evaluated in yield trials at Quetta (western Pakistan) and the hill areas in northern Pakistan.

South Africa. The similarity in climate, soils and production problems of South Africa and Oregon has stimulated a desire to exchange germ plasm. The IWSWSN and F2 bulk populations are presently being evaluated at Bethlehem. One of their scientists is presently visiting our program to select germ plasm and learn more about management of a plant breeding program. Severe attack of stem rust in South Africa will provide OSU with valuable information as to the best sources of resistance for incorporation into new hybrin combinations.

Spain and Portugal. Both Spain and Portugal are excited about the winter segregants from winter x spring F2 populations and selections from the IWSWSNs. The nurseries are being observed in the northern areas of both countries.

Syria. Close linkage has been established with ICARDA. Dr. J. Srivastava has requested and received the F2 bulk populations (250 entries) and the IWSWSN for selection in the zones of lower winter temperatures.

Tunisia. A number of cultivars from OSU are doing well in the higher altitudes of western Tunisia where late frost and occasional freezing temperatures occur. This is a region where production of spring wheats is frequently damaged by frost.

Turkey. Very close linkages with the Turkey wheat program and OSU for several years has provided winter x spring germ plasm to all winter and intermediate wheat zones. Both OSU and CIMMYT provided teams of scientists to develop a nationally coordinated wheat research program and winter x spring germ plasm has also been disseminated from the Turkey program.

Korea. The desire for earliness to facilitate double cropping with either rice or soybeans is a major breeding objective. Two advanced lines which look extremely promising and will be released as new varieties are Suweon #215 and #216. These lines resulted from the cross Strampelli/69D-3607//Jokwang. The parent 69D-3607 was a selection they obtained from the 1st IWSWSN. In addition, 12 lines from the IWSWSN are being used extensively for mildew resistance and 10 lines for stem rust resistance.

There is a definite potential for increasing yield levels in many LDCs. When yields of lines in the screening nursery are compared to the yield of the local check grown in the same trial, several spring x winter lines exceed the local check significantly.

Graduate training is an area that has benefited greatly from the spring x winter program. Many young scientists from LDCs who received their training at OSU have now returned to their country programs where they are assuming leadership roles and are making significant contributions in the area of wheat improvement. Many are now cooperators in the IWSWSN and return complete and extremely useful data annually.

Many thesis problems have been a direct spin-off of the spring x winter program. Factors effecting emergence and stand establishment have been studied. Earliness and winterhardiness in winter x spring crosses has been evaluated as well as the inheritance and association of earliness and grain yield. A study is currently underway of vernalization and photoperiod responses as related to earliness in wheat. Also in progress is an evaluation of breeding methods in certain spring x winter populations.

One important measure of the effectiveness of the program has been in the linkages established. Because of the prominance and worldwide reputation of the program based at OSU, many scientists from all over the world come to Oregon to interact with OSU staff and graduate students and to make selections in the breeding material for their country programs. Young trainees who have completed a course of study at CIMMYT frequently spend time observing and interacting in the program at OSU before returning home. This exposure has proved a definite benefit as it has increased the completeness and accuracy of the data returned from these country programs.

The program has been effective in establishing lines of communication and germ plasm exchange with countries such as The People's Republic of China and The USSR where political considerations had previously made such an exchange impossible.

AREAS NEEDING GREATER EMPHASIS

Early maturity and disease resistance, specifically stem and leaf rust resistance, are two areas which must receive greater emphasis in the germ plasm development phase of the program.

Even though progress has been made in developing earlier maturing lines, it is apparent that in developing countries, where moisture stresses are common late in the growing season or where multiple cropping is practiced, earlier maturity is a necessity. In addition to modifying vernalization requirements and day-length sensitivity, much more detailed information will be needed regarding various stages of growth, particularly the flowering, grain filling and physiological maturity stages of development. It appears that there is considerable genetic variability for differences involving grain filling and physiological maturity. A breeding procedure using recurrent selection to accumulate favorable minor factors for earliness has also been initiated.

Stem rust is not a major disease in Oregon and leaf rust, although becoming more important, may be inconsistent from year to year. Therefore, segregating populations are inoculated at Toluca, Mexico to insure that resistance to these diseases are incorporated into the materials. Also, additional sources of resistance are being obtained from the programs in South Africa and Argentina. Barley yellow dwarf virus is becoming a serious limiting factor with only minor sources of tolerance identified in wheat; thus, greater attention must be focused on this problem.

The desire to receive the screening nursery has prompted some to request the material where it has no chance of being adapted; therefore, an evaluation will be undertaken next year to determine that the nurseries are, in fact, going to winter wheat producing areas. The increasing demand for the nursery requires such an evaluation and reassessment. Currently, developing countries receive first priority on all germ plasm, including the IWSWSN, with other public breeding programs or institutions in various countries receiving lower priority. In the latter instance, only ongoing wheat breeding programs which are willing to share germ plasm receive any consideration. Greater emphasis must also be directed to South and Central American countries both in germ plasm exchange and training of scientists.

Increasing demand for the IWSWSN and the need to strengthen the graduate training program would suggest the need for an additional full time staff position. Currently the post-doctorate position is carrying a great deal of responsibility for various phases of the program.

APPENDIX I. Experimental Sites

The diversity of environments found in Oregon simulated conditions in most winter wheat growing areas of the world, making Oregon an ideal outdoor laboratory for screening material destined for other parts of the world.

Hyslop Agronomy Farm, Corvallis

Hyslop Agronomy Farm, one of the three major screening sites, has an average rainfall of 1000 mm per year and an elevation of 68 meters. The soil is an acidic (5.3- 5.5 pH) Woodburn silt loam. The mild wet winters and cool springs offer ideal infection courts for the fungal leaf diseases such as stripe rust, septoria and powdery mildew. Take-all, a root rotting diesase, and the aphid transmitted barley yellow dwarf virus are also factors that limit or inhibit yield in wheat in the Willamette valley.

Pendleton

At the Pendleton screening site, with an average rainfall of 500 mm, the primary cropping patterns involve a wheat-pea rotation. Bush beans can also be grown in rotation if irrigation is available. Here the elevation is 452 meters, soil pH is 6.5 and the primary soil type is Walla Walla silt loam. Pendleton is very similar to Ankara, Turkey in climate and rainfall patterns.

Stripe rust and Cercosporella (a foot-rot known as straw-breaker or eyespot) are the major diseases that limit production. Depending upon the year, selection for leaf rust and powdery mildew resistance can also be accomplished at this site. In cooperation with Dr. Robert Metzger, USDA-SEA, all the promising lines are screened for smut resistance on the Pendleton Experiment Station.

Hermiston, a site near Pendleton, provides excellent screening for barley yellow-dwarf virus, greenbug resistance and various root and mineral stresses associated with very sandy soils. This area has recently come under cultivation with the advent of circle irrigation. The green foliage resulting from continuous cropping under the circles provides a home for hosts of insects including the oat bird cherry aphid, a carrier of barley yellow-dwarf virus.

Sherman Experiment Station

The third major screening area is the dryland site of the Sherman County experiment station. Because of the low rainfall (250 mm) in this area, a wheat-fallow system of management is practiced. In this area, which is similar to the Anatolian plateau of Turkey, management and variety interactions are very important. Stand establishment and erosion control are the major areas where breeding and management converge. In order to prevent erosion, stands should be established early; consequently, lines that germinate under high soil temperatures and low moisture must be developed. Concurrent with stand establishment, drought tolerance and shattering resistance are major selection criteria in this area. Early lines, which escape the moisture stress, and those lines which are more efficient water users can be evaluated at this experimental site. Dry winds are a constant factor at this location exerting strong selection pressure for shattering resistance.

Other Experimental Sites

Besides these major screening sites, elite material and specific problem studies are grown in other areas of the state.

Madras and Ontario are high-production, relatively disease free irrigated areas where yield potential can be assessed. In the former area, the major crops are alfalfa, potatoes, peppermint and cereals. The latter area produces sugar beets, onions, peppermint, potatoes and cereals.

There are two high elevation sites: Burns (1413 meters) and Klamath Falls (1225 meters). Burns, on the high desert of eastern Oregon, provides good and consistent testing for winter-hardiness. In Klamath Falls, where the major crops are barley, potatoes, alfalfa and pasture, there are no guaranteed frost-free days. Breeding material is screened for frost tolerance at this site.

The acid soils on the slopes of the Willamette valley approximate the soil problems of areas like southern Brazil. On these hillsides screening for aluminum and manganese tolerance is carried out.

APPENDIX II. FORMER AND CURRENT GRADUATE STUDENTS IN THE CEREAL RESEARCH PROJECT

NAME	COUNTRY	SUPPORT	DEGREE	THESIS TITLE	CURRENT POSITION
FORMER STUDENTS					
Michel Abi-Antune	Lebanon	Rockefeller	Ph.D.	Competitive Stress as it Influences the Components of Yield in Winter Wheat.	Cereal Research Beirut, LEBANON
Selman Aktan	Turkey	USAID	M.S.	Nitrate Nitrogen Accumulation in the Soil Profile during a Fallow-Wheat Rotation.	Research Agronomist Zirai Aristirma Enstitus Samsun, Turkey
Maximino Alcala	Turkey	Rockefeller	Ph.D.	Evaluation of Parental Performance for Grain Yield in Two Populations of Wheat.	Seed Office CIMMYT, Mexico
Ali Bayraktar	Turkey	Rockefeller	M.S.	Inheritance of Plant Height in Barley	Instructor Roseworthy College, Aus.
Terd Charoenwatana	Thailand	Self	Ph.D.	Evaluation of Three Methods of Selection in Relation to Yield and Yield Stability in Winter Wheat.	Head, Plant Science Dept Khon Kaen University THAILAND
Mohamed Chemli	Tunisia	USAID	M.S.	Effect of Row Spacings, Seeding Rates and Nitrogen Fertilizer Rates on the Agronomic Performance of Yamhill and Hyslop Wheat.	Extension Service TUNISIA
Mike Conway	USA	Self	M.S.	The Relationship between ATP and Early Germination in Wheat.	Ph.D. student at University of Minnesota
Abderrazak Daaloul	Tunisia	USAID	M.S.	Evaluation of Early Generation Testing in a Diallel Cross Involving Four Winter Wheat Cultivars.	Director, Institute du Grande Culture du KEF TUNISIA
Ertug Firat	Turkey	Rockefeller	M.S.	Inheritance and Association of Earliness and Grain Yield in Four Winter X Spring Wheat Crosses.	Director Zirai Arastirma Enstitus Diyarbakir, Turkey
Mapangada Ganapathy	India	Self	Ph.D.	Influence of Population Density on Light Interception and Grain	Plant Genetics New Dehli, INDIA

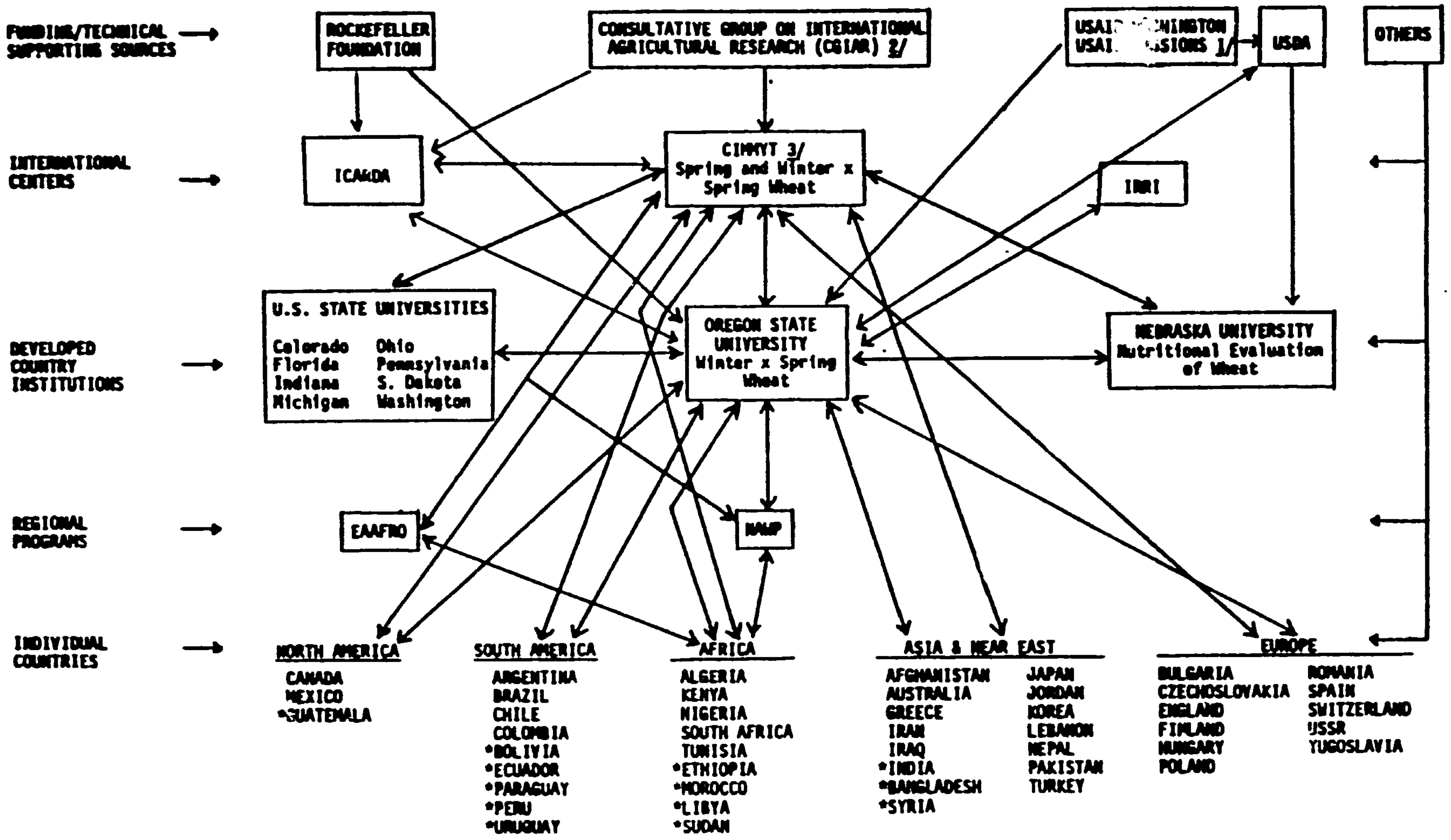
Name	Country	Support	Degree	Thesis Title	Current Position
Mengu Guler	Turkey	USAID	M.S.	Yield and Other Agronomic Characters of Winter Wheat Cultivars as Affected by Five Seeding Rates and Three Different Environmental Conditions.	Agronomist Wheat Research & Training Center Ankara, TURKEY
Moncef Harrabi	Tunisia	Rockefeller	M.S.	Estimates of Genetic Variance and Heterosis in Winter X Spring Barley Crosses (<u>Hordeum vulgare</u>, L.)	Barley Breeder TUNISIA
James H. Helm	USA	OSU Exp. Sta.	Ph.D.	Chemical and Genetic Evaluation of High Lysine and Protein in Selected Barley Crosses.	Professor Plant Science Dept. Univ. of Alberta, Canada
Charles A. Ihrke	USA	NASA	Ph.D.	Influence of Chelating Agents on Genetic Recombination in <u>Zea mays</u> L.	Biology Department University of Wisconsin
Erdogan Indelen	Turkey	Rockefeller	M.S.	Relationship of Composite Versus Pure Line Cultivars with Regard to Grain Yield in Winter Wheat.	Station Director and Breeder Edirne, TURKEY
Don Jones	USA	Self	Ph.D.	Influence of Chelating Agents on Cytological Crossing Over and Genetic Recombination in <u>Zea mays</u> L.	Department of Biology Centralia College Centralia, Washington
Don Keim	USA	OSU Exp. Sta.	Ph.D.	Drought Resistance in Winter Wheat.	Dept. of Plant Science S. Dakota State Univ.
Alfonso Lopez	Mexico	Rockefeller	Ph.D.	The Inheritance of Aluminum Tolerance from the Rye and Wheat Parentage in Triticale.	Teaching - University "Antonio Narro" MEXICO
Claudio Lovato	Brazil	Brazl Gvt.	Ph.D.	Inheritance of Tolerance by Wheat Cultivars to Magnesium Toxicity.	Teaching and Research Ste. Maria, BRAZIL
Cesar Martinez	Colombia	Rockefeller	Ph.D.	Study Involving the Inheritance and Mode of Action of Aluminum Toxicity in Rice.**	Director - National Rice Breeding Program Palmira, COLOMBIA
Jose Luis Maya	Mexico	Rockefeller	Ph.D.	Breeding Potential of Various Sources of Dwarfism in Wheat.	Director, INIA National Cereal Research Program, MEXICO

Former Students (continued)

Name	Country	Support	Degree	Thesis Title	Current Position
Alpaslan Pehlivantu:k	Turkey	Rockefeller	M.S.	Effect of Soil Temperature, Seeding Date, and Straw Mulch on the Plant Development and Grain Yield in Two Winter Wheat and Two Winter Barley Cultivars.	Agronomist, National Wheat Program Ankara, TURKEY
Clarence Peterson	USA	ARS	Ph.D.	Genotype-Environment Interaction in Winter Wheat F1 Progeny.	Wheat Breeder, SEA-USD Washington State Univ.
Don Roberts	USA	ARS	Ph.D.	Inheritance of Disease Resistance in Hops.	Mint Breeder, SEA-USDA OSU, Corvallis, Oregon
Surinder K. Saini	India	Self	Ph.D.	Influence of Plant Densities on Gene Action Estimates and Associations in Seven Winter Wheat Parents and Their F2 Progeny.	Teaching University of Ohio
Krisda Samphantharak	Thailand	OSU Exp. Sta.	Ph.D.	Nitrate Reductase Activity and Inheritance of Grain Protein in Six Barley Cultivars.	Sorghum Breeder THAILAND
Polat Solen	Turkey	Rockefeller	M.S.	Heritability Estimates and Associations for Protein Content and Grain Yield Involving Four Winter Wheat Crosses.	Spring Wheat Breeder and Coordinator Iyir, TURKEY
Mohammed Vahabian	Iran	Ford-CIMMYT	Ph.D.	Factors Influencing Stand Establishment of Winter Wheat under Dryland Conditions.	Cereal Breeder National Program IRAN
Kamil Yakar	Turkey	Rockefeller	M.S.	Earliness and Winterhardiness in Winter X Spring Crosses.	Principal Winter Wheat Breeder, Wheat Res. and Training Cent Ankara, TURKEY
Carlos Camargo	Brazil	USAID	Ph.D.	Aluminum Toxicity in Winter Wheat.	Plant breeder in charge of winter wheat Instituto Agronomico Campinas, Brazil

Name	Country	Support	Degree in Progress	Thesis Title
W. Larry Alexander	USA	Grad. Asst.	Ph.D.	Evaluation of General Combining As Influenced by Genotype X Environmental Interactions and the Development of a Model to Predict Progeny Performance.
Pedro Brajcich	Mexico	Rockefeller	Ph.D.	Combining Ability Analysis in Winter X Spring Crosses.
Mary C. Boulger	USA	OSU Exp. Sta.	M.S.	Relationship Between ATP and Early Germination in Barley.
Luz Gomez-Pando	Peru	CIMMYT	M.S.	Aspects of dryland winter wheat and barley production.
Federico Cuevas-Perez	Dom. Rep.	Rockefeller	Ph.D.	Rattooning Properties and Inheritance in Rice.***
Suthat Julsrigival	Thailand	Ford Fdn.	Ph.D.	Vernalization and Photoperiod Responses as Related to Earliness in Wheat.
Jim Mareck	USA	Grad. Asst.	Ph.D.	Evaluation of Recurrent Selection in Wheat.
Stephen Oakley	USA	Grad. Asst.	M.S.	Inheritance of Yield Components and Other Plant Characters in Four Winter and Four Spring Barley Cultivars
Guillermo Ortiz	Mexico	Rockefeller	Ph.D.	Evaluation of the Pedigree, Modified Bulk and Bulk Selection Methods in Winter X Spring Wheat Populations.
Vichien Petpisit	Thailand	Rockefeller	Ph.D.	Predicting Grain Yield and Selected Agronomic Traits in Parents Involved in Single, Three-Way and Double Cross Wheat Progeny.
Karen Schumaker	USA	Grad. Asst.	M.S.	Evaluation of Different Varietal Responses to Manganese Toxicity in Wheat.
Rollin Sears	USA	OSU Exp. Sta.	Ph.D.	Improvement of Nutritional Properties in Winter Barley.
Antonio Valencia	Mexico	Mexican Gvt.	Ph.D.	Wheat Composites vs. Pure Stands - Disease and Yield.
David Altman	USA	Grad. Asst.	M.S.	Inheritance of Quality Characteristics in Spring X Winter Hard Red Wheat.
Ali Osman Ekse	Turkey	Rockefeller	M.S.	Gametocide studies in wheat, barley and triticale.
Hwang Kee Min	Korea	I.I.E.	M.S.	

**Thesis research conducted at CIAT in cooperation with Drs. Jerry Grant and Peter Jennings.
***Thesis research to be conducted at IRRI in cooperation with Dr. W. R. Coffman.



1/ AID IS SHOWN APART IN ORDER TO INDICATE FUNDING LINKAGES TO U.S. RESEARCH INSTITUTIONS. AID ALSO CONTRIBUTES THROUGH BILATERAL ARRANGEMENTS TO INDIVIDUAL COUNTRY PROGRAMS. OTHER DONOR MEMBERS OF CGIAR HAVE CORRESPONDING ADDITIONAL FUNDING LINKAGES.

2/ THE DONOR MEMBERS SUPPORTING CIMMYT ARE CGIAR, FORD FOUNDATION, ROCKEFELLER FOUNDATION, GERMANY, UNDP AND IBRD. OTHER CGIAR DONORS INCLUDE BELGIUM, DENMARK, FRANCE, JAPAN, KELLOGG FOUNDATION, NETHERLANDS, NORWAY, SWEDEN, SWITZERLAND, UNITED KINGDOM. ALL CGIAR MEMBERS ARE POTENTIAL FINANCERS OF OPERATING LINKAGES WITHIN THE NETWORK.

3/ THE LINKS BETWEEN CIMMYT AND THE INDIVIDUAL COUNTRIES TAKE THE FORM OF INFORMATION AND MATERIALS EXCHANGE, THE CONDUCT OF SEMINARS AND WORKSHOPS, COOPERATIVE RESEARCH PROJECTS, ADVISORY SERVICES AND TRAINING.

* FUTURE COOPERATORS

CONTRIBUTIONS BY OSU AND OREGON WHEAT COMMISSION TO S X W PROGRAM

The total cost in conducting the spring x winter program is being provided by the USAID contract supplemented by funds and facilities contributed through Oregon State University and the Oregon Wheat Commission. Research funds obtained from the Oregon Wheat Comission are the result of the farmers taxing themselves one cent per bushel for all wheat sold.

Oregon State University, in addition to such items as office space, greenhouses, various laboratories and the computer center, is providing .50 of Dr. Kronstad's time and .20 of Ms. Boulger's and Mr. Knight's in recognition of their efforts on the spring x winter program. The university also just completed an $88,000 laboratory to facilitate the winter x spring program on the Hyslop Agronomy Farm. This laboratory was furnished from state appropriations. Included in this facility is a quality laboratory which will allow for an efficient evaluation of nutritional properties being incorporated into the germ plasm.

The Oregon Wheat Commission has contributed $27,000 for the purchase of equipment for quality evaluation in direct support of the winter x spring program. Their funds, along with Oregon State University's, are also contributing substantially to the operating budget for such items as part time employees, travel to experiment stations, and purchase of supplies.

A very significant aspect of the spring x winter program is that it provides a viable research program for the training of graduate students. These students may receive their stipends and living allowances from their own governments, USAID (separate from the W X S program), Rockefeller Foundation or the Ford Foundation. The ongoing international research program provides a more meaningful educational experience. It also serves as a mechanism which will establish future linkages for graduates from developing countries.

VISITORS FROM FOREIGN COUNTRIES TO THE CEREAL BREEDING PROJECT

July 1977 - July 1978

Visitor	Country	Position
Mr. Mostefa Laabassi	Constantine, Algeria	Short term trainee
Mr. Monsouar Batata	Algeria	" " "
3 Algerian Scientists	Algeria - CIMMYT trainees	" " "
1 Syrian Scientist	Syria - CIMMYT trainee	" " "
Mr. Nisi	Bordenave, Argentina	" " "
Mr. Jean-Bernard Dubois	Nyon, Switzerland	Long Term Trainee
Mr. Charl van Deventer	Bethlehem, South Africa	" " "
Mr. Christian Heustone	Temuco, Chile	" " "
Mr. Meallado	Chilian, Chile	" " "
Dr. Fahri Aktey	Ankara, Turkey	" " "
Dr. Harry Darling	Director, ICARDA - Syria	Visiting Scientist
Dr. Robert Havener	Dir. Elect, CIMMYT, Mexico	" "
Dr. Martinic	Zagreb, Yugoslavia	" "
Mr. Bartria	Kathmandu, Nepal	" "
Dr. Peter Jennings	Costa Rica - Rockefeller F.	" "
Dr. Ronnie Coffman	IRRI - Philippines	" "
Dr. R. G. Anderson	CIMMYT- Mexico	" "
Dr. N. E. Borlaug	" "	" "
Dr. S. Rajaram	" "	" "
Dr. Bent Skovmand	" "	" "
Mr. K. Z. Budin	Leningrad, USSR	" "
Dr. A. N. Lukyanenko	Krasnodar, USSR	" "
4 Turkey Scientists	4 Research Stations - Turkey	" "
4 Syrian Scientists	Syria	" "
Dr. K. S. Nathawat	Rajistan, India	" "
Dr. M. Duwayri	Wheat Coordinator- Amman, Jordan	" "
Dr. Art Klatt	CIMMYT - Quito, Ecuador	" "
Dr. Mike Prescott	CIMMYT - Ankara, Turkey	" "
Mr. Johnson Douglas	Rockefeller Foundation - Colombia	" "
Mr. Mir	Kashmir, India	" "
Dr. Jalalayar	Kabul, Afghanistan	" "
Dr. Bill Wright	IADS - New York	" "
Mr. John Doolette	ICARDA - Syria	" "
Mrs. Lily Aguayo	Chilian, Chile	" "
Dr. F. Zillinsky	CIMMYT, Mexico	" "
Dr. K. P. S. Chauhan	Pantnagar, U.P. India	" "
Mr. Ron Martin	Wagga, Wagga, Australia	" "
Mr. Ejhar Langkilde	Denmark	" "
Dr. A. Daaloul	Tunis, Tunisia	" "
Dr. SungHo Bae	Suweon, Korea	" "
Dr. Min	Suweon, Korea	" "
Dr. Max Alcala	CIMMYT, Mexico	" "
Mr. Flemming Juncker	Denmark	" "
Dr. Marco Quinones	CIANO - Mexico	" "
Dr. Kulb	Japan	" "
Dr. Singh	India	" "

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Oregon State University

Wilbur T. Cooney
Dean, School of Agriculture
Oregon State University

John Davis
Director
Agricultural Experiment Station
Oregon State University

Wilson Foote
Associate Director
Agricultural Experiment Station
Oregon State University

Dale Moss (and 10 faculty members)
Department Head
Crop Science Department
Oregon State University

Warren E. Kronstad
Professor of Agronomy
Crop Science Department
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(and 15 members of the Wheat League)

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F2 MASA SENT TO FOREIGN COUNTRIES

1977

Cooperator	Country
Dr. L.J. M. Noulard	Belgium
Dr. Kosta Gatzov	Bulgaria
Mr. P. Auriau	France
Dr. M.S. Swaiminathan	India
Dr. Art Klatt	Ecuador
Dir. E.E.A. INTA	Argentina
Dr. Milton Rocha	Brazil
Dr. O. de Sousa Rosa	Brazil
Dr. D. V. Almanza	Colombia
Mr. M. A. Noory	Afghanistan
Dir. Crops & Pastures	South Africa
Mrs. Ho	Canada
Dr. Manuel T. Barradas	Portugal
Mr. Gunnar Svensson	Sweden

1978

Cooperator	Country
Dr. L.J.M. Noulard	Belgium
Dr. Kosta Gatzov	Bulgaria
Mr. P. Auriau	France
Dr. Malik & Mr. Mir	India
Dr. Art Klatt	Ecuador
Dr. E.E.A. INTA	Argentina
Dr. Milton Rocha	Brazil
Dr. O. de Sousa Rosa	Brazil
Dr. V. Almanza	Colombia
Mr. M. A. Noory	Afghanistan
Dr. Pakendorf	South Africa
Mrs. Ho	Canada
Mr. John Bingham	England
Dir. Jean Roussineau	France
Dr. Aristeo Acosta-UAAAN	Mexico
Dr. R. K. Rai	The Netherland
Dr. K. J. Symes	Australia
Dr. Sung Ho Bae	Korea
Dr. J. Maya-CIANO	Mexico
Gil Hollamby	Australia
Dr. M. A. Kahn	Australia
Dr. Martinic	Yugoslavia
Dr. L. Aguayo	Chile
Dr. Varughese	Algeria
Dr. Daaloul	Tunisia
Dr. Fossati	Switzerland
Dr. L. MacFarlaine	Iran (ICARDA)

Don Kaminski - USA, Washington

Crossing Block and other selections also sent to numerous cooperators.

1979

7th IWSWSN

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WINTER	SPRING PLANTED
Hyslop	Hyslop
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Rugg	
Hermiston (2 sets)	
Flora	
Squaw Butte	

7TH IWSWSN

(Southern Hemisphere)

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