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ASSAYING IMPROVED HIGH PROTEIN CROP CULTIVARS FOR DEVELOPING COUNTRIES

Report of Workshop, Washington, D.C.
May 6-7, 1971

Convened by

Office of Agriculture and Fisheries, Technical Assistance Bureau
U.S. Agency for International Development
Washington, D.C. 20523

INTRODUCTION

TA/AGF is engaged in sponsoring research investigations and training of responsible scientists in improving high protein crop cultivars and production for developing nations. This effort is being supported directly from research being conducted in the United States with winter wheat at the University of Nebraska, with maize at Purdue University, with sorghum at Purdue and Puerto Rico Universities, with cassava at Georgia University, with soybeans at Illinois and Puerto Rico Universities, with beans and cowpeas at Puerto Rico (USDA cooperation) and to a lesser extent with yams and cassava at Puerto Rico.

Abroad TA/AGF directly supports the Regional Food Legume Improvement Project based in Iran. It concentrates on beans, cowpeas, chickpeas, mungbeans and lentils, and to a lesser extent broadbeans and pigeon peas. At Lima, Peru, TA/AGF is assisting in establishing a potato research and training center, commencing at first as a national program and in time with multilateral financing serving as an international center for research and training for this crop.

Indirect support for protein improvement from crops from AID financing is through increased production of protein from resulting research and training of national technical staff and workers for corn and wheat at the International Center for the Improvement of Maize and Wheat (CIMMYT) in Mexico, for rice at the International Rice Research Institute (IRRI) in the Philippines, and for corn, rice, food legumes and root and tuber crops, particularly cassava, at the International Tropical Agricultural Center (CIAT) in Colombia and Institute (IITA) in Nigeria. In addition to these agricultural specialties indicated for CIAT, this center is expected to

provide specialized support to bean and soybean improvement. IITA, on the other hand, could well be the international improvement center for the important legumes, cowpeas and peanuts, and possibly also for sorghum and millet. In addition to these international research institutes, AID is also financing such regional crop improvement projects as the USDA PASA East and West African Major Cereals (corn, sorghum and millet) Project and in part the West African Rice Development Association (WARDA). All of these projects in one way or another support increased protein production, the element most limiting to man's existence next to total food or calory production.

The worldwide nutrition gap is best illustrated in the following table.

Item of Comparison	Developed Countries	Developing Countries
Calories	2,941	2,033
Total protein per person, daily grams	84.1	52.4
Animal protein only, per person, per day	38.8	7.2
Population in millions	1,089	1,923

In developing countries where protein deficiency is considered most critical some 20 percent of the population is undernourished, i.e., one in five persons does not receive enough food of any kind or his intake of calories is much less than it ought to be. A far larger proportion, about 60 percent, is malnourished. This means that three out of five people in the developing world do not receive balanced nutrition in what food is available to them. The 60 percent value for the developing populations masks an even grimmer

reality. Protein deficiencies in human diet result in ill health and lowered productivity in adults. Over 300 million children in the world have been estimated to be victims of malnutrition.

Results from AID-financed intensive research efforts on protein improvement during the past five years with cereals at Purdue and Nebraska Universities have shown that genetic improvement of protein content and quality is not only possible but readily feasible. Genetic improvements to the extent of a three-fold increase (biological value) from opaque-2 maize and a minimum increase of 25 percent in protein without proportionally lowering lysine in wheat are established facts. These improvements are being incorporated into improved varieties for farmers of developing nations. Similar improvement as with wheat is expected with rice at IRRI and in time throughout the developing world. With Sorghum the extent of genetic improvement possible is not exactly known. It could far exceed that of the other cereals as the range in composition in protein and the limiting amino acids found to date is as follows:

7 to 26 percent for protein (commercial varieties average about 8 percent)

0.34 to 4.51 for tryptophan (the lowest levels may involve destruction. methodology still in developmental stage)

0.98 to 4.62 for methionine/crystine (sulfur bearing amino acids)

3.26 to 5.51 for isoleucine

9.5 to 17.1 for leucine

0.272 to 0.380 for isoleucine/leucine ratio (highest ratio desirable)

In South America the Llanera cultivar of cassava and a number of related strains have been chemically analyzed with about six percent protein.

The normal for this crop is generally recognized to be less than two percent. Related uncultivated species are known to contain twice this amount. The exact situation of the several thousand entries included in the cassava collection at CIAT and IITA for protein and amino acid balance is yet to be determined as are the agronomic and industrial values. As for other important root and tuber crops, such as the potato, sweet potato and yam, the true merits of the crops for improved nutrition, especially as related to more and better protein, are yet to be investigated. And as for the food legumes, work is now just beginning. From the investigations completed to date, improvement for content and quality of protein, inhibitors, etc., are essentially yet in their infancy. AID believes the first priority with the legume or pulse crops is to increase the yield of grain so that the crop can be economically competitive. As this is being accomplished, increased emphasis will be placed upon the nutritional values of the cultivars produced.

The gains in protein effected to date have been primarily based on chemical tests. Animal feeding and in vitro tests with sorghum and maize and more recently with triticale the man-made wheat-rye specie have demonstrated that all protein is not equally assimilable. This fact has opened up the entire subject of reevaluating newly-developed improved protein cultivars. If discrepancies exist, what are they? How can they be corrected? Should new techniques of evaluation be sought? Are current investigations being properly oriented? Or, should they be emphasizing other methods of approach? In a hybridization program, at what level of segregation should intensive evaluation for protein be started and to what extent

should the different amino acids be taken into account? If experimental animals are to be used, what should be the considerations for their selection? At what level should the protein be fed? Or, should other methods of evaluation such as fungi, bacteria, etc., be encouraged as the evaluation agencies? Or, should it be a combined effort? These are only a few of the many questions that confronted researchers working in the different disciplines of breeding and nutritional evaluation of improving cultivars for protein content and quality. In view of this status, it appeared opportune for TA/AGF to convene leading scientists representing the different crops and disciplines in Washington, D.C. on May 6-7, 1971, to determine what was known to date on the subject of improving protein content and quality of crop plants and based on the resulting interchange of information and experience attempt to identify for researchers and financing organizations the nature and magnitude of new efforts that might be undertaken to enchance effectiveness and accelerate the pace of development.

This report contains a copy of the agenda which lists the subjects that were covered during the meeting on progress, problems and potential for the improvement of various high protein crops and the recommendations developed by task groups for future operation and research. Summary copies of reviews presented at the seminar during the first day were made available to the participants during or following the meeting. Those interested in obtaining copies of the summaries should obtain them directly from the respective authors. Task group recommendations are included in this report.

We are grateful to the participants for the level of competence, interest and dedication displayed at the Seminar and reflected in their participation. Future progress in crop improvement can be assured. A beginning dialogue has been initiated. Annual seminars of this type are deemed essential to progress and anticipated.

Sanuel C. Litzenberger, Workshop Chairman
Agronomy Research Specialist
TAB/AGF/AID

Omer J. Kelley, Director
Office of Agriculture and Fisheries
Technical Assistance Bureau, AID

TASK GROUP REPORTS

Crop Improvement Considerations

Dr. L. P. Reitz, Work Group Leader

Cereals - Since there is underway considerable work on cereals, less time was spent discussing cereal improvement considerations than in discussing food legumes and root and tuber crops. It was suggested that genetic vulnerability not be forgotten as improved varieties of similar germplasm are being used over large areas. Therefore, it was suggested that cereal improvement programs maintain a broad germplasm base in developing improved varieties.

The need for developing hazard-resistant varieties was pointed out. Varieties and populations being developed by institutes, laboratories, etc., for use in LDCs must be developed in line with the hazards of diseases, insects, weather and problems peculiar to the areas into which such populations will be moved, otherwise such materials may be quite useless. Further, introductions of working collections or populations to certain areas may be of little usefulness since expertise is not available for proper examination and extraction of breeding lines. It is at this point that training and guidance need to be provided.

The importance of feedback to the originating centers, institutes, laboratories, etc., from the countries receiving lines and populations in regard to disease, insect, and other reactions of these lines and populations is important if hazard-resistant materials are to be developed.

Finally, the group reaffirmed the need for establishing an international institute for sorghums and millets responsible for the basic work of collecting, maintaining and improving sorghum and millet germplasm.

Food legumes - Germplasm used in soybeans and other food legumes has been very limited. In most cases, germplasm collections are either inadequate or not available. Some of the earlier collections are no longer viable. Some of the more important centers of origins have not been sampled since the early 1930's.

Many of the food legumes have limited adaptation. In soybeans, and perhaps the other food legumes, there is a need to develop plant types with broad adaptation, perhaps including determinant growth habit, appropriate leaf type, early maturity, and day-length insensitivity.

A primary consideration in the food legumes is to increase yield. Germplasm available has not been sufficiently exploited. Specific food and taste habits of peoples for food legumes have developed that are difficult to overcome. Such personal preferences should be kept in mind when developing lines or populations for use elsewhere.

There is a need for international nurseries, especially for soybeans, and should include the arid and humid tropics as well as temperate zones.

Roots and tubers - Many of the root and tuber crops are in a primitive state, or varieties are inaccessible or unavailable to workers. A start towards the exchange of information and materials is the International Association For Root Crops. A newsletter edited by Dr. Martin serves as the communicating vehicle.

Internationally, programs and scientific manpower assigned to root crop improvement have been very few in number. Many of the root crops are of some importance all over the tropics but only a few are of great importance in any one place. The more important ones are cassava, yams, and sweet potatoes.

Root and tuber crops pose special problems of storage, germplasm maintenance, and shipping. Because many roots and tubers have extremely short shelf life, processing techniques must be developed in order to extend the storage time in a durable but readily available form.

Most of the root and tuber crops are low in protein. However, the yam appears to have the greatest protein and nutritional potential. In some of the roots and tubers, only a part of the nitrogen is in an avail able form.

Along with the problems of lack of personnel and small programs are the lack of clearly defined objectives for root and tuber improvement. IITA and CIAT are established major international centers for root and tuber crop improvement and training of research and production workers.

The group concluded from the discussions that:

1. For varietal improvement of cereals, root crops, food legumes, and oil crops the primary considerations were (a) yield; followed by (b) increased protein and the best combination of nutritional factors; (c) stability of performance as determined by adaptation and hazard resistance; and (d) problems of processing and storing, especially of items with short shelf life.

2. Germplasm resources need to be upgraded in order to preserve rapidly dwindling native types, to facilitate collection, and to aid in the maintenance, evaluation, and exploitation of these collections. Root and tuber crops which often are not reproduced by seeds pose special problems of maintenance, exchange, and quarantine.
3. If international research centers are established, they should be centers of coordination and communication with interdisciplinary approaches. They should provide for formal and informal exchanges of materials (germplasm and working populations) and information (provide expertise to cooperating scientists regarding utilization of available materials).

Food Protein Nutritional Factors

Dr. Constance Kies, Work Group Leader

Various factors interact as determinants of the protein value of a food. These include the following:

Total protein content. A 5% protein product is less likely to make an important contribution than is a 30% protein product.

Amino acid profile. The closer the amino acid profile of a food "matches" the human amino acid need profile, the lower is the amount of the food protein necessary to meet human requirements. Amino acid profile imbalances resulting in increased protein need may be the result of a relative low or a relative high content of any of several specific amino acids.

Digestibility and availability. Regardless of the quality of amino acid profile or quantity of protein, a product of poor digestibility or a protein of poor availability will be of limited protein value.

Toxic factors and antimetabolites. Cereal and plant products may contain a variety of materials which inhibit protein utilization and metabolism either directly or indirectly. Increasing protein quality or quantity of a cultivar may be ineffectual to total improvement of protein nutriture of animals or people if these materials are also increased.

Organoleptic characteristics. People tend to eat specific foods for properties other than nutrition. Regardless of the nutritional merits, a product is not nutritious if people won't eat it. Hence, baking properties, taste, odor, color, etc., must be considered.

Total nutritional value. A product which sacrifices certain vitimin/mineral characteristics for improvement in protein content or amino acid profile, may adversely affect the population to which it is fed; protein adequacy is closely tied to adequacy of other nutrients.

Sociological factors. Understanding of countless economic, political, psychological, cultural, behavioral considerations is necessary to explain why people act as they do. If a product is not adopted, its nutritional value is meaningless.

These above factors are not necessarily listed in order of importance; in fact, order probably varies with food product and situation involved. Ideal methods of biological evaluation would take all of these factors into consideration to the appropriate degree for insurance of accurate and valid prediction of protein value of the food for the particular number of population involved. Obviously, practical considerations necessitate compromise with this ideal for initial mass screening of cultivars for improvement in protein quality.

A systematic approach to mass biological screening is needed. While it is highly desirable that a single methodology approach be developed in which all cultivars for evaluation could be logged, it may very well be that such a single panacea method is non-existent. Possibly assay methodology will need to be adapted to the type of cultivar to be evaluated and its assumed use.

Current evaluation standards involving biological assay are perhaps not those most appropriate. By nature, biological assay methods are most useful for assay of total nutritional quality but are less precise for

individual nutrients than are chemical methods. There is a great need for further research for establishment of appropriate standard methodology for the particular problems posed by mass screening of large numbers of cultivars for which only limited amounts of the product are perhaps available (possibly 1/2 to 1 kg). Specifically, the following points need immediate stress:

Selection of animal model. Time, expense and limited product availability necessitate the use of a small animal as the biological model for initial screening. Ideally, the nutritional requirements, particularly as related to protein and amino acid requirements, should be well defined and be closely similar to those of the human--assuming the product is being evaluated for ultimate human consumption. (While the discussants were in agreement on this general point, precisely what is meant by the term "well defined" obviously was a point of contention, particularly in reference to the vole.) This also includes considerations related to comparable digestibility and availability of these animal models with human beings. The desirability of feeding small groups of animals for short periods of time was also noted because of limited product availability. However, limiting animal group size and term of feeding probably necessitates uniformity in genetic background of animals used. Human beings have great diversity in genetic background with resulting variation in nutritional need which suggests the desirability of using animals of non-uniform genetic backgrounds. Obviously, these two considerations work at opposition to one another. Among discussants immediately

involved, the rat, the mouse, the chick and the vole were animal models of choice. In the interim until results of research on comparative value of specific small animal models, the discussants agreed that concentration should be on those animal models for which nutritional requirements are well known.

Development of a step sequency for evaluation with initial steps applicable to large numbers of samples. The initial step of mass screening should include collection of data on digestibility and growth. "Less promising or poorer" samples should be eliminated on this basis. The next step should involve methods for collection of data related to carcass composition. Again, samples should be eliminated on this basis. Succeeding steps might involve collection of data related to longevity, reproduction and lactation. The ultimate step should involve evaluation using human subjects. (It is assumed that multiplication of samples will be concurrently occurring.)

Formation of precise details related to the step-wise evaluation procedures. Test ration formulation and control ration formulation should be uniform among laboratories evaluating similar cultivars if data is to be interchanged. The basic question of formulation of rations on the basis of equal amounts of product or equal amounts of protein was not resolved in the time allowed. This question needs fast resolution because of the disagreement of discussants on this vital point. That a great many other details need resolution was recognized by the discussants but time limitations necessitated exclusion even of their discussion.

In conclusion, it was agreed that AID could best be of help by creating a small committee to investigate and resolve the problems of methodology presented in the above discussion.

Methods of Analysis

Dr. E. T. Mertz, Work Group Leader

Protein Determination

These recommendations apply specifically to the setting up of working laboratories in the less developed countries (LDCs).

The laboratory must be furnished with certain items of basic equipment: (1) grinder, (2) centrifuge, (3) soxhlet extractor, (4) analytical balance, (5) colorimeter, (6) pH meter, (7) oven, (8) basic microkjeldahl equipment, (9) distilled or deionized water, and (10) electrical power.

Standard microkjeldahl procedures should be used to obtain reference protein values. Depending upon the crop, faster methods such as the dye-binding or the direct methods can be used for mass screening.

Specific Amino Acids

Lysine. We recommend the pyridine method which has been standardized with primary standards for the determination of lysine in selective maize, wheat, rice and triticale samples. The method has not been adapted successfully as yet for sorghum. Mass screening may be accomplished by relating quantitative lysine values in the reference samples to the dye-binding method. These methods also appear to be suitable for barley and oats. With maize, the defatted endosperms are usually more quantitative than the whole kernel values.

Tryptophan. We recommend the papin-Opienska-Blauth procedure which has previously been standardized with reference samples for the determination of tryptophan in maize samples. The best screening is obtained using the separated defatted endosperm.

Methionine. We recommend a microbiological method such as the *streptococcus zymogenes* method which has been standardized against reference samples for determination of methionine in legumes.

Cystine. Satisfactory colorimetric and microbiological methods are available for determination of cystine in the legumes.

Roots and Tubers

We recommend that the LDC Laboratory use a protein screen first using the microkjeldahl method. Those samples with a satisfactory level of total protein could then be sent to an outside laboratory for determination of complete amino acid pattern using an automatic amino acid analyzer. Once the first limiting amino acid of the root or tuber protein is identified, specific simple methods could be devised for the improvement of the crop by genetic means.

Contribution of technically advanced research centers to the operation of the LDC Centers

The major contributions of technically advanced research centers should be (1) the development of improved methods of protein and amino acid analysis adaptable to the laboratory capabilities of the LDC Laboratory, and (2) the provision of suitable samples of cereals, legumes, tubers and roots with appropriate instructions for their use as primary standards in the LDC Laboratory. Special attention should be given by both the technically advanced research centers and the LDC Laboratories to the proper grinding and preparation of samples for analysis.

Cooperating Organizations and Linkages Workshop

Dr. Omer J. Kelley, Work Group Leader

In summarizing the general attitude and feelings of the scientists representing the subject of "cooperating organizations and linkages" they supported the broadest view possible, one that encourages initiative and cooperation, not competition, in developing and providing support to increased agricultural production for developing nations.

With an ever increasing interest in international agricultural production in the LDCs and a general scarcity of resources, the establishment of international networks of improvement and training centers is evolving as a result of greater coordination among donor and recipient countries and organizations as a means of meeting international research needs. In response to those needs, two types of institutions or centers have come into being beyond the boundaries of the U. S. One is the international center whose research covers global problems and is supported by international donors; the other is the center which restricts its coverage to limited areas. It satisfies regional needs, countries with specific needs which are climatologically or ecologically limited and likely to benefit similar regions elsewhere.

Currently there are four international centers which are organized to satisfy worldwide research and training needs for the major food crops as well as related production factors. All are crop-oriented. They are as follows:

1. CIMMYT - International Improvement Center for Maize and Wheat, established by the Rockefeller and Ford Foundations in Mexico and now also supported by financial assistance from AID.

2. IRRI - International Rice Research Institute, originally established in the Philippines with assistance from the Rockefeller and Ford Foundations and now also assisted by AID.

3. CIAT - International Center for Tropical Agriculture, incorporated in 1968 in Colombia by Rockefeller, Ford and Kellogg Foundations cooperating to support rice, maize, food legumes, root and tubers, and two classes of livestock, beef and swine. Currently, CIAT is also financially supported by AID. In rice, corn and wheat, CIAT is considered subordinate to CIMMYT and IRRI and the international cooperation effort.

4. IITA - International Institute for Tropical Agriculture, established in Nigeria by the Rockefeller and Ford Foundations, Canada and AID to support rice, maize, food legumes, and root and tuber crops.

A fifth international center is under consideration. It would support research and training for potato improvement in Peru. The project was initiated with U. S. assistance to be established where potato germ plasm sources exist naturally. It originally started as a national improvement program. Multi-donor financing and support of this center in Peru as an international research and training institution are being negotiated among

interested cooperators--AID, Germany, France, Canada, United Kingdon, Belgium, Sweden, Netherlands, Spain, IBRD, FAD and the Rockefeller Foundation.

At the regional level of international cooperation a number of centers of coordination have been established with U. S. support to provide special assistance to cooperating national programs which have in some way pooled their resources to more effectively provide research and training needs for the organized regional areas. The major ones are as follows:

1. Southeast Asian Cereal Improvement Program, established in Thailand in support of sorghum and maize in that country, Philippines, Laos, Vietnam and Cambodia. The Rockefeller Foundation is a major supporter.

2. North African Wheat Improvement Program, established in Tunis to increase wheat production in Tunisia and Morocco. Major technical assistance is through CIMMYT with outside financing from AID with some financial assistance from the Ford Foundation.

3. East African Major Cereals and Legume Program, established in Kenya and Uganda to improve sorghum, millet, corn and food legumes in these two countries and Tanzania, a USDA PASA effort.

4. West African Major Cereals Program, established in Nigeria to increase maize, sorghum and millet production in Nigeria and other interested West African nations, a PASA activity.

5. Central American Crop Improvement Program, established in Nicaragua to provide research and training support primarily

through CIMMYT to the six cooperating republics beginning first with maize and now including sorghum and food legumes, especially beans.

6. West African Rice Development Association (WARDA), is in the process of being established to support fourteen West African republics, basic applied research and training for increased rice production, to be a multi-donor activity involving AID, FAO France, United Kingdom, IBRD, and others.

7. Middle East and Latin American Food Legume Improvement Project, established in Iran and Puerto Rico, respectively, to support applied regional research and training needs of cooperating countries, a PASA project.

Other centers under consideration for increased protein development are for sorghum and millet, upland crops, livestock production and food legumes.

With respect to the international center for potatoes, the Peruvian government took the initiative with AID support in 1970 in the development of a national program which is to take on an international research and training responsibility as soon as financial support can be worked out with the multi-donor contributors.

An ever increasing need exists for the LDCs to increase their own capacity to conduct their own research so they can better utilize the resulting efforts of the international research network. To a great extent this can best be accomplished by proper linkage with the international

centers. National programs must be equally supported as without national efforts or abilities to cooperate, the international centers' cooperation could go wanting. Centers of expertise should be more fully utilized wherever they might exist (U. S. Universities, USDA, individual nations, etc.) and tied into an internation system of research and training. This should be a normal sequence of events as each should be encouraged to contribute according to their abilities and competence.

AGENDA OF PROGRAM

ASSAYING IMPROVED HIGH PROTEIN CROP CULTIVARS FOR LDCs

May 6-7, 1971

New State Building*

Thursday, May 6, 9:00 a.m. - Conference Room 5951

INTRODUCTION

9:00	Components of Protein Nutrition of Crops for LDCs - Dr. Milner, UNICEF/UN
9:15	AID Projects Supporting Higher Protein Crop Development for LDCs - Dr. Peterson, AID

PROGRESS TO DATE

	A. Development of Higher Protein Cultivars - Dr. Schmidt
	1. Major Cereals
9:30 - 9:50	Wheat - Nebraska, USDA - Drs. Reitz and Schmidt
9:50 - 10:10	Corn - Purdue, USDA, CIAT - Drs. Sprague, Alvarez-Luna, and Bauman
10:10 - 10:30	Sorghum and Millet - Purdue, USDA - Drs. Pickett and Webster
10:30 - 10:45	Triticale, CIMMYT - Dr. Zillinsky
10:45 - 11:00	Barley, Oats, Rice - USDA - Drs. Adair and Webb
	2.
11:15 - 11:40	Food Legumes - USDA, Rockefeller Foundation - Drs. Meiners and Roberts
	3.
11:40 - 12:00	Roots and Tubers - CIAT USDA - Drs. Grant, Albrecht and Martin

*It will be convenient to use the 21st Street Entrance.

LUNCH

B. Laboratory Analyses - Dr. Mertz

1. Chemical and Enzymatic Evaluation

Nutritional factors investigated, analytical methods employed and unresolved problems of major consequence.

Cereals

1:15 Dr. Mattern - University of Nebraska

1:30 Dr. Mertz - Purdue University

1:45 Dr. Villegas - CIMMYT

2:00 Dr. Hoover - Kansas State University

Legumes

2:15 Drs. Meiners and Howell - USDA

2:30 Dr. Adams - Michigan State University

2:45 Dr. Kelly - Campbell Institute

3:00 Dr. Hymowitz - University of Illinois

Roots and Tubers

3:10 Drs. Martin and Webb - USDA

3:20 Dr. Alvarez-Luna - CIAT

2. Biological Evaluations

Nutritional factors being evaluated and methods employed.

Cereals

3:30 Dr. Mertz - Purdue University

3:45 Dr. Borchers - University of Nebraska

4:00 Dr. Sullivan - University of Nebraska

4:15 Dr. Harpstead - Michigan State University

4:30 Dr. Kies - University of Nebraska

Legumes

4:45 Dr. Kelly - Campbell Institute

5:00 Dr. Adams - Michigan State University

Roots and Tubers

5:15 Dr. Grant - CIAT

Friday, May 7, 8:30 a.m.

ESTABLISHING PRIORITIES AND GUIDELINES FOR PRESENT AND FUTURE RESEARCH

8:30 - 10:00 Individual Work Groups

A. Crop Improvement Considerations - Cereals, legumes, roots
Drs. Reitz, Schmidt, R. Webb, Meiners, Zillinsky, Pickett, Tahir, Bauman, Adair, Webster, Jackobs, Litzenberger, and Martin - Room No. 5941

B. Food Protein Nutritional Factors
Drs. Kies, Clark, Alvarez-Luna, Hoover, Kapsiotis, Jambunathan, Forman and Hornstein - Room 2243

C. Methods of Analysis
Drs. Mertz, Mattern, Howell, Villegas, Harpstead, Bill Webb, Adams, Rechcigl, Kelly, Sullivan, Borchers, and Hymowitz - Room No. 2243

D. Cooperating Organizations and Linkages
Drs. Kelley, Roberts, Hulse, Caldwell, Perez, Albrecht, Grant, Strasburg, Broadnax, Breitenbach, and Wellhausen - Room No. 2245

10:00 - 12:00 Room No. 5941

A. Crop Improvement Considerations - Dr. Reitz, USDA

B. Food Protein Nutritional Factors - Dr. Kies, Nebraska Univ.

C. Methods of Analysis - Dr. Mertz, Purdue University

D. Cooperating Organizations and Linkages - Dr. Kelley, AID

ADJOURNMENT

LIST OF SEMINAR PARTICIPANTS

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Dr. F. Zillinsky, Triticale Investigations, Mexico

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Dr. O. J. Webster, Sorghum, Millet and Corn Investigations (Nigeria, P.R.)
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Dr. Ray L. Borchers, Biochemistry and Nutrition Dept. (Rat feeding)
Dr. John W. Schmidt, Plant Breeder (Wheat)
Dr. Constance Kies, Department of Food and Nutrition (Human nutrition)
Dr. Paul Mattern, Biochemist
Dr. Tom W. Sullivan, Poultry Science Dept. (Chick feeding)

University of Puerto Rico

Dr. Mario Perez, Agricultural Experiment Station, Rio Piedras

Michigan State University, East Lansing

Dr. D. D. Harpstead, Chairman, Crop and Soil Science Dept.
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