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Improvement

IMPROVEMENT OF NUTRITIONAL QUALITY OF WHEAT THROUGH
INCREASED PROTEIN CONTENT AND IMPROVED AMINO ACID BALANCE*

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International Research Networks for the
Production and Two-Way Flow of Knowledge

The technological tools to improve the protein nutrition of wheat developed over the past 17 years. During this time analytical methods for amino acids were automated and a genetic source for higher protein was discovered in wheat. Genes for higher lysine in corn were identified about eight years ago and immediately interest developed in the possibility to improve protein nutrition in the cereal crops.

The project "Improvement of Nutritional Quality of Wheat Through Increased Protein Content and Improved Amino Acid Balance" was initiated at the University of Nebraska July 1, 1966. The initial thrust was to screen 16,000 entries in the USDA World Wheat Collection as quickly as possible for lysine and protein differences. Promising higher lysine sources were to be combined with newly identified high protein sources and with already existing high protein experimental winter wheats from the Nebraska-ARS program. Secondly, we were to make available to developing countries hybrid populations and improved lines for evaluation and use.

Work activities of the project are summarized in Table 1. The project has used a team effort among laboratory and wheat breeding personnel to achieve the objectives of the project. Major responsibilities for the laboratory and breeding activities are given in Tables 2 and 3, respectively.

It became evident very quickly that the most difficult aspect of the effort was that concerned with introducing into developing countries new wheats with improved protein and lysine adapted to the varying environments of these countries. We had no established lines of communications and

*One of four papers on the Uses of Research presented at the Review of Centrally Funded AID Research, Washington, D.C., May 28, 1971

almost no information about the adaptation of wheat varieties to serve as recipient genotypes for protein and lysine genes. Our need to obtain information on wheat variety adaptation led to the establishment of an International Winter Wheat Performance Nursery (IWWPN) in 1969. Because of its key role in our communications effort, the IWWPN will be discussed in detail.

Objectives and Intent of the IWWPN

The following summarize the objectives of the IWWPN:

1. Identify superior winter wheat cultivars for use as parents to combine with best identified nutritional wheats.
2. Measure the impact of environment on high protein varieties.
3. Provide a vehicle for future testing of nutritionally superior types.
4. Provide convenience for establishing and maintaining communications with key wheat research personnel in LDC's.

Work Activities in the Operation of the IWWPN

A time schedule of the work effort associated with the International Winter Wheat Performance Nursery is outlined in Table 4. You will note that these activities occur throughout the year and have added substantially to our work load.

Evidence for Impact of the IWWPN

The interest in the IWWPN is very high and most of the winter wheat producing countries in the world have asked for and receive the nursery. The third planting of the IWWPN at 38 nursery sites in 24 countries will be harvested during 1971. In 1972 the Fourth IWWPN will be planted at 44 sites in 27 countries (Figure 1).

Foreign cooperators have sent more varieties for inclusion in the nursery than can be accommodated. Thus, it has been decided to establish a preliminary screening nursery to identify the very best entries for eventual inclusion in

the main nursery (Table 5). Therefore, IWVPN cooperators will be evaluating promising materials more quickly.

We were able to confirm the superiority of protein content in a high protein variety during one year of testing in the IWVPN. Wheat varieties with outstanding agronomic characteristics have also been identified. The inquiries about varieties in the nursery provide evidence of the level of interest among foreign cooperators and utilization of the information. In Afghanistan four varieties tested in the IWVPN are being increased for possible release in that country.

We issue preliminary reports of IWVPN results promptly to all cooperators, AID, FAO, CIMMYT, and most other wheat researchers of the world. Comprehensive IWVPN reports are being published annually as Nebraska Experimental Station Bulletins for world-wide distribution through our usual channels.

Project personnel have visited 16 of the nursery sites and established personal contacts with cooperators. The increasing size of international effort has required that we add a staff member to coordinate nursery and other international activities.

Currently, we are organizing an international seminar of IWVPN cooperators for May, 1972. Accumulated data and results of the nursery and our nutritional research effort will be discussed. Future plans for continuing the cooperative nursery effort will be formulated.

The conference will be held in one of the LDC's growing the IWVPN, and at a time when conferees can see and discuss the local IWVPN. Such a conference is extremely important in promoting involvement on the part of wheat researchers in LDC's. Their counsel is sought and will be reflected in future plans.

Suggestions have been received from cooperators for ways to improve the nursery and provide additional valuable data. We have been most gratified

with cooperation to date. For example, samples of seed from each plot for two years of harvest have been promptly returned to Nebraska for protein and lysine analyses.

Efforts to Promote Early Utilization of our Research Results

Laboratory reports are issued periodically to a large and comprehensive group (Table 6). We try to keep the reports concise and to the point. Masses of data of questionable relevancy or value are eliminated. Reports are organized in relation to project objectives with a brief summary prefix.

In order to develop an adequate mailing list, copies of the first progress report were sent to domestic, foreign and international agricultural agencies with instructions to circulate the report to wheat researchers or other interested personnel. Names and addresses were returned for addition to our mailing list. This preliminary endeavor was fairly successful; however, the mailing list continues to be expanded as a result of personal contacts.

Evidence of Utilization of Reports

Each progress report concerned with screening activities carried two selected lists of better nutritional samples identified from the USDA World Wheat Collection. One consisted of higher protein lines and another of higher lysine materials. Requests for seed from these lists followed the publication of each report (Table 7). Requests are forwarded to Dr. Joe Craddock, who is in charge of the USDA World Wheat Collection in Beltsville, Maryland. We inform researchers that seed requests should go directly to Dr. Craddock. Therefore, subsequent and many other initial requests undoubtedly go directly to the USDA and are not summarized in Table 7.

Requests for Additional Technical Information

Several countries have asked for an individual summary of screening data from the World Wheat Collection by country of origin. Several agencies

are putting our screening data on magnetic tape along with their own for other characteristics so that data processing and retrieval is more flexible.

A Swedish researcher interested in germination emergence vigor asked for C.I. numbers of varieties with the largest germs. This was available from morphological measurement studies on selected samples in which we were comparing lysine levels with various kernel characteristics.

Communication Efforts Through Publications

The Nebraska Wheat Team, consisting of four professionals working to improve the nutritional value of wheat, has presented a total of 23 papers, 16 of which were given at domestic and 7 at foreign meetings (Table 8).

In addition, 36 printed abstracts, book chapters, journal articles, proceedings, and lectures have been published.

There have been 296 requests for these publications by foreign researchers and 125 for domestic workers for a total of 421 (Table 9).

Requests for Laboratory Techniques

A large screening effort requires many laboratory innovations. Existing analytical procedures or handling techniques must be modified in order to provide the necessary data to sustain a large wheat breeding effort. Part of the requests for information are made by visitors to the laboratory (Table 10). Others are made through requests for publications related primarily to laboratory screening techniques.

Foreign Students

In addition to foreign students working in the Department of Agronomy, there are foreign visitors from adjacent states, the CIMMYT training program and from students attending or traveling to scientific meetings in the U.S.

Cooperation with Other International Groups

CIMMYT

In 1967 we asked CIMMYT researchers for their expertise in organizing the International Winter Wheat Performance Nursery (IWWPN). In addition, CIMMYT made some of the initial contacts with potential nursery cooperators for us.

We have made available to CIMMYT many hybrid wheat populations involving the Mexican dwarf spring wheats crossed with high protein and/or high lysine types. In this way segregating spring types may be identified. These same duplicates, which involve the winter growing factor, are propagated under winter environment in our nurseries to identify the winter progenies.

Project personnel have made four trips to Mexico to counsel with CIMMYT people and exchange information and ideas (Table 11).

FAO

We have also involved FAO expertise in nursery management. FAO aids in distributing nursery seed to certain countries. FAO (and others) are making suggestions as we plan for an International Seminar on the IWWPN to be held in May, 1972. In turn, we have participated in FAO wheat seminars in the Near and Mid-East.

International Research Networks for the Production and Two-Way Flow of Knowledge

We have attempted to summarize our major communication efforts in Figure 2. Our contacts are primarily with working scientists in the various agencies. We have not identified groups with whom we have had only an occasional exchange of information. Foundations sponsoring CIMMYT are also not identified separately. We realize many more than these identified are making contributions.

Utilization of Research Results in the LDC's

There is a continuing large number of requests for seed of lines identified in our reports and publications. Early use of the wheat variety Bezostala in central Turkey was in part the result of its superior performance in the IWPN in Turkey and neighboring countries.

Nebraska adapted lines have performed well in other growing environments. Two Nebraska entries in the International Winter Wheat Rust Nursery are a case in point. Bolal was registered and released in Turkey, and Belinda will be released in South Africa. On this basis we would expect other Nebraska adapted wheats to do well in other winter wheat areas.

Our Techniques for Feeding Information and Material into LDC's and Other Organizations

1. Public release of high protein germ plasm from Atlas 66. In 1970, 26 lines of high protein winter wheats were released. We have received a great number of requests for samples of this seed.
2. Twelve, more advanced, promising, high protein experimental varieties are under release at several locations. Following harvest this summer, arrangements have already been made to send seed in quantity to Turkey, Afghanistan, and probably Iran for testing and propagation. Agronomic data from these lines would suggest their superiority in the Near East locations.
3. We compile and distribute lists of promising hybrid populations coming from the project. These crosses contain genes for high protein and/or high "lysine" and are available to foreign and domestic wheat breeders. Several populations are being grown in Korea for selection and evaluation. This distribution activity will increase because several new populations with better nutritional potential are ready for distribution in 1971.
4. Initial screening of promising hybrid populations in our laboratory is made to identify segregates with best nutritional potential. These will be offered to LDC's not having the laboratory capability to do their own screening. They are requested to return the best agronomic selections in their country to our laboratory for final nutritional quality evaluation.

Our Philosophy for the Project to Improve the Protein Nutritional Quality of Wheat

The initial thrust of the project was to identify existing wheat varieties with higher protein and/or lysine. The breeding effort did not wait

until this portion of the project was completed. As materials were identified they were crossed with the best known agronomic types. At times nutritional data on some better agronomic parents were not known. At other times rechecks on improved lines had not been verified by recheck. However, crosses are easy to make and easy to throw away.

The result of this approach is that we now have a large group of exciting hybrid populations for analysis and distribution. Had we waited for all the screening effort to be completed we would just now be making a large number of crosses. This continuing approach of putting the best parental materials together has gained several years of breeding effort. However, we caution researchers to wait and/or check for verification in order to prevent working too many populations of questionable value.

TABLE 1
PROJECT SCHEDULE

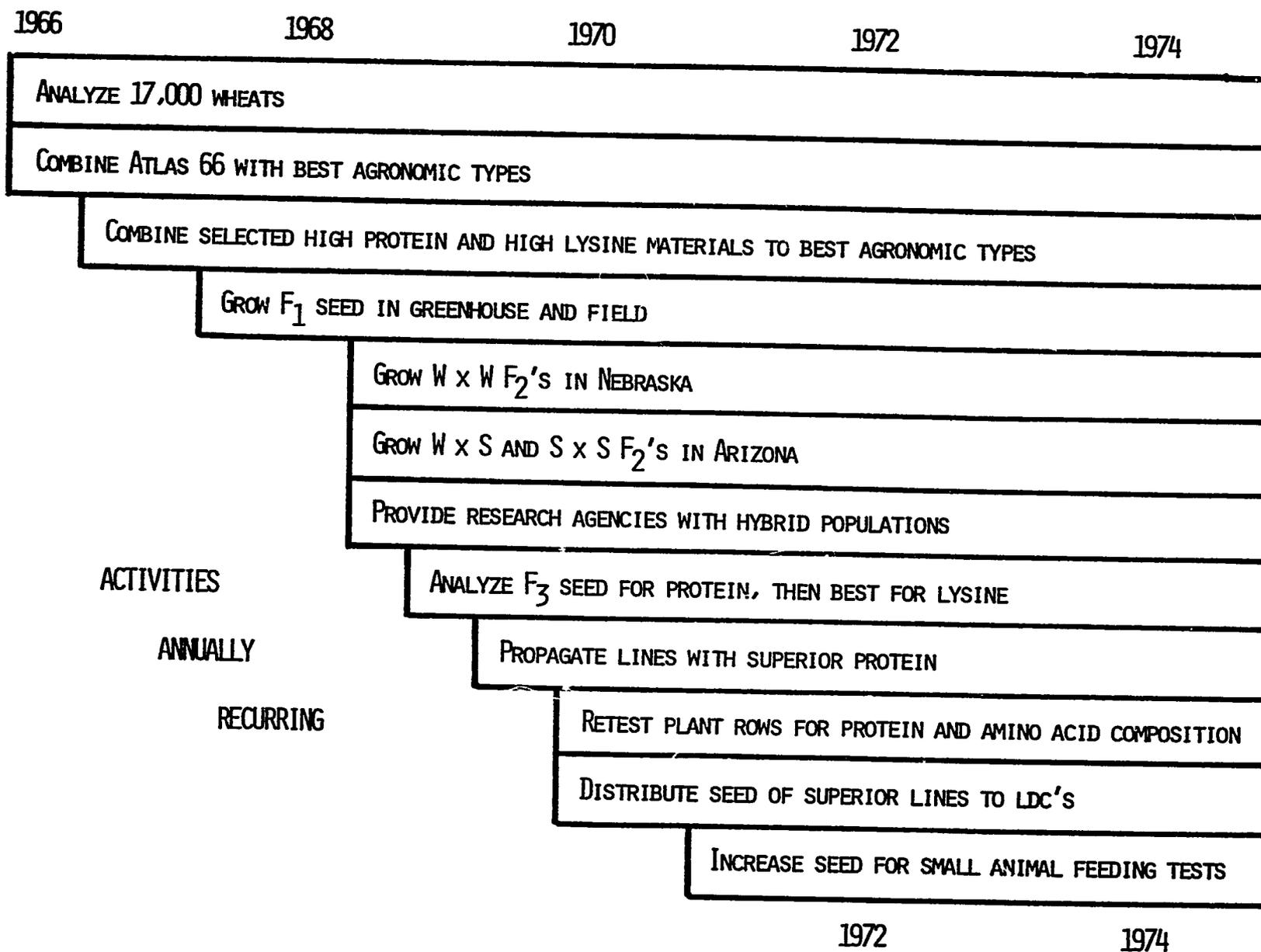


TABLE 2
LABORATORY ACTIVITIES

PROCESS AND STORE SAMPLES
ANALYZE FOR PROTEIN AND LYSINE
ANALYZE FOR ALL AMINO ACIDS
TEST IN VITRO METHODS FOR BIOLOGICAL AVAILABILITY
FEED SELECTED CULTIVARS TO SMALL ANIMALS
DEVELOP AND MODIFY LABORATORY METHODS
CONSULT WITH LABORATORY DIRECTORS ON METHODS AND
ORGANIZATION

TABLE 3
FIELD ACTIVITIES

BREEDING PROGRAM

GREENHOUSE CROSSING
PROPAGATION OF SEGREGATING POPULATIONS
GENETIC ANALYSIS OF HYBRID POPULATIONS
IDENTIFICATION AND INCREASE OF SUPERIOR LINES
SECOND AND THIRD BREEDING CYCLES FOR IMPROVED
NUTRITION

TABLE 4
INTERNATIONAL NURSERY SCHEDULE

- NOVEMBER - SEED TO ARIZONA FOR QUARANTINE INCREASE.
- MARCH - COMPLETE PREVIOUS IWPN DATA FOR PUBLICATION.
- APRIL - DETERMINE NURSERY ENTRIES, PREPARE FIELD BOOKS, ETC. FOR NEXT IWPN.
- MAY - HARVEST ARIZONA INCREASE PLOTS, SHIP SEED TO NEBRASKA.
- JUNE - PREPARE 31,000 IWPN NURSERY PACKETS, SHIP TO COOPERATORS N. HEMISPHERE. VISIT AS MANY IWPN SITES AS POSSIBLE.
- SEPTEMBER - PROCESS IWPN DATA, ANALYZE SEED.
- OCTOBER - PREPARE AND DISTRIBUTE PRELIMINARY IWPN REPORT. SHIP SEED TO S. HEMISPHERE.

TABLE 5
NURSERIES

- INCREASE -- ARIZONA AND NEBRASKA
- U.S. ENVIRONMENTAL -- TO STUDY LYSINE AND PROTEIN
- SCREENING -- ARIZONA
- IWPN -- 144 SITES -- 27 COUNTRIES -- TO EVALUATE CULTIVAR PRODUCTIVITY AND ADAPTATION

TABLE 6
DISTRIBUTION OF REPORTS

	<u>COPIES</u>
AGENCY FOR INTERNATIONAL DEVELOPMENT	150
FOREIGN RESEARCHERS AND INTERNATIONAL AGRICULTURAL AGENCIES	60
DOMESTIC RESEARCHERS	145

TABLE 7
REQUESTS FOR SEED
IDENTIFIED BY SCREENING PROJECT

	<u>REQUESTS PER COUNTRY</u>	<u>TOTAL</u>
19 FOREIGN COUNTRIES	1 - 7	35
DOMESTIC	42	42

TABLE 8
COMMUNICATIONS EFFORT

<u>SPEAKING</u>	
DOMESTIC	16
FOREIGN	7
<u>PUBLICATIONS</u>	
ABSTRACTS	6
BOOK CHAPTERS	2
JOURNALS	20
PROCEEDINGS	7
LECTURES	<u>1</u>
TOTAL	36

TABLE 9
REQUESTS FOR REPRINTS
OF PROJECT PUBLICATIONS

FOREIGN -----	296
DOMESTIC -----	125

TABLE 10
 SCIENTISTS VISITING THE LABORATORY
 NEBRASKA WHEAT PROJECT
 1966 - 1970

	<u>VISITORS</u>
29 FOREIGN COUNTRIES	70
DOMESTIC	60

TABLE 11
 PERSON TO PERSON CONTACTS

<u>NO. OF NEBRASKA PERSONNEL INVOLVED</u>	<u>COUNTRY OR ORGANIZATION VISITED</u>
2	CIMMYT, OREGON
1	" "
3	CIMMYT, MEXICO, D.F.
1	" "
1	JAPAN AND KOREA
2	NEAR EAST
1	EUROPE, NEAR EAST AND NORTH AFRICA
1	SWEDEN
1	ENGLAND

Figure 1

**4TH INTERNATIONAL WINTER WHEAT PERFORMANCE NURSERY
44 SITES; 27 COUNTRIES**



Figure 2

