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THE PHENOMENAL CONTRIBUTIONS OF THE JAPANESE NORIN DWARFING GENES TOWARD INCREASING THE GENETIC YIELD POTENTIAL OF WHEAT, AND RICE VARIETIES AND CEREAL PRODUCTION WORLDWIDE

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I want to thank Dr. Man-emon Takahashi and all members of your Society for inviting me to participate in the Thirtieth Anniversary Celebration of The Founding of The Japanese Society of Breeding. It is doubly gratifying for me that the Anniversary Meeting of your Society is held, in part, to commemorate the Fiftieth Anniversary Celebration of The Registration of Norin #1 Dwarf Wheat and Rice Varieties.

As some of you may know, I have worked for the past thirty-seven years attempting to help food deficit nations improve their agriculture and food production. Although I have been based in Mexico during this entire period, I have also worked on wheat, barley, and triticale research and production in many national programs in Asian, African and other Latin American Countries. During these many years, I have had the good fortune of employing as parents of Norin 10 and a number of other Japanese wheat derivatives. I have had the satisfaction of seeing progeny derived from crosses of these materials with the Mexican spring wheat varieties become important varieties in many spring wheat growing countries of the world. They have contributed greatly toward increasing wheat production in many countries.

In the time that I have available, I would like to describe: 1) the origin and lution of the CIMMYT-INIA (Mexican) Wheat Research and Production program and the role that the Norin dwarf wheats have played in increasing genetic yield potential and world wheat production.

The First Foreign Technical Assistance Program in Agriculture

The first foreign technical assistance program designed to assist a food deficit developing nation improve its agricultural production was the Cooperative Mexican Agricultural Program. It preceded by five years the Marshall Plan for Post-War industrial recovery, and the so-called Point 4 Program of President Truman, which advocated foreign technical assistance for developing nations, by seven years. This program, launched in 1943, was established as the result of a request by the Mexican Government for technical assistance to improve its agriculture. It was organized as a joint effort and responsibility of the Mexican Ministry of Agriculture and The Rockefeller Foundation. The objectives of the program were:

1) To launch a research to determine how to increase the yield and production of the basic food crops, maize (corn), wheat and beans. From the outset it was perceived the program would conduct research on all factors affecting yield, e.g., varietal improvement, agronomic practices, soil fertility, and disease, insect, and weed control.

2) To train a corps of young Mexican scientists in all of the disciplines affecting crop production. They were to actively participate in the research program as apprentices, and the most outstanding of these young scientists were to be awarded fellowships to permit them to study toward advanced degrees at foreign universities, since there were no graduate faculties in Mexico at that time.

From the beginning, it was established that the Rockefeller Foundation scientists assigned to the programs would be "working scientists" (not consultants) who would be active participants with their Mexican colleagues in all of the details of the research program. Moreover, it was understood that as soon as significant research results became available, they should be formulated into a package of improved production practices so that the benefits could be promptly transferred to farmers which in turn would soon begin to increase production. Finally, it was understood from the outset that the ultimate objective of the Rockefeller Foundation's staff was "to work itself out of a job" as soon as possibl and transfer all responsibility for the continuation of the program to a well trained corps of Mexican scientists.

I was privileged to join the Cooperative Mexican - Rockefeller Foundation Agricultural Program in 1944, and soon thereafter became director of its wheat research and production program. I continued as a member of its staff until the program was successfully terminated in 1960, when responsibilities for its continuation were transferred to the then newly organized National Institute of Agricultural Research (INIA), which was directed and largely staffed by scientists who had been trained in the aforementioned prograr

Since the completion of the Mexican program, I have continued to be involved in the development and execution of the international wheat research ar production program under the auspices of the International Maize and Wheat Improvement Center, whose origin is described below.

During the thirty-seven years that I have been privileged to work in international wheat research and production programs, I have been both pleased and surprised by the progress that has been made in increasing wheat production in many developing nations. Nonetheless, I recognize that there can be no room for complacency. The relentless advance of the human population monster continues unabatedly. The increase in human numbers requires increased food production. The line must be held on the food production front while population growth is being slowed to manageable levels. Meanwhile failure to produce the food that is required by a growing world population will result in increasing social, economic, and political chaos.

When the Cooperative Mexican - Rockefeller Foundation Agricultural Program was established 38 years ago, world opinion reflected no concern over food production or population growth. Indeed, at that time, most political leaders of new emerging and developing nations gave major emphasis to industrialization in their development programs, while largely ignoring improvement of their inefficient traditional agricultures. Without exception, these ill-perceived short cuts to industrialization and higher standards of living failed. Within a decade, the anticipated leaps forward by these nations to rapid industrialization became strategic retreats to try to improve their stagnant agricultural systems.

As it became increasingly apparent that there was no rapid and easy road to industrialization, and as word of the success of the Cooperative Mexican - Rockefeller Foundation Agricultural Program spread, both the Rockefeller Foundation and Ford Foundation were besieged with requests from many developing nations for assistance in establishing similar agricultural programs. The tw foundations responded during the late 1940s and early 1950s by establishing bilat programs in a number of countries, which in turn soon produced only another greater avalanche of new requests from other developing countries for technical assistance. It soon became apparent that the funds of the two foundations were inadequate to continue meeting these requests on a purely bilateral basis. It was obvious a different approach was needed to assist developing nations to improve their agriculture.

The Rockefeller Foundation and Ford Foundation in 1960 jointly perceived the establishment of the International Rice Research Institute (IRRI) as a more feasible approach. This institute, to be located in the Philippines, was charged with the responsibility of assisting all developing nations to solve their rice production problems, not just those of the host nation.

In concept, principles, and research program organization, IRRI was modeled after the Cooperative Mexican Government - Rockefeller Foundation wheat and maize programs. Subsequently, the two foundations established three other international crop research centers: The International Maize and Wheat Improvement Center (CIMMYT) in Mexico, and two international centers for tropical agriculture - Centro Internacional de Agricultural Tropical (CIAT) in Colombia and International Institute of Tropical Agriculture (IITA) in Nigeria. By the late 1960s, there were again many additional requests and pressures for technical assistance to improve the yield and production of crops (and livestock), not covered by the aforementioned four International Agricultural Research Institutes.

In May 1971, the Consultative Group on International Agricultural Research (CGIAR) was organized to bring together countries, public and private institutions, international and regional organizations, and representativ from developing countries in support of a network of international agricultural research centers and programs. Currently, the network is made up of thirteen institutes and programs, as is indicated in Figure 1.

I want to congratulate and thank the Government of Japan for the generous and continuing financial and technical assistance it has given to the CGIAR in support of the improvement of agriculture in the developing food deficit nations. I am convinced that the network of International Agricultural Research Institutes has a vital role to play in assisting the national programs of developing nations to improve their agriculture and food production. The future social, economic, and political stability of the world will depend in no small part on the success or failure of this effort.

I also wish to take this opportunity to acknowledge and thank the Japanese Government for the financial assistance it has provided to enable CIMMYT to construct a germ plasm storage facility at its El Batan headquarters. Finally, I would be remiss if I failed to acknowledge the great benefits CIMMYT has received from the wise counsel provided by Dr. Kan-ichi Murakami during the years he has ably served on the CIMMYT Board of Trustees.

The Mexican Wheat Research Program and Its Impact on Wheat Research and Production in Other Countries.

Maize is the king of the cereals and by far the most important food grain in Mexico. During the decade of the 1970s the annual production has varied from 9 to 11 million metric tons. Wheat is the second most important food grain, but production and consumption generally are only about one-fourth to one-fifth that of maize. Nevertheless, great changes have taken place in both wheat yield and production since the research program was initiated in 1943. Yield then was low (750 kilograms/hectare) and production was only about 245,000 metric tons, less than half of consumption. As a result of the development of high yielding rust resistant varieties and improved agronomic practices, and the widespread application of the new technology on Mexican farms, both yields and production had begun to increase significantly by 1949. Yield had increased to 880 kilograms/hectare and production had climbed to 560,000 metric tons. Mexico became self-sufficient in wheat production for the first time in 1956, when yield reached 1.2 metric tons per hectare and a production of 1,200,000 metric tons was harvested. By 1962, yields had increased to 1.8 metric tons per hectare, and 1,400,000 tons were produced. By the 1964 harvest, the first full impact of the high yielding semidwarf Norin 10 derivative varieties Pitic 62 and Penjamo 62 (which had been released in 1962) was evident. Yields then reached 2.6 tons per hectare and production reached 2,200,000 tons. In the period from 1964 to 1976, with only minor annual variations, both yield and production continued their upward trend, achieving a peak in 1976 when 3,354,000 tons were harvested with an average yield of 4.2 tons per hectare.

During the past four years, Mexico has again become a wheat importer. This has resulted from the combined effect of a dramatic increase in population (from 19 million in 1943, to 80 million in 1980) and increasing per capita consumption of wheat products, coupled with a decrease of 20 to 30 percent in production. The drop in production was largely caused by a reduction of area sown to wheat, primarily due to a shortage of water for irrigation. Mexico has the potential for again becoming self-sufficient in wheat production. To do so, however, will require successfully extending the wheat area further southward into less favorable ecological zones.

From the beginning of the Mexican wheat breeding program in 1943 until 1961, twenty-five improved varieties of bread wheat and one improved variety of durum wheat were multiplied and distributed to farmers in Mexico. Only five of these varieties were subsequently grown commercially outside of Mexico. In all cases, the use of these varieties was on a rather modest commercial hectarage, and in all but one case (Kenya), they were confined to Latin America. The situation has changed dramatically with respect to the number of Mexican varieties that have been found to be useful for growing commercially in other countries, since the release of the first semidwarf bread wheat varieties in Mexico in 1962. Table 1 indicates the names and date of release of the twenty five dwarf bread wheat varieties that have been developed, released, and grown on a large commercial hectarage in Mexico between 1962 and 1977. Eighteen of these twenty five varieties have been subsequently grown on large commercial hectarages in one or more other countries. Moreover, it is estimated that approximately 200 additional lines from the International Bread Wheat Screening Nurseries have been reselected and/or used directly as commercial varieties in many countries in other parts of the world.

The widespread use of Mexican dwarf bread wheat varieties has had a dramatic effect on increasing wheat production in many countries during the past 15 years.

At present, there are probably more than 35 million hectares worldwide sown to CIMMYT-INIA dwarf spring wheat varieties and/or to varieties derived directly from CIMMYT germplasm. Indirectly, there are many untold millions of hectares of both spring and winter wheats that were derived by employing CIMMYT varieties or lines as parents. The largest proportion of the hectarage sown to CIMMYT-INIA varieties and their direct derivaties is found in the spring wheat areas in developing nations, e.g., India, Pakistan, People's Republic of China, Bangladesh, Iraq, Iran, Turkey, Egypt, Tunisia, Algeria, Morocco, Kenya, Guatemala, Brazil, Argentina, Chile, Colombia, Peru, Bolivia, Ecuador, etc. There are also large hectarages of the CIMMYT-INIA wheat varieties and their derivatives in many developed countries, including the USA, Canada, Australia, the USSR, Spain, Portugal, Israel, Greece, Italy, and South Africa.

The CIMMYT-INIA wheat varieties have found their way into these countries by various avenues.

In the early years, before the International Nurseries came into being, they were spread by young scientists who came to CIMMYT to train. When they returned home they invariably took with them many small experimental samples. In recent years, they were first grown and observed in these countries as varieties or lines that were included in one of the International Wheat Yield Nurseries or in one of the International Wheat Screening Nurseries. In most cases, the promising lines or varieties, after being identified as of potential economic value, were named, multiplied, and distributed by the national wheat research team of the recipient country. More than twenty countries, however, to save time have opted for the direct importation of commercial quantities of seed from Mexico, ranging from 200 to 42,000 metric tons of a considerable number of CIMMYT-INIA commercial varieties. Of course, the majority of CIMMYT derived varieties have been obtained from reselections made among the most outstanding lines in the International Screening Nurseries, as identified by scientists in the recipient countries.

The Case of India

The data presented in Table 3 clearly shows the tremendous impact the use of Mexican semidwarf bread wheats have had on Indian wheat production, since the pre-wheat revolution 1961-66 base period, when production was slightly less than 11 million metric tons. The rapid expansion in area sown to the high yielding semidwarf varieties, together with the use of an accompanying package of appropriate improved agronomic practices (which permitted the varieties to express their superior genetic yield potential), production increased rapidly to a peak harvest of more than 35 million tons in 1979. This was more than a three-fold increase during the thirteen year period from 1966 to 1979. The increase in grain yield per hectare, gross income, and the number of people that could be fed from the increased production are also shown in Table 3. More than 20 million hectares of land were available for other crops compared to the land that would have been required to have produced the 1979 harvest with 1961-66 yields. In addition, the use of the early maturing, high yielding semidwarfs also facilitated double cropping on much of the area sown to wheat, which was much more difficult to achieve before the advent of the improved technology. As a result of the widespread use of the new technology in wheat and rice production, India became self-sufficient in cereal production for the first time in 1977. As a result of good 1978 wheat and rice harvests, followed by the record 1979 wheat harvest, India was able to accumulate from domestic production a reserve stock of grain of more than 22 million tons. The 1979 monsoon failed and resulted in what was reputed to have been the worst drought in 90 years. Rice production dropped by 12 million tons. Nevertheless, because of the grain in storage, the country survived without difficulty until the 1980 wheat harvest. If not for the parallel revolutions in wheat and rice production, India would have been plunged into famine.

Similar data for Pakistan are presented in Table 4, which indicate the changes that have taken place there in wheat production since the Mexican dwarf varieties were introduced in 1966. Production has more than doubled in the last 13 years, while yields have increased by 82 percent.

Durum Wheat

Impressive progress also has been made in increasing durum wheat yields and production by the development and use of high yielding broadly adapted semidwarf varieties. Table 4 shows the six high yielding dwarf durum wheat varieties, all derivatives of Norin 10, that have been developed, released, and grown on a large commercial area in Mexico since 1965. Three of these varieties have been subsequently grown on large hectarages in one or more Asian, African, or Latin American countries. Moreover, it is estimated that worldwide 30 additional semidwarf durum wheat varieties have been selected from International Durum Screening Nurseries, named, distributed, and grown on commercial hectarages in recent years.

Why Has the CIMMYT-INIA Wheat Breeding Had Such and Incongruous and Large Impact on World Wheat Production Over the Past Two Decades?

There appears to be something strange and unusual about the large impact that the CIMMYT-INIA (Mexican) wheat breeding program has had over the past two decades on world wheat breeding programs and world wheat production. Part of the increased impact is undoubtedly due to the effect of two factors that have over the past twenty years permitted more judicious identification of potentially valuable material in nurseries received from CIMMYT. I refer to the International Wheat Yield Nurseries and The International Screening Nurseries that are now widely distributed annually to collaborators in many parts of the world. These nurseries generate a great amount of precious biological performance data, derived under a wide range of climatic and soil conditions. The reports derived therefrom serve as a valuable guide to scientists in many countries for choosing the best lines for direct use as commercial varieties. It is my belief that currently there are many more better trained and competent wheat breeders and wheat pathologists in the developing nations than there were twenty years ago. These scientists know how to identify and capitalize on the use of potentially valuable materials that are included in these international nurseries. I personally believe that this improvement in the efficient utilization of the germplasm, to a considerable degree, has resulted from CIMMYT's training program. In this training program, more than 500 young wheat scientists have received practical training in wheat breeding, pathology, agronomy, and cereal technology, and thereby preparing them for identifying and effectively utilizing outstanding lines.

Moreover, I am now beginning to believe that there is something more basic involved in the breeding methodology that has been employed in the CIMMYT wheat breeding program that is contributing to developing varieties, line and unselected populations that are increasing more broadly adapted to or toleran to a range of climate and soil conditions, and to a widening spectrum of wheat pathogens. My reasons for believing this are indicated in the remainder of this paper, wherein I explain some of the methods we have used to develop the high yielding broadly adopted disease resistant CIMMYT wheat varieties.

Wheat As A Crop In Mexico

Wheat was introduced into Mexico in the 1520s by the Spaniards, soon after the conquest. It was grown primarily as a winter season irrigated crop, as it is today. The original successful introductions were almost certainly primarily spring habit varieties of bread wheat (*Triticum aestivum*), although durum (*T. durum*) wheats were also introduced in the early colonial period. At the time of the conquest, maize was grown extensively and was the basic food of all of the indigenous peoples throughout "New Spain". During the Colonial Period, and continuing on through to the present, wheat never seriously challenged the position of maize as the "king of the cereals". As during the Colonial Period, wheat is planted in Mexico at the onset of cool weather in late October and early November. The rust diseases have always been a constant threat to wheat production, and sometimes caused serious losses in the Colonial Period just as they do today.

The wheat varieties that were being grown in most of the traditional wheat-maize producing areas of Central Mexico during the early 1940s were old land races of unknown origin. They were often a mixture of ten to twenty morphologically distinct types, primarily representatives of *T. aestivum*, with occasional mixtures of *T. durum*, *T. turgidum* and *T. compactum*. The soils throughout the region were infertile, having been depleted of one or more nutrients by repeated cropping over many untold decades without the use of fertilizer. Wheat was usually planted as a second crop following the harvest of the summer maize crop. Wheat yields throughout the region were low, ranging from 0.5 to 1.0 metric ton per hectare.

The situation, however, was very different in the newly irrigated areas on the coast of Sonora. In this region the most widely cultivated variety was a wheat known as Barrigón (T. turgidum), which had successfully withstood three disastrous stem rust epidemics in 1939-40. During these epidemics, the bread wheat varieties Mentana, Ramona, and Baart had been seriously damaged or destroyed. Economic losses had been ruinous. Since most of the land in this newly irrigated area had only been cultivated for ten to fifteen years, the soil was more fertile, and when not damaged by stem rusts, wheat yields ranged from 1.0 to 2.0 metric tons per hectare.

The effect of low yields in the old wheat producing areas of Central Mexico, combined with repeated serious losses from stem rust in Sonora, made it necessary for Mexico to import more than 50 percent of the wheat it consumed. This was the situation that prevailed when the Cooperative Wheat Research Program was initiated in 1943.

The Early Years of the Mexican Wheat Breeding Program 1943-48

During 1943 to 1945, small samples of a large number of wheat varieties were obtained from many of the spring wheat producing countries of the world. At the same time, many samples of the various wheats sown by farmers in the different areas of the Republic were obtained. In addition, about 5000 individual heads were selected from land races growing in farmers' fields in different parts of the country.

These materials were grown and studied twice each year during 1944 and 1945, at Chapingo, (19^{o}N and 2,249 meters elevation), near El Batan, the present site of CIMMYT. One planting was made under irrigation in mid-November and harvested in May, which corresponded to the commercial wheat crop cycle. A second cycle was planted in late May at the onset of the summer rains. This cycle was especially effective for screening the material for resistance to stem, leaf, and stripe rust.

It soon became apparent that all of the Mexican bread wheats had tall weak straw and were extremely susceptible to the rusts, particularly stem rust. The introduced spring wheats from Canada, Minnesota, and North Dakota were highly resistant to stem rust, but tillered poorly and did not yield well under Mexican conditions. It thus became clear that Mexico would need to launch an aggressive breeding program to develop early maturing, rust resistant, high yielding varieties adapted to its climate and soil. An aggressive breeding program was initiated in March 1945 to achieve this objective.

There were several introduced wheats that showed sufficient promise to consider using them as stopgap varieties. Among this group were two unnamed lines received from Dr. E. S. McFadden of Texas, subsequently named and distributed as Supremo 211 and Frontera 209. These lines possessed good rust resistance and acceptable yield, but had weak glumes and a weak rachis, which meant they had to be harvested opportunely to avoid losses. Two Kenyan wheats, subsequently named Kenya Rojo and Kenya Blanco, possessed good rust resistance and had a fair yield, but were tall and late maturing. Because of the urgent need for wheat varieties with resistance to stem rust, it was decided to multiply and distribute as interim stopgap varieties Supremo 211, Frontera 209, Kenya Rojo, and Kenya Blanco, despite their recognized weaknesses. They served usefully in the period from 1948 to 1951 until seed became available from the first varieties developed by the breeding program.

TABLE 1

CIMMYT-INIA NORIN 10 DERIVATIVE DWARF BREAD WHEAT VARIETIES THAT WERE DEVELOPED, NAMED, RELEASED, AND WIDELY GROWN IN MEXICO DURING THE 1962-1980 PERIOD

Year of Release	MEXICAN VARIETAL NAME
1962	Pitic 62*, Penjamo*
1963	Sonora 63*
1964	Sonora 64,* Mayo 64*, Lerma Rojo 64*
1965	INIA 66*, Siete Cerros 66*, Super X*, Tobari 66*
1967	CIANO 67*, Norteño 67*
1970	Yecora 70*, Saric 70 , Nuri 70*
1971	Tanori 71*, Cajeme 71*
1973	Jupateco 73*, Torim 73
1975	Cocoraque 75, Zaragoza 75
1976	Pavon 76*, Tezopaco 76, Nacozari 76*
1977	Pima 77
1979 (1)	CIANO 79, Imuris 79, Tesia 79
1980 (1)	Glenson 81, Genero 81, Ures 81, Tonichi 81

* Varieties that were subsequently grown on large commercial hectares in Asian, African, European, or other American countries.

(1) Too early to know whether these varieties will be grown commercially elsewhere, outside of Mexico

** It is estimated that worldwide 200 varieties, derived from reselection of lines or varieties in CIMMYT screening nurseries, have been named, released and grown commercially since 1963.

TABLE 2

CIMMYT-INIA NORIN 10 DERIVATIVE DWARF DURUM WHEAT VARIETIES THAT WERE DEVELOPED, NAMED, RELEASED AND WIDELY GROWN IN MEXICO IN THE 1965 TO 1979 PERIOD

Year of Release	MEXICAN VARIETAL NAME
1965	Oviachic 65
1967	Chapala 67
1969	Jori 69*
1971	Cocorit 71*
1975	Mexicali 75*
1979 (1)	Yavaros

* Varieties that have subsequently been grown on a large commercial hectarage elsewhere in African, Asian or Latin American Countries.

(1) It is too early to tell whether this variety will be grown on a commercial hectarage in other countries in the future.

TABLE 3 THE IMPACT OF IMPROVED TECHNOLOGY ON INDIAN WHEAT YIELD AND PRODUCTION AND LAND USE BEFORE AND AFTER THE WHEAT REVOLUTION

Year	Area Harvested 1000 ha	Yield Mt/Ha.	Production 1000 M. tons	Gross value of Increased Production (Million $) (B)	Millions of adults provided with 65% carbohydrate needs by increased wheat production over 1961-66 period (C)	Area Required to Produce Crop at 1961-66 Yield 1000 hectares	Area save by yield increase ov 1961-66 bas 1000 ha.
(1961-66)(A)	13,191	0.830	10,950	-.-	-.-	-.-	-.-
1967	12,838	0.887	11,393	88	3	13,726	888
1968	14,998	1.103	16,540	1,118	41	19,928	4,928
1969	15,958	1.169	18,652	1,540	56	22,472	6,513
1970	16,626	1.209	20,093	1,828	67	24,208	7,582
1971	18,241	1.307	23,833	2,576	94	28,714	10,472
1972	19,154	1.382	26,471	3,092	113	31,893	12,738
1973	19,461	1.271	24,735	2,758	101	29,801	10,339
1974	18,583	1.172	21,778	2,166	79	26,238	7,655
1975	18,111	1.338	24,235	2,630	96	29,198	11,087
1976	20,458	1.410	28,846	3,580	131	34,754	14,295
1977	20,966	1.387	29,080	3,626	133	35,036	14,069
1978	20,946	1.480	31,000	4,010	147	37,349	16,402
1979	22,560	1.574	35,510	4,912	180	42,783	20,222
1980	21,962	1.437	31,560	4,122	151	38,024	16,061

A - Average for 6 years
B - Wheat value used in calculations US$200/Metric ton, similar to landed value in India of imported wheat
C- Calculation based on providing 65% of carbohydrate portion of a diet of 2350 calories/day or 375 g. wheat/day

TABLE 4 THE IMPACT OF IMPROVED TECHNOLOGY ON PAKISTAN WHEAT YIELD AND PRODUCTION AND LAND USE BEFORE AND AFTER THE WHEAT REVOLUTION

Year	Area Harvested 1000 Ha	Yield M.T./Ha.	Production 1000 M.T.	Gross value of increased production over 1964-66 (B) Millions (US dlls)	Additional people provided with 64% carbohydrate from increased production over 1964-66 base (C) (Millions)	Land area required to produce crop at 1964-66 yield 1000 Ha.	Land area saved by yield increased over 1964-66 base 1000 Ha.
1964-66 (A)	5164	0.82	4223	-	-	-	-
1967	5344	0.81	4334				
1968	5983	1.07	6418				
1969	6160	1.07	6617	614	22.4	8895	2666
1970	6229	1.17	7294				
1971	5978	1.08	6476				
1972	5797	1.19	6890				
1973	5971	1.25	7443				
1974	6113	1.25	7629	690	25.2	9357	3545
1975	5812	1.32	7673				
1976	6111	1.42	8691				
1977	6390	1.43	9144				
1978	6360	1.32	8367	1,144	41.7	12127	5431
1979	6696	1.49	9944				

1 DATA SOURCE: FAO PRODUCTION YEARBOOK

A- Average for the three year period

B- Wheat value used in calculations U.S.$200/Metric Ton similar to 1979 landed price of wheat in Karachi

C- Calculations based on providing 65% of carbohydrate portion of a diet of 2350 k cal/day or 375 grams wheat/day

FIGURE 1

CGIAR Membership as of October 1979

Continuing Members

Countries

Australia
Belgium
Canada
Denmark
France
Germany
Iran
Ireland
Italy
Japan
Netherlands
New Zealand
Nigeria
Norway
Saudi Arabia
Sweden
Switzerland
United Kingdom
United States

International Organizations

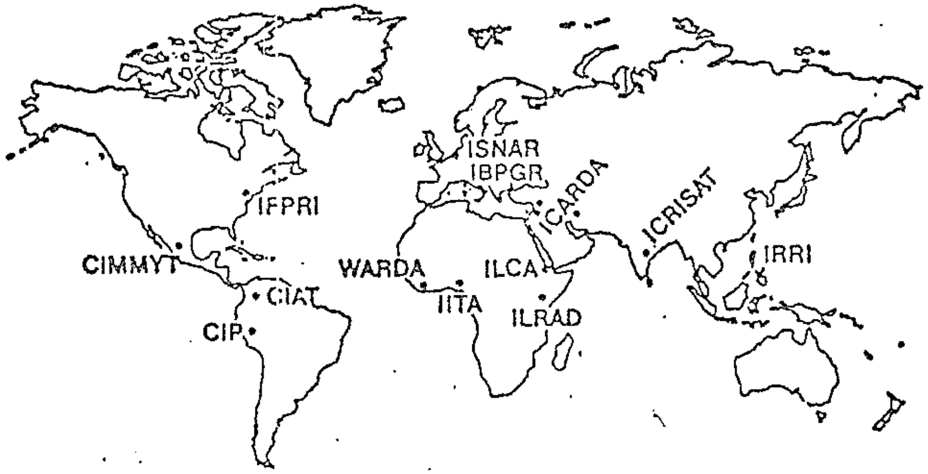
African Development Bank
Arab Fund for Economic and Social Development
Asian Development Bank
Commission of the European Communities
Food and Agriculture Organization of the United Nations
Inter-American Development Bank
International Bank for Reconstruction and Development
International Fund for Agricultural Development
OPEC Special Fund
United Nations Development Programme
United Nations Environment Programme

Foundations

Ford Foundation
International Development Research Centre
Kellog Foundation
Leverhulme Trust
Rockefeller Foundation

Fixed-Term Members Representing Developing Countries

Asian region	India Philippines
African region	Kenya Senegal
Latin American region	Costa Rica Peru
Southern and Eastern European region	Greece Romania
Near Eastern region	Egypt Syria



The CGIAR–Supported Centers

CIAT: Centro Internacional de Agricultura Tropical. Cali, Colombia
CIMMYT: Centro Internacional de Mejoramiento de Maíz y Trigo. Mexico, D.F., Mexico
CIP: Centro Internacional de la Papa. Lima, Peru
IBPGR: International Board for Plant Genetic Resources. Rome, Italy
ICARDA: International Center for Agricultural Research in the Dry Areas. Beirut, Lebanon
ICRISAT: International Crops Research Institute for the Semi-Arid Tropics. Hyderabad, India
IFPRI: International Food Policy Research Institute. Washington, D.C., United States
IITA: International Institute of Tropical Agriculture. Ibadan, Nigeria
ILCA: International Livestock Center for Africa. Addis Ababa, Ethiopia
ILRAD: International Laboratory for Research on Animal Diseases. Nairobi, Kenya
IRRI: International Rice Research Institute. Los Baños, Philippines
ISNAR: International Service for National Agricultural Research. The Hague, Netherlands
WARDA: West Africa Rice Development Association. Monrovia, Liberia

THE RELATIVE PERFORMANCE OF THE BEST BREAD WHEAT, DURUM WHEAT AND TRITICALE VARIETIES IN INTERNATIONAL YIELD TESTS OVER THE PAST THREE YEARS

The International Spring Wheat (T. aestivum) Yield Nursery (ISWYN) showing Yield of The Highest Yielding Bread Wheat Compared to Yield of The Highest Yielding Check Variety of Durum Wheat and Triticale

NURSERY	YEAR	LOCATIONS	PROGRAM	VARIETIES	KG/HA
14th ISWYN	1977-78	69	Bread Wheat	Nacozari	4020
			Durum	Mexicali	3478
			Triticale	Mapache	4212
15th ISWYN	1978-79	74	Bread Wheat	Veery	4477
			Durum	Mexicali	3537
			Triticale	Mapache	4382
16th ISWYN	1979-80	61	Bread Wheat	Veery	4339
			Durum	Bittern	3717
			Triticale	Mapache	4228

The International Durum (T. durum) Yield Nursery (IDYN) Showing Yield of The Highest Yielding Durum Wheat Compared to The Yield of The Highest Yielding Check Variety of Bread Wheat and Triticale

NURSERY	YEAR	LOCATIONS	PROGRAM	VARIETIES	KG/HA
9th IDYN	1977-78	49	Durum	21563-AA"S"xFG"S"	4344
			Bread Wheat	Jupateco	4031
			Triticale	Snipe	4207
				Bacum	4135
10th IDYN	1978-79	41	Durum	"YAV"s	4137
			Bread Wheat	Pavon 76	4233
			Triticale	Mapache	4423
11th IDYN	1979-80	62	Durum	Cocorit	4564
			Bread Wheat	Pavon	4674
				Nacozari	4645
			Triticale	Mapache	5220

The International Triticale Yield Nursery (ITYN) Showing The Grain Yield of The Highest Yielding Triticale Compared to The Highest Yielding Check Variety of Bread and Durum Wheats

NURSERY	YEAR	LOCATIONS	PROGRAM	VARIETIES	KG/HA
1st ITYN	1969-70	39	Triticale	Armadillos	2578
			Bread Wheat	Pitic 62	3284
				Tobari	3034
			Durum	Albatros	2739
9th ITYN	1977-78	67	Triticale	Mapache	3842
				Beagle	3820
			Bread Wheat	Nacozari	3508
			Durum	Mexicali	2846
10th ITYN	1978-79	56	Triticale	Beagle	4014
				Mapache	3893
			Bread Wheat	Pavon	3450
			Durum	Bittern	3016
11th ITYN	1979-80	62	Triticale	Beguelita	4339
				Mapache	4058
			Bread Wheat	Pavon	3933
			Durum	Bittern	3103