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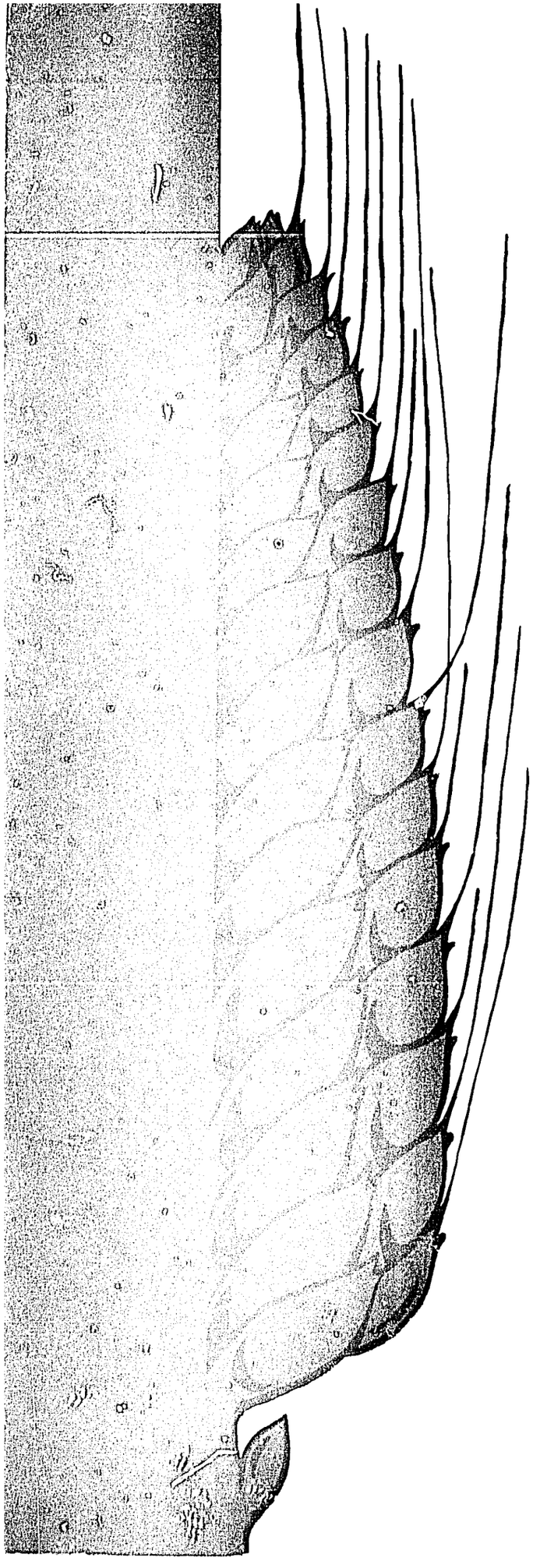

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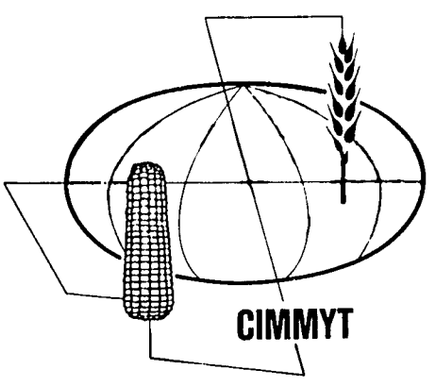

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Edited by:

R. A. FISCHER
DEAN BORK

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Introduction

The impact of CIMMYT's outreach programs is largely dependent upon the quality of information, materials, training and coordination emanating from its core program in Mexico and from the highly effective cooperative network of national programs in countries with which it collaborates.

The quality of this vast cooperative effort is mainly dependent upon the effectiveness of specific scientists, either nationals of a country or expatriate scientists employed by CIMMYT or by other organizations interested in increasing food production, especially in developing countries.

CIMMYT believes that the effectiveness of these scientists can be further enhanced by bringing them together periodically to get better acquainted with each other, with the various programs and, above all, with the major problems that can best be solved locally, regionally or globally. Also, CIMMYT believes there is much to be gained from seeing the research and training activities underway in the core program.

So, CIMMYT invited key maize and wheat scientists, working toward a greater efficiency in maize and wheat production in several areas of the world, to Mexico to participate in a workshop with the specific purposes of:

1. Reviewing the present research and training activities underway in the core program;
2. Promoting a better understanding among participants of work in progress and the common problems and limitations to maize and wheat production in the areas or regions in which they are working;
3. Discussing CIMMYT's role and how can this role be made more useful;
4. Planning ahead, regionally and globally; and
5. Discussing plans for a detailed symposium on each crop.

The papers presented at the wheat workshop by participants from around the world are presented here. All the papers were edited for consistency of style, most were condensed, and some were revised and restructured. During the translation and editing, efforts were made to maintain the authors' emphases and philosophies.

Wheat Improvement in Morocco

Aristeo Acosta
Wheat Breeder, CIMMYT
Morocco

Wheat is to Morocco what corn is to Latin America. Wheat has been grown in North Africa and the Near East since biblical times. It probably originated in this general area. In Morocco, bread is eaten at least three times a day.

Most wheat is grown under rainfall conditions. Even when the distribution of this rainfall is not good, it falls within the wheat cycle. This, the temperatures, the photoperiod conditions and its soils give Morocco relatively good potential for growing wheat under dryland conditions.

PRODUCTION AND VARIETY COMPOSITION

Morocco exported wheat more or less regularly from 1939 to 1962 when it exported 220,659 quintals, the last big recorded export (Table 1). Imports of bread wheat since 1966 are shown in Table 2.

TABLE 2. Bread wheat (T. vulgare) importations from 1966 to 1970.

Year	Tons	1000 DH[1]	Source
1966	537,893	201,719	Sit Eco. 1966
1967	855,189	303,197	Eco du Maroc 1968
1968	591,478	216,226	" " " 1969
1969	98,470[2]	39,858	" " " 1969
1970	650,000	234,000	" " " 1970-71
Average	546,606	199,000	

[1] One U.S. dollar = 5.02 DH (Dirhams).

[2] Highest production in history of country.

TABLE 1. Morocco's cereal exports from 1938-39 to 1961-62 in quintals.[1]

Period	T. vulgare	T. durum	Barley	Corn	Rice	Oats
1938-39	1,121,000	17,000	350,000	100	—	293,150
1939-40	778,000	95,000	2,141,000	396,000	—	156,750
1940-41	2,020,000	47,000	2,997,000	865,000	—	416,340
1941-42	1,186,000	—	1,416,000	709,000	—	197,920
1942-43	387,000	—	756,000	242,000	—	22,120
1943-44	—	—	210,000	170,000	—	64,090
1944-45	57,000	53,000	232,000	6,000	—	9,630
1945-46	—	—	55,000	50	—	—
1946-47	207,000	—	1,000	—	—	—
1947-48	35,000	—	925,000	70,000	—	59,000
1948-49	64,000	230,000	1,795,000	698,000	—	199,000
1949-50	297,000	198,000	4,096,000	1,390,000	—	175,000
1950-51	452,000	211,000	2,370,000	324,000	—	364,000
1951-52	88,000	207,000	3,525,000	311,000	12,000	346,000
1952-53	20,000	273,000	2,859,000	237,000	14,000	304,000
1953-54	221,000	516,000	2,422,000	922,000	51,000	595,000
1954-55	1,418,000	715,000	5,814,000	807,000	124,000	281,000
1955-56	1,745,000	933,000	3,700,000	1,095,000	131,000	54,000
1956-57	34,000	1,080,000	2,768,000	892,000	70,000	65,000
1957-58	—	483,000	289,000	653,000	47,000	100,000
1958-59	—	1,572,000	563,000	837,000	62,000	39,000
1959-60	—	1,658,027	351,495	995,935	51,084	34,218
1960-61	49,794	404,581	225,479	533,484	26,610	32,837
1961-62	—	220,659	—	—	18,766	—

[1] 1 quintal = 100 kilograms.

After barley, wheat is the most widely grown cereal in Morocco (Table 3). Durum wheat occupies about 70% of all wheat area. This area has been practically the same during the last 30 years (Table 4). The average yield from 1938 to 1962 was 605 kg/ha.

Five durum varieties have been grown during the 1970-71 season. One of them, BD-2777, has occupied more than 50% of the area planted with durum varieties (Tables 5 and 6).

The bread wheat varieties more extensively grown are BT-908, BT-3597 (Mara) and BT-2308. The first two occupy most of the bread wheat area. These two varieties (BT-908 and BT-3597) have good tolerance to *Septoria* and produce good yields.

Siete Cerros produces good yields in the South where its area has been increasing. Tobari produces fairly good yields in spite of heavy epiphytotics of *Septoria*. These two Mexican varieties have been retained by the Moroccan Seed Certification Office. Less Penjamo 62 and Inia 66 have been grown.

TABLE 3. Cereal production (10-year average for years without extreme climatic variations).

Species	Production quintals[1]	% of Total
Barley	15,685,000	53%
T. durum (BD)	5,846,000	20%
T. vulgare (BT)	3,653,000	12%
Corn	2,367,000	7%
Oats	539,800	
Sorghum	288,300	
Rice	223,000	8%
Canary grass (Phalaris sp)	117,500	
Millet	104,600	
Rye	11,900	

[1] 1 quintal = 100 kilograms.

TABLE 5. Morocco's commercial wheat varieties, their origin, their Septoria tolerance and the estimated area planted to each of the varieties.

Species	Variety Name	Origin	Septoria Tolerance	Estimated area (70-71)
T. durum	BD-2777 (Kyperounds)	(Cyprus)	—	50% +
	BD-3225	Morocco	—	—
	BD-2909	Morocco	—	—
	BD-1658	Morocco	—	—
	BD-272	Morocco	—	—
T. vulgare	BT-908	Italy	Good	—
	BT-3597 (Mara)	Italy	Good	—
	BT-2306	Morocco	—	—

TABLE 6. Quintals of T. durum (BD) Seed produced (1969-70).

Province	Variety					Total by Province
	272	1658	2777	2909	3225	
Taza			9,555			9,555
Fes		10,514	27,166	862		38,542
Meknes	1,047	548	21,066	784		23,445
Kenitra	4,095	3,693	22,576	8,542	2,205	41,111
Settat	1,050		14,678	2,297	1,828	19,853
Khouribga	3,073	366	3,793			7,232
Beni Mellal		1,520	6,304			7,824
El Jadida			6,926			6,926
Safi			7,887			7,887
Marrakech	3,219				1,338	4,557
Oujda			350			350
Total	12,484	16,641	120,301	12,485	5,371	167,282

TABLE 4. Wheat area, production and yield in Morocco during various periods.

	Species	WHEAT CYCLES					Five-year average (1967-71)	25-year average (1938-62)
		1966-67	1967-68[1]	1968-69[2]	1969-70	Estimated 1970-71		
Area (Hectares)	T. durum	1,362,000	1,502,000	1,332,000	1,381,000	1,300,000	1,375,000	968,760
	T. vulgare	408,000	475,000	432,000	497,000	500,000	462,400	427,800
	Total	1,770,000	1,977,000	1,764,000	1,878,000	1,800,000	1,837,800	1,396,560
Production (Metric tons)	T. durum	850,000	1,775,000	1,192,000	1,400,000	1,595,000	1,362,400	585,836
	T. vulgare	240,000	636,000	421,000	639,000	612,000	509,600	293,900
	Total	1,090,000	2,411,000	1,613,000	2,039,000	2,207,000	1,872,000	879,736
Yield (kg/ha)	T. durum	624	1,182	895	1,014	1,227	988	605
	T. vulgare	588	1,339	974	1,286	1,224	1,082	687
	Average	616	1,219	914	1,086	1,226	1,012	630

[1] Highest production in history.
[2] Severe epiphytotic of Septoria.

PRODUCTION LIMITATIONS

Climate

One word describes the climate in Morocco —irregular. However, the country can be divided into regions with similar climatic conditions, especially rainfall and temperature.

The South is normally dry, the North has more rainfall and the intermediate zone has intermediate rainfall under average conditions. Most of the wheat plains are between the Atlantic Ocean and the Atlas Mountains, and in the South.

The relative humidity during the wheat cycle is generally high with short dry periods. Cloudy weather might persist for three or more weeks.

Soils

Low fertility levels, soil (seed bed) preparation and soil management in general present production limitations.

Weeds

Wild oats and several other species of weeds are important.

Diseases

Climatic conditions favor development of *Septoria* and rusts. *Septoria* is the most important disease (Tables 7, 8 and 9). Usually, yellow rust appears first, followed by leaf rust and then stem rust, due to the gradual increase in temperatures as the season advances.

TABLE 7. Best yielding varieties or crosses at two locations in Morocco under Septoria attack in 1971.

Variety or cross and pedigree	Sidi Kacem			Merchouch[1]		
	Septoria	Yield		Septoria	Yield	
	5/20/71	kg/ha	% of check	5/21/71	kg/ha	% of check
CNO-Pj x CNO-7 Cerros (26265-22Y-300M-302Y-2M)	9	4911	126	6	2638	81
Pj 62-WRT x Calidad (26978-2M-300Y-1M)	7	4709	121	4	2496	77
INIA-CNO x Calidad (27220-302M-301Y-1M)	7	4636	119	3-4		
NP 876-Pj 62 x Calidad (27110-303M-301Y-1M)	8	4470	115	4	2401	74
CNO-Pj x CNO-7 Cerros (26265-22Y-301M-301Y-2M)	9	4423	136	8	1722	53
CNO-Pj x CNO-7 Cerros (26265-22Y-300M-300Y-1M)	8	4353	118	8	2560	79
CNO-7 Cerros/(S 64-Y50 EXGTO) Tob (25918-20Y-1M-300Y-1M)	7	4345	111	3	2737	84
Calidad (22429-10M-6T-0M)	9	4258	109	5-6	3459	106
INIA-CNO x CAL (27220-301M-300Y-2M)	9	4225	108	6	1973	61
INIA-CNO x CAL (27220-302M-302Y-2M)	7	4187	107	3		
CNO-7 Cerros y CNO Pj (25917-7Y-11M-300Y-2M)	9	4130	106	8	2484	76
Jar-Napo/LR 64 x Tzpp-Ame (21823-10Y-2M-4Y-1M)	8	4093	105	6	1895	58
CAL/CNO "S" x LR2 64-S64 (27172-303M-302Y-1M)	8	4075	105	5	2165	67
NP-876 Pj x CAL (27110-303M-301Y-2M)	8	4054	104	4	3591	111
KALYAN 227 A x Bb "S" (26992-30M-300Y-1M)	9	4007	103	8		
BT-908	5	3894[2]	100	5	3245[3]	100

[1] Yields were greatly affected by a heavy infestation of wild oats, Septoria, leaf rust and mechanical damage.
[2] Average of 28 replications in yield trials.
[3] Average of 36 replications in yield trials.

Insects

Insect pests include the Hessian fly *(Mayetiola destructor)*, sawfly *(Cephus cinctus)* and wheat stem maggot *(Meromyza americana)*.

Sociological Factors

The human element and its role in wheat production, as far as resistance to accepting new varieties and techniques for obtaining better yields, cannot presently be evaluated adequately.

Judging by the scarce evidence, obtained mainly through general observations, it appears that this problem will disappear when the farmers realize the benefits of using good varieties and techniques for increasing yields.

Economic Factors

It is very difficult to give an estimate of the cost for growing one hectare of wheat. The type of farming varies greatly. Also, the machines and tools used for soil preparation vary greatly, as well as the methods employed.

One estimate gives an average cost of US $60 per hectare under dryland conditions and US$120 per hectare for irrigated land. But, these figures could be in error either way.

The official price of durum wheat last season was US$94.60 and US$86.60 per ton. According to these estimates, a yield of 2.5 tons per hectare would give a 100% profit to the farmer.

WORK UNDERWAY TO OVERCOME LIMITATIONS

1. Use of fertilizers ("Operation Engrains").
2. Crop rotation.
3. Research on:

TABLE 8. Best yielders in the international nurseries yield trials under Septoria attack, 1970-71.[1]

Exp. & Var. No.	Variety or cross and pedigree	Merchouch		
		% Septoria 5/4/71	kg/ha	% Septoria
ISWYN-12	Pato Argentino (21974-4R-4M-2Y-0Y-0P-0Y)	3	3984	164
" 34	CAJEME 71 (Bb # 4) (23584-26Y-2M-3Y-2M-0Y)	7	3746	154
" 22	(LR 64 x N IO B) An (E)[1]	2	3454	141
" 13	Son 64 x Tzpp-Nai 60 (B) (18889-6T-4T-2Y-1T-2B)	5	3392	139
" 31	POTAM S-70	5	3359	138
" 14	SIETE CERROS	6	2621	108
" 50	BT-908	2	2433	100
RSWYN-11	Calidad "S" (22429-16M-1Y-1M-0Y)	3	3883	180
" 10	PATO	3-9[2]	3875	179
" 13	ARIANA 66	3	3759	174
" 8	POTAM S-70	6	3596	167
" 14	BT-2297 (19975-68Y-1J-4Y-1J-4Y)	5	3592	166
" 18	SIETE CERROS	6	2538	118
" 12	INIA 66	6	2521	117
" 25	FLORENCE AURORE	5	2500	116
" 6	D 5825	2	2383	110
" 20	PENJAMO 62	5	2175	101
" 5	BT-908	2	2158	100

[1] Yields were greatly affected by a heavy infestation of wild oats, mechanical damage, Septoria and leaf rust.
[2] Last reading was done on June 14, 1971, to ratify the previous reading.

TABLE 9. Best-yielding lines and varieties in Morocco during 1970-71.

No. of Variety	Variety or cross and pedigree	Sidi Kacem			Fes		Marrakech		Merchouch	
		Septoria %	Yield		Yield		Yield		Yield	
		5/10/71	kg/ha	% check	kg/ha	% check	kg/ha	% check	kg/ha	% check
88	Son 64-Kl. Rend/Bb "S" (26804-6Y-1M-0Y)	60	4542	117	3838	105				
142	Son 64-LR 64 (HD-1799)	50	4504	116	5525	151				
39[1]	Bb "S"-CNO (26572-61Y-3M-0Y)	60	4454	114	4529	124				
68	Son 64-Y50e x Gto/INIA "S" (23528-7M-1T-1M-8Y-0M)	80	4454	114	4479	122				
66	Son 64-Y50e x Gto/INIA "S" (23528-7M-1T-1Y-0M)	80	4446	114	4567	125				
118[1]	NO "S"-CNO "S" (24941-13M-3Y-1M-2Y-1M)	40	4384	112	4250	116				
98	INIA "S"(Son 64 A x Tzpp-Y54) (LR64[2]-Son 64 x Jus) (23817-4T-1M-1Y-1M-0Y)	50	4296	110	2792	76				
157	Tacuari-Pj 62 (Mj-119-100M-100Y)	40	4284	110	4896	134			2854	88
101[1]	Jar 66-CNO "S" (25067-32M-2Y-1M-1Y-0M)	30	4041	104	3742	102				
193	Son 64-Y50 ex Gto/CNO-Son 64 (30426-2M-0Mch)				4009	109				
191	Son 64-Y50e x Gto CNO-Son 64 (30426-6M-0Mch)				3979	108				
144	LR 64A (Tzpp-Y54) (HD-1622)	40	3967	102	5404	147				
	POTAM S-70	70	3928/28[2]	101	4413/32	120	6075	184	3369/44	104
150	LR 64 "S" x Huar (HD-1675)	20	3917	100	5279	149				
	NURI F-70	50	3879/28	100	4355/32	119	6162	186	3160/36	97
13	Bb "S"-INIA 66 (26591-1T-7M-0Y)	90	3870	99	5384	147	5900	178		
	Penjamo 62	70	3827/28	98	4223/32	118	5117	155	2599/48	80
	CAJEME 71 (Bb # 4)	40	3821/20	98	4743/12	129	6442	195	3257/44	100
7	CNO "S"-INIA "S" (23959-52T-1M-3Y-0M)	90	3820	98	6584	179	6542	198		
(4)	Bt-908	30	3894/28	100	3666/32	100	3304	100	3245/36	100
	Siete Cerros	100	3772/36	97	3950/32	108	5571	169	2798/88	86
	YECORA F-70	90	3568/28	92	3986/32	109	5779	175	3125/44	96
	TOBARI 66	70	3337/28	86	3954/32	108	5050	153	2885/60	89
	INIA 66	70	3287/36	84	4052/32	110	5846	177	2839/88	87
163	MID-7	30	3179	82	3258	88			2300	71
169	MID-324	30	2764	71	3113	85			2667	82
	BT-2306						2653	80		

[1] These lines were also among the best yielders during the 69-70 season.

[2] The number indicates replications considered for the average yield used in the table at each location.

(a) Wheat breeding (Tables 7, 8 and 9 give a summary of the best breeding material, under severe attack of *Septoria* and without such attack).

(b) Cultural practices.

(c) Extension.

ROLE OF CIMMYT

1. Research on:
   (a) Wheat breeding.
   (b) Cultural practices.
2. Extension: To what extent, if at all, would it be advisable for CIMMYT to play a role in this important aspect of wheat production?

The Tunisian Accelerated Cereal Production Program

W. J. McCuistion
Wheat Breeder, CIMMYT
Tunisia

Once the bread basket of the Roman Empire and recently an exporting country, Tunisia has shown an increasing need during the last 10 years to import wheat for human consumption.

Considering the rapid population growth (2.8% annually) and the increase in per capita consumption, Tunisia will need about 800,000 tons of wheat to meet its annual domestic demands by 1972-73. Tunisia normally produces 450,000 to 500,000 tons of wheat annually. If needs are to be met, the annual production should be increased by 300,000 to 350,000 tons as a result of unitary yield increases which presently are very low (0.5 to 0.7 tons/ha).

The total area planted to wheat annually is one million hectares. Durum wheat covers about 600,000 to 850,000 hectares and bread wheat, 150,000 to 400,000 hectares.

Tunisia's normal annual wheat production is about 500,000 tons while present annual needs are 800,000 tons. Durum wheat provides 300,000 tons and bread wheat provides 500,000 tons, including imports.

The annual deficit and importation—all bread wheat—is 300,000 to 350,000 tons.

ORGANIZATION

In 1965, CIMMYT wheat varieties and advanced lines were introduced and tested by the *Institut National de la Recherche Tunisienne* (INRAT) during two crop seasons. These limited comparative experiments showed that the CIMMYT-developed varieties yielded about 50% more than the local varieties when grown under only 400 to 600 millimeters of rainfall.

For this reason and because CIMMYT varieties had been performing well in other parts of the world, Sonora 63, Inia 66, Tobari 66 and Jaral 66 were selected for large-scale field testing during the 1967-68 crop season. These tests, under guidance of the U.S. Agency for International Development (USAID), were successful.

An exploratory mission of CIMMYT and Ford Foundation officials in the spring of 1968 resulted in an agreement between the government of Tunisia and CIMMYT (with backup support from the Ford Foundation and USAID) to establish a vertical, nationally coordinated project to further the rapid development of wheat production in Tunisia. It was called the Accelerated Cereal Production Project.

CIMMYT was chosen as the technical executing agency and Tunisian *ingénieurs* were selected as counterparts for each of the technicians assigned by CIMMYT. These local *ingénieurs* are being trained to direct research and extension phases of the program.

By integrating the wheat research and production program within the Ministry of Agriculture, all services involved with improvement of wheat production were connected. The Ministry of Agriculture named a project coordinator directly responsible to him and a project director to work with technical and administrative staff.

The four technical areas of responsibility assigned to the CIMMYT staff and their Tunisian counterparts were: (1) varietal improvement; (2) production research; (3) fertilization research; and (4) extension of production practices.

The Varietal Improvement Section has been closely integrated into INRAT, where some work was already underway in crossing, selection, varietal testing and quality analysis. Both INRAT and the agricultural college have plant pathology and entomology divisions.

Therefore, we are attempting to combine our efforts in these areas. Major emphasis has

been on bread and durum wheat improvement with less work on barley, triticales and oats.

The Production Research Section conducts comparative trials of the most promising new lines from the Improvement Section. The best fertilizer-responsive varieties from CIMMYT and the local varieties serve as checks.

Date-of-seeding trials are conducted to determine optimum varietal response with different maturity dates. Work is also underway to compare various herbicides for controlling major weed pests.

The Fertilization Section conducts trials with nitrogen to determine the optimum application time and the best application rate in the various rainfall zones. Trials are designed to compare the different forms of nitrogen and test response to phosphorus, potassium and microelements.

All trials of the production and fertilization sections are conducted on farmers' fields and are distributed throughout the wheat growing region. Experiments have been kept relatively simple in design with emphasis on their use for farmer demonstrations in addition to applied research.

The Extension Section distributes the package of practices prepared from research results directly to the farmer. This is accomplished through young Tunisian technicians assigned to the various regions, organized field days, radio, television and pamphlets.

The Extension Section is also involved with the government agencies responsible for distribution of seed, fertilizer and herbicides and for providing credit to farmers.

PRODUCTION

During 1969-70, Mexican wheat varieties were planted on 53,560 hectares, 5.8% of the total wheat area of 930,000 hectares, and produced 107,320 tons, about 20% of the total wheat yield (Table 1). However, the Mexican bread wheat varieties were planted on 29.5% of the total soft wheat area and produced 50% of the total soft wheat harvest.

Average yields over all locations and varieties for experiments conducted by the project during the past three years range from 3,000 to 4,000 kg/ha. All locations were under rainfed conditions and attempts were made to use good management practices. Many farmers' fields are now yielding 2,500 to 3,500 kg/ha and the maximum yield was 6,900 kg/ha in varietal demonstrations.

One of the major problems in rapid development of wheat production in Tunisia is the lack of a high-yielding durum wheat variety. All of the CIMMYT lines and varieties tested in Tunisia are susceptible to either stem rust, *Septoria tritici* or powdery mildew *(Erisyphe graminis)*.

For this reason, none of the advanced lines tested have given consistent yields. A few earlier-generation selections with promising resistance were advanced this year. The local varieties are tall, susceptible to disease and lack yielding ability.

Therefore, 75% of the total wheat area is required to produce a sufficient supply of durum wheat for *couscous*, macaroni and spaghetti.

The long-standing price differential of US$ 1.50 to US$2.00 more per 100 kilograms for durum wheat (US$10.45) than bread wheat (US$8.55) has encouraged farmers to grow durum varieties. If a good durum variety cannot be provided soon, the higher yielding bread wheats will replace the local durum varieties.

Nitrogen fertilizer use by Tunisian farmers for crop year 1969-70 was 17,000 tons, 40,000 tons for 1970-71 and is estimated at 60,000 tons for 1971-72. Although these figures represent the requirement for all crops in Tunisia, the large increase in demand has come from farmers applying more fertilizer to their wheat crop.

The price of various fertilizers is: ammonium nitrate (33%), US$5.51/100 kg; urea, US$8.55; ammonium sulfate, US$9.69; and superphosphate, US$6.65.

TABLE 1. Production targets for new, improved wheat varieties and production realized to date.

Year	Proposed area (has)	Estimated yield increases[1] (tons)	Actual area sown (has)	Actual yield (tons)	Actual yield tons/ha	
					Mexican	Local
1968-69	15,000	18,200	10,253	14,435	1.4	0.5
1969-70	50,000	70,000	53,560	107,320	2.0	0.54
1970-71	100,000	140,000	103,000	164,800	1.6	0.6 - 0.7
1971-72	200,000	280,000				
1972-73	300,000	420,000				

[1] Yield estimated 1.4 tons/ha more for Mexican varieties over local varieties with proper cultural practices and average rainfall conditions.

A yield increase and benefit-cost (BC) ratio of 3:1 is normally necessary for farmers to rapidly adopt a new fertilizer practice. Considering the cost of ammonium nitrate in Tunisia and the price that farmers receive for their wheat, a BC ratio of 4.1:1 was calculated for the 28 fertilizer experiments this year.

These results should encourage Tunisian technical personnel and farmers to emphasize nitrogen use to increase wheat production.

Inia 66 continues to produce the highest average yield of all commercial varieties grown in Tunisia. However, its susceptibility to powdery mildew, *Septoria tritici* and leaf rust warrant its replacement very soon.

Tobari 66, although slightly lower in yielding ability, possesses the best overall resistance to the three rusts, to *Septoria tritici* and to powdery mildew.

Penjamo 62 has been maintained for its superior tolerance to *Septoria tritici*. This variety has been impossible to purify in North Africa due to outcrossing of male-sterile Penjamo heads resulting from fluctuating temperatures. Sterility is not caused by frost but rather a 15° to 20°F drop in temperature within two hours when prevailing southerly winds change to northerly predominance.

The continued high yield of Siete Cerros, in the absence of *Septoria tritici,* has encouraged its continuation in the lower rainfed areas of the South and with irrigation.

Hopefully, three new lines will be released as varieties this year to provide yielding potential and tolerance or resistance to the major diseases. The lines, although not officially released, have been named: Zaafrane, catalog number BT-2292, with a pedigree of Son 64 x Kl. Rend. 19975-68Y-1J-1Y-1J-5Y-1T; Soltane, BT-2296, Son 64 x Kl. Rend. 19975-68Y-1J-6Y-1J-3Y; and Utique, BT-2348, Calidad "S" 22429-16M-1Y-4M-0Y (Mex 1603).

Zaafrane and Soltane have consistently yielded higher than Inia during four years of testing in micro-yield trials and two years of demonstration trials in farmers' fields widely distributed over the country. These two sister lines have expressed good tolerance to *Septoria tritici* under heavy attack and have produced high yields with high levels of powdery mildew resistance. They have good resistance to the three rusts in Tunisia.

Utique, one of three sister lines surviving heavy attack of *Septoria tritici* in Morocco during 1968-69, has continued to express a high level of tolerance to this disease in Tunisia during the past two seasons. This variety gave yields equivalent to Inia last year in the absence of *Septoria* and has been yielding 10 quintals/ha more than Inia in the heavily infested *Septoria* areas this year.

Utique contains resistance to stem rust, sufficient tolerance to leaf rust, and medium susceptibility to stripe rust and powdery mildew. It has balanced quality characteristics.

LIMITATIONS TO INCREASED PRODUCTION

Problems thus far encountered prohibiting the realization of maximum potential from fertilizer responsive varieties are:

1. Movement during 1968-69 to cooperativize all farms in Tunisia prevented full cooperation of farmers in applying the package of practices. Also, there was poor rainfall distribution and a generally dry season.
2. Late seeding in 1969-70 due to decooperativization and poor distribution of seed, fertilizer and herbicide reduced yield potential.
3. A very dry fall in 1970-71 with essentially no rainfall until December 15 and then continued wet soils until March made seeding difficult and weed control impossible. Following this wet period, April and May were very dry, causing light, shriveled grain in many instances.

General problem areas confronted and research being developed are:

1. Continued emphasis on timely cleaning, treating and distribution of seed to farmers.
2. Timely distribution of fertilizer, herbicide and provision for credit.
3. Improved practices of seed certification and roguing for varietal purity.
4. Better weed control, one of the greatest hinderances to yield, through improved cultural practices and timely chemical control.
5. Introduction of cereal-legume pasture rotation to combat weeds, build soil structure, increase the nitrogen content, and provide good pasture and hay for livestock.
6. Increased emphasis on known factors as part of the package of practices for increasing yields.
7. Emphasis on selection and release of a new, short-statured, fertilizer-responsive, disease-resistance, good-quality durum wheat variety.
8. Continued search for new lines of bread and durum wheat containing resistance to *Septoria tritici,* powdery mildew, stem rust, leaf rust, stripe rust and *Fusarium culmorum.*
9. Search for lines of bread and durum wheat resistant to Hessian fly, sawfly, cereal leaf beetle and oat cyst nematode.

10. Timely harvest to avoid shattering and cracking the grain.

Conclusions from Research

Seed rates of 60 to 80 kg/ha give yields equivalent to 100 kg/ha rates when seeded with a drill and properly managed.

Yield increases up to 300% above the check plots are observed with proper nitrogen utilization. Of course, this increase depends on the base level of fertility, preceeding crop and rainfall. Average increases of 700 to 1,030 kg/ha were observed from nitrogen use over all experiments during the past three years.

The optimum nitrogen rate for the high rainfall areas (500 mm) appears to be 90 kg/ha, and 67 kg/ha for areas receiving less than 500 millimeters of annual rainfall. These recommendations vary with soil type, preceeding crop, soil moisture reserves, rainfall, variety, etc.

The best time to apply nitrogen in the higher rainfall regions is half at seeding and half at tillering, or all at seeding in the lower rainfall areas.

Experimental trials and soil tests indicate sufficient available phosphate at most locations. This may result in phosphate accumulation due to relatively low grain yields the past two years and to annual phosphate applications by the better farmers.

Potassium and microelement studies give no yield differences and, therefore, are not limiting production factors.

Optimum seeding dates for the early-maturing varieties are from November 25 to December 25. Varieties with the maturity of Siete Cerros should be seeded around November 25 and earlier varieties similar to Inia, about December 10-25.

CONCLUSIONS

The Tunisian program has made great strides toward its goals of reaching self-sufficiency and developing a strong research base for the future. Continuing efforts for coordination of the various government agencies concerned with the wheat crop and its associated products will make Tunisia a strong wheat center for the North African region.

The Wheat Situation in Algeria

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PRODUCTION AND DISTRIBUTION OF SPECIES AND VARIETIES

Cereal growing dominates Algerian agriculture, both in an economic and social sense. Cereals are the basic nourishment of the rural population and they cover almost 6 million hectares (fallows included). This is 90% of the cultivated land.

In 1969-70, cereal area and production was distributed as shown in Table 1.

Changes in Production and Consumption

From 1951 to 1970, the average cereal production in Algeria was 18.5 million quintals.

Durum wheat represented 48% of the area and 45% of the production in 1969-70. For bread wheat, barley and oats, these figures were 25% and 23%, 28% and 27%, and 2% and 2%, respectively.

Despite a production increase from 1951 to 1960, exports tended to decrease in this period. The decrease was due to a considerable population increase and a rise in national income, both increasing cereal consumption. Since 1963 imported cereals averaged 4 million quintals annually, mainly bread wheat (Table 2).

Systems of Production

Two sectors dominate in Algeria—the socialist sector and the private sector.

The socialist sector has 25% of the cereal area. This sector is concentrated in the Middle West (Oran). It provides nearly a third of the production and 50% to 70% of the wheat entering the market.

Yields in the socialist sector are 7 to 8 quintals per hectare (Table 3). Depending on the season, this sector sows from 780,000 to 820,-

TABLE 2. Wheat production, imports, exports and consumption for 1959-71 (thousands of quintals).

Year	Production	Imports	Exports	Consumption
1959-60	17,554	6,673	1,161	23,066
1960-61	23,486	3,588	464	26,610
1961-62	8,977	8,565	293	17,249
1962-63	23,262	1,916	1,508	20,670
1963-64	22,762	980	3,101	20,641
1964-65	14,405	2,249	1,658	14,996
1965-66	17,003	4,250	38	21,215
1966-67	7,800	10,280		18,080
1967-68	16,300	6,588		22,888
1968-69	21,090	5,514		26,604
1969-70	18,319	2,446		20,765
1970-71	20,426	6,754		27,180

TABLE 3. Yields in quintals per hectare of cereals in the socialist and private sectors (1963-68).

Sector	Durum wheat	Soft wheat	Barley	Oats
Socialist	7.9	7.1	8.2	5.4
Private	5.3	5.3	5.7	5.1

TABLE 1. Cereal area and production for the socialist and private sector (1969-70).

	Socialist Sector		Private Sector		Total	
	Hectares	Quintals	Hectares	Quintals	Hectares	Quintals
Durum wheat	321,429	2,342,990	1,226,180	6,762,012	1,547,669	9,105,002
Bread wheat	328,777	2,425,266	413,572	2,776,775	742,349	5,202,041
Barley	82,709	753,739	769,262	4,947,679	852,171	5,701,418
Oats	29,089	213,633	37,182	204,462	66,271	204,462
Total	762,004	5,735,628	2,446,386	14,690,928	3,208,390	20,426,556

000 hectares. Durum wheat occupies 42% of this area, soft wheat, 43%, barley, 11%, and oats, 4%.

The private sector occupies almost 75% of the cereal area, but yields are low and little wheat is marketed. The low yields are caused by the Fellaheens' concentration in the marginal or hilly regions, lack of practices designed to conserve the soil, neglect of crop rotation and lack of fertilizers. The cereals sown in the sector are, by area, durum wheat, 50%, soft wheat, 17%, barley, 31%, and oats, 2%.

Cultural Systems

A biennial rotation is the most common system. Because of the various cereal rotations, different fallows are used.

A pastured fallow and a mowed fallow are used with the aim of increasing cereal productivity. However, these two practices are not recommended since they reduce the yield of the subsequent crop.

The spring fallow involves a scarification after straw gathering, a deep tillage in spring and three light workings from May to August aimed at destroying weeds and reducing evaporation of the soil-stored water.

The integral-worked fallow is recommended for soils with good waterholding capacity. It consists of superficial tillages and working patterns all year long, beginning immediately after harvest.

The cultivated fallow is the best fallow. We are attempting to introduce it into rational rotations. It consists of growing green manure or forage crops to: improve the fertility and structure of the soil; enrich the soil in organic and nitrogenous substances; enable the land to produce harvests every year without exception; and diminish the cost of production.

Varieties

Durum and soft wheat varieties utilized until 1968 were generally late maturity, sensitive to lodging and seldom yielded more than 30 quintals per hectare. However, there is a certain hardiness in these varieties.

Durum wheat varieties include the following:

Hedba 3. Hardy, heavy tillering, drought resistant, susceptible to rust and lodging, late. Scattered in the regions of Sour, El-Ghozlane, Bouira, Le Sersou, Sidi-Bel-Abbes, Tiaret, Hauts Plateaux and Guelma.

Qued Zenati 368. Earlier than Hedba and more productive, sufficiently resistant to lodging and to rust, relatively short straw suitable for fertile soils.

Zenati Bouteille 13953. Earlier but sensitive to rust and lodging. It is suitable for warm regions of the subcoastal plains.

Saba 22738. Relatively early, fairly resistant to rust and suitable in both highland and coastal regions.

Bidi 17. Similar to Qued Zenati, lodging resistant, good yield capacity but poorer industrial quality.

Mohamed Ben Bachir 8037. Scattered north of Setif, excellent quality semolina but susceptible to black rust.

Bread wheat varieties are listed.

Mahon Demias. Not suitable for coastal areas but satisfactory for dry parts of the highlands and for semi-arid zones, with frosts and with calcareous and shallow soils; sensitive to rust and lodging.

Baroota 8791. Algerian selection from the Australian variety Baroota. Hardy, early, resistant to frosts and stable yielding. Has medium baking quality.

Florence Aurore 8193. Selection from the French variety Florence Aurore. Early but sensitive to frosts. It requires fertile soils well prepared; good for coastal zones and for Tell Nord; strong gluten.

Pusa Florence 380. Resistant to frost and less exacting in regard to soil. Thus, it may substitute barley in some areas; strong gluten.

Aegylops 14257. Very hardy hybrid, it may replace the Mahon Demias variety in the frost-free Tellian zone; moderate baking quality.

Puma Flore 22259. Hybrid resistant to lodging, productive but exacting; medium baking quality.

FACTORS LIMITING WHEAT PRODUCTION

Soils

All the regions are not equally suitable for cereal growing. They are all entirely rainfed. If 350 millimeters of annual rainfall constitutes a minimum below which growing cereals is neither agronomically nor economically feasi-

ble, and if we fix the upper limit of slope at 12.5%, then 25% of Algeria's cereal area should be in pasture production.

This area furnishes only 7% to 8% of the wheat production. Technical and sociological reasons prevent the reorganization of these marginal zones at present.

Climate

Variations in climate and rainfall are the main causes of production fluctuations.

The area sown and the nature of the cereals cultivated depend principally—in the traditional sector—on the abundance and earliness of rains in the fall. Yields and production depend on rainfall in the winter and spring.

Late frosts, which particularly menace areas above 1,000 meters elevation, early siroccos (hot winds), premature termination of the season, storms and hail constitute the many climatic hazards to cereal growing in Algeria.

Cereal Diseases

The principal cereal diseases are: stem rust *(Puccinia graminis tritici);* yellow rust *(Puccinia striiformis);* brown rust *(Puccinia recondita); Septoria tritici; Helminthosporium vulgaris tritici;* bunt of bread wheat *(Tilletia foetida);* wheat smut; mildew and *Fusarium.*

When the season is favorable for disease attacks, damage to the wheat crop is considerable. To avoid contamination, each variety is cultivated in its most appropriate area. Disinfection and fungicide treatment of seed wheat also help reduce disease problems.

Insect Pathogens

We categorize insect pathogens as soil pathogens (nematodes) and pathogens of stored grain (weevils). To control pathogens of stored grain, we use fungicides and insecticides such as Aldrin.

Weeds

Weeds are one of the important limiting factors for cereal production. Weeds may reduce yields by half. Use of herbicides alone is not sufficient to eliminate weeds such as wild oats.

Proper cultural techniques, surface cultivation and choice of rotation help in this struggle against weeds. The most widely used herbicide is 2,4-D.

Sociological and Economics Factors

The sociological and economic factors that hold back production may be summarized briefly: use of poor quality seed in the private sector; little use of fertilizer; retention of grain on the farm; and inadequate cultural techniques.

THE NATIONAL PLAN

Soon after Independence, increasing consumption caused a deficit in wheat production. Today, production satisfies only 80% of Algeria's needs. Growth in demand was accompanied by a change in demand. Demand for bread wheat has grown most rapidly. During 1965-68, two actions were carried out.

1. Wheat acreage was distributed according to this change in demand. Thus, the bread wheat acreage increased from 526,000 hectares in 1965 to 742,000 hectares in 1970.
2. Increased production of selected seed during this same period was: 1965, 132,809 quintals; 1966, 271,019; 1967, 206,856; 1968, 698,236; and 1969, 804,181. It is obvious from earlier tables that these two actions have not been a great aid to increasing overall production. The agricultural development plan for 1969-73 has defined a strategy of intensification of cereal growing in our country.

Area Cultivated

During the last two years, the area reserved for each cereal has been distributed according to changes in consumption.

In Algeria there is no possibility of increased area for cereals. On the contrary, the area must be reduced because of substitution of pasture for cereals in the marginal areas, substitution of more intensive cropping in the irrigated zones, and reforestation of soils with considerable slope.

Yields

Our cereal policy is directed principally towards increasing yields (5.9 q/ha average now, 7.6 q/ha in the socialist sector).

We need varieties with: earliness; great capacity of adaptation; high genetic potential; responsiveness to fertilizer; insensitivity to lodging, consequently, short straw; and resistance to diseases.

The cultivation of such varieties can be achieved by introducing Mexican and Italian varieties, and genetic improvement of local varieties by crossing. Algeria has embarked on a program involving large areas sown to varieties that had been grown only under irrigation in their country of origin.

Encouraging results from 5,100 hectares of the varieties Inia, Tobari, Siete Cerros, Sonora and Jaral urged us towards a more ambitious program. In 1970-71, 138,000 hectares of three Mexican varieties and 2,000 hectares of Italian varieties were sown.

Genetic improvement by crossing high-yield-potential wheats and local varieties will be the second phase, starting in 1971-72 thanks to CIMMYT assistance and some Algerian trainees who studied at CIMMYT headquarters.

High-yield-potential varieties must be accompanied by the intensification of other factors. These will be discussed.

Chemical fertilization was rarely used in Algeria. The objective of the colonial sector was minimum investment and maximum production through extensive cereal growing.

TABLE 4. Fertilizer applications (kg/ha) in the socialized and private sectors in recent years.

	Average applications since 1963		
	Socialized Sector	Private Sector	Estimated for 1973
Nitrogen	3.3 - 6.6	0.4 - 0.6	66
Phosphorus	10 - 19	0.3 - 0.8	64

The objective of the fertilization plan is optimum fertilization for about 800,000 hectares before 1973. After 1972, the national fertilizer industry will satisfy the needs of the country and reduce prices of the principal fertilizers 50%.

Begun in the earlier years, the seed production program aims to include one million quintals annually—the annual renovation of a third of the seed used. This objective has almost been achieved. In 1969, the figure was 800,000 quintals. The program is directed towards the production of quality seed. Seed of natural origin has been progressively replaced.

The support structures for improved seed production are strengthened each year. Training periods have been organized for seed production technicians, multiplying fields have been equipped and an extensive program of establishing seed treatment stations has been initiated. A large station has been created at Sidi-Bel-Abbes and some other stations have been prepared.

Substituting the cultivated fallow for the pasture fallow is the first phase of a program to reorganize the fallow system. The second phase includes substitution of the traditional biennial rotation by more elaborate rotations (described previously).

Spring tillage developed in the self-directed socialized sector (80% of the area) and must be spread to the private sector. Also, improved rotations in the socialized sector have started. Weed control by aerial or soil treatment will help reduce losses due to weeds. The Ministry of Agriculture and Agrarian Reform has made provision for needed machinery such as seeders, fertilizers and cultivators by 1973.

Training and Cereal Research

Training in cereal growing started several years ago and involves four levels:

1. Training of farm leaders in practical tasks at the professional training center in all cereal regions.
2. Training of agricultural technicians in the regional schools of agriculture. Also, two institutes of technology specializing in cereals will be opened in October 1972.
3. Training of applied engineers at the Technological Institute of Mostaganem. The first students to complete this course will graduate in 1971-72.
4. Courses have finally been set up for 1971-72, with the assistance of CIMMYT, for specialization in phytopathology, fertilization, breeding and seed production.

Priority is given to cereal research at the National Institute of Agronomic Research. A new station will be established at Tiaret. Seven stations will cover all of the cereal regions.

Also, Algeria is studying the creation of a national center of research and cereal improvement.

The application of a national program in limited time has presented the problem of administrative structures. Consequently, the Ministry of Agriculture and Agrarian Reform has created a vertical project structure to efficiently mobilize all available people, utilize resources (material and vehicles) and maintain direct communication.

CIMMYT CONTRIBUTIONS

With regards to Algeria, CIMMYT contributed to the holding of the international seminar on cereal cultivation at Algiers in 1970. During 1970-71, CIMMYT has advised the Ministry of Agriculture and Agrarian Reform on the introduction of high-yielding varieties and has helped train Algerians in breeding, pathology, etc.

More importantly, within the outline of the Algerian program, CIMMYT will provide assis-

tance for agronomical research, breeding and training.

The recommendations we make to CIMMYT are the following:

1. Train and strengthen the agronomic teams and research workers at the national level.

2. CIMMYT should be the vehicle for dialogue on cereal problems for agronomists and projects of all the countries, enabling comparison of the results obtained by different methodologies.

3. Conduct research to obtain new durum wheat varieties and new rotations.

4. Provide regular publication of a review of cereal research in the various countries (English, Spanish and French editions).

We believe that the high-yielding varieties program opens new horizons for achieving national goals.

Current Wheat Situation in Ethiopia

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The principal cereal crops are teff *(Agrostis abissinicus)*, barley, sorghum, millet, wheat and maize with an estimated total production of 6.23 million metric tons in 1970. Most of this is produced by subsistence farmers so only a small part reaches the market place, mostly in favorable years.

STATISTICS OF WHEAT PRODUCTION

The figures in Table 1 are based on estimates with a fairly wide margin of error. Figures presented for the Chilalo Agricultural Development Unit (CADU), a relatively small, comprehensive project area in Arussi Province, are more reliable and more informative.

TABLE 1. Wheat production statistics for Ethiopia and for the CADU Project.

Ethiopia[1]	1969-70	1970-71	1971-72
Area (1,000 ha)	1,070.3	—	—
Yield (q/ha)	7.6	—	—
Production (1,000 tons)	808.0	—	—
CADU Project[2]			
Improved wheat with fertilizer			
Area (1,000 ha)	13.0	25.0	57.0
Yield (q/ha)	19.7	18.4	19.7
Production (1,000 tons)	25.6	46.0	112.3
Improved wheat without fertilizer			
Area (1,000 ha)	.5	1.5	4.5
Yield (q/ha)	16.0	13.7	16.0
Production (1,000 tons)	0.8	2.1	7.2
Local wheat without fertilizer			
Area (1,000 ha)	76.5	63.5	38.5
Yield (q/ah)	11.8	12.7	12.7
Production (1,000 tons)	90.3	80.6	48.9
Total (within CADU)			
Area (1,000 ha)	90.0	95.0	100.0
Production (1,000 tons)	116.7	128.7	168.4

[1] Source: Imperial Ethiopian Government, Central Statistical Office, Addis Ababa, 1970.

[2] Source: Planning and Evaluation Section, CADU (SIDA), Addis Ababa, 1971.

Exports and Imports

Durum wheat grain and flour exports continued until 1957 but have been insignificant since 1953 when the demand for bread, principally in urban areas, started to increase. Imports of wheat flour were started in 1962 and by 1965 grain was also being imported.

The annual value of imports (1962-69) was about US$1.28 million. Imports have risen appreciably since then. In the first quarter of 1971, more than 12,000 tons of wheat valued at US$1.1 million, were imported.

Imports of wheat flour are about 31% of the total quantity consumed, macaroni, 2%, and biscuits, 14%. Domestic production has not kept pace with the consumption increase.

There are 18 grain mills and 43 bakeries registered in Ethiopia. According to the Ministry of Commerce, Industry and Tourism, local production capacities are insufficient to meet domestic demand.

For example, the wheat flour production capacity of the five biggest mills is 56,100 tons. The two largest macaroni firms produce 20,418 tons. These capacities are small in relation to total domestic production and need to be much enlarged if local production is to replace imports.

Variety Composition

In 1969, probably more than 90% of the varieties grown were *Triticum turgidum*, represented by the varietal groups *T. durum* and *T. turgidum*. The production of bread wheat has received greater emphasis in recent years.

In the CADU Project area, the 1971 production of bread wheat is estimated at 120,000 tons, 14% of the national production. Probably more than 20% of this crop is seeded with improved varieties of bread wheat, mostly Su-

premo-Kenya x Yaqui 48, Romany, 8156 (white), Penjamo 62, FW/68, Salmayo, Kt-Fn x My 48, Kenya 1 and Yaktana 54.

All, except FW/68, are susceptible to the local stem rust races. At higher altitudes, Romany and Salmayo have done well. The average quality of these varieties is mediocre and overproduction of these wheats could be embarrassing.

LIMITATIONS TO WHEAT PRODUCTION

Climate

Wheat is grown in the highlands between 6° and 15° North and 37° and 42° East from 1,700 to 2,500 meters. Rainfall in the highlands is bimodal and ranges between 800 and 2,000 millimeters annually. Most of the rain falls between June and September and about half of the total falls in July and August. October to February is usually dry.

Absolute maximum and minimum temperatures are 25° to 30°C and 3° to 8°C. Sunshine and radiation intensity are very low in July and August. Desiccating winds in October cause premature drying of ears. Wheat is generally sown from July through August but in many areas sowings extend into September. It matures under low temperatures in November and December.

Soils

The highlands include high mountains and deep gorges. Soil erodes from 52% of the land area at a rate of about 2,000 tons per square kilometer per year.

Soils are variable. They are mostly shallow, red ferrisols on the slopes and deeper, black, brown-gray or brown clays in the valleys.

These soils crack badly on drying. During the main rains they quickly become waterlogged. They can only be worked with oxen-drawn plough when at an optimum moisture content, so cultivations are late and cultivated areas are small.

Because the soil becomes waterlogged soon after the start of the rains, sowings are often delayed until after the heavy rains. As a result, plant stands are usually poor and yields are reduced by moisture stresses and cracking soils.

Proper management of these soils is of paramount importance in crop production.

Diseases

Two groups of fungus diseases are important—the rusts and the blotches. Epidemics of stem rust are new because susceptible varieties are now grown in large, contiguous areas, especially east of the Rift Valley.

Previously, the rust never reached epidemic proportions because of the composite variety effect of the many local cultivars. At altitudes above 2,200 meters, stem rust is relatively unimportant unless early infections build up in the lower surrounding areas.

The stem rust races have recently been identified by pathologists in Kenya as: EA 5(Int. Race 34, 55%); EA 7(Int. 40, 35%); and EA 9 (Int. ?, 6%). In the United Arab Republic, the Ethiopian races were identified as: Race 53 (32%); 24(15%); 34(12%); 17; 117; 11; 9, and 21 (under 10% each).

Leaf rust and stripe rust are lesser problems.

Among the blotches, the most important is caused by *Septoria tritici.* Climatic conditions in the highlands, the clay-type, waterlogged soils and the low-light intensities during July through August contribute to making this a serious disease with yield losses of 53% to 96% in susceptible varieties. The current dwarf varieties are particularly prone to this disease.

Social Factors

About 80% of the 24 million Ethiopians are subsistence farmers. The average farm size in the highlands is about 2.3 hectares. Also, 50% of the farms are smaller than one hectare.

Illiteracy is high and agricultural information is still very scanty. Land ownership, tenancy and crop sharing systems are among the most complex in the world and present serious limitations to increased production.

Where the infrastructure is organized and following the successful demonstration of improved packages, some landlords have started large-scale, mechanized production. This leads to the eviction of hundreds of tenants at short notice.

On the technical side, there is a dire need for more staff with the required skills. Extension needs greater intensification while research needs a more extensive effort.

Economic Factors

Ethiopia's economic factors are much the same as in most developing countries. The lack of an organized infrastructure is significant. Over most of the country, communications are poor.

There is a lack of incentives, capital and credit for the necessary inputs, marketing agencies, and storage and distribution facil-

ities. Grain prices are not regulated and they fluctuate widely by season and by location.

There is no national seed multiplication and distribution organization and no supporting legislation.

NATIONAL PROGRAMS

Research

There are nine institutions doing some research on wheat. Only two deal with irrigated wheat in the lowlands.

One of the first tasks of the Institute of Agricultural Research was to coordinate activities of wheat workers. This was done through the National Crop Improvement Committee. Later, crop subcommittees were formed. They make reviews, plan work on the particular crop, and arrange national variety and cultural trials.

It has taken two years to formulate a national research policy for wheat. The main aspects of this policy are listed.

Bread wheat production should be geared to meeting the internal requirements of the country. Production should be encouraged in parts of the region at 1,700 to 2,200 meters altitude. The research emphasis is on early maturity, stem rust resistance, above-average quality and good adaptation.

For areas in the Central Highlands at altitudes of 2,200 to 2,500 meters or more, the emphasis should be on developing: (a) triticales of high nutritional quality for human food; (b) durum wheats with good quality for pasta products; (c) soft wheats of acceptable quality for biscuit making; and (d) bread wheats of average quality for bread.

Researchers are seeking widely adapted varieties with early-to-medium maturity, good resistance to *Septoria* and stripe rust in bread and biscuit wheats, and also to stem rust in durum wheats. Triticales work emphasizes utilization and nutritional value.

To be effective, the research program would have to be comprehensive, involving many related disciplines, all aiming at evolving the best package of factors conducive to optimal yields and quality. All facets of this objective are being investigated. Generous assistance is being given by the Plant Breeding Station, Njoro, Kenya, for rust testing and quality analysis.

Information on varieties and their optimum cultural and fertilizer requirements is already available for some areas, but with such diverse soil and climatic conditions, the optimum package of factors needs to be determined on a wider geographical basis.

Soil drainage is receiving attention, but corrective measures require machinery and capital. Some other problems being tackled are: diversifying crop production through suitable crop rotations; overcoming the practice of soil burning through better drainage; use of fertilizers; and proper utilization of fallow land.

Current Work in Related Fields

The Commission For Planning is aware of the problems that arise in the wake of a green revolution. The Third Five-Year Plan encourages commercial, mechanized farms as the quickest means of increasing production, substituting imports and increasing foreign exchange earnings.

Cereals are not exported because, despite incentives to the agricultural sector, farm costs are high and local transportation costs are prohibitive. Durum wheats might prove an exception, especially if productivity can be improved.

The present emphasis is on raising the peasant farmers' standard of living. Comprehensive projects such as CADU, WADU, Awassa and the proposed Ada and Shashamene projects aim at improving life for the peasant farmers.

The CADU pilot project has made good progress since 1967, especially in crop production. Its credit and other facilities have reached 15,000 farmers in the project area. The immediate tangible result has been doubled wheat yields.

Such comprehensive projects are too expensive to extend to other parts of the country. Apart from the local impact, their main usefulness has been the information gained about organization and administration of extension, credit and marketing on a large scale in a subsistence community.

The reorganization of the Ministry of Agriculture in 1970 resulted from the recommendation of a Rockefeller Foundation committee and now includes an Extension and Project Implementation Department (EPID). The EPID works with the Commercial Farms and Comprehensive Projects and has executive control of the Minimum Package Program.

This program demonstrates innovations and methods, provides inputs and credit, promotes formation of primary cooperatives and will operate in limited regions of good potential where research results are available or applicable.

The detailed organization of the Minimum Package Program has been worked out with IBRD and progresses in three stages—observation, demonstration and implementation. Each year about 10,000 new farmers will be served in each implementation area.

A parallel training program for research workers, administrators and extension workers is under way.

UNDP/TA Program plans call for drafting seed legislation as a basis for a seed production organization. Hopefully, the Grain Board and Grain Corporation can be more effective in organizing storage, distribution and stabilization of grain prices.

The Ministry of Agriculture has recently formed a Soil and Water Conservation Division. Its work should make a significant contribution to increasing crop production.

The recent merger of the Development Bank and the Investment Corporation to form the Agricultural and Industrial Development Bank will make possible agricultural credit on a much larger scale than previously.

A bill has been submitted to Parliament relating to land tenure, ownership and tenancy. These are long-term measures and any impact might not be felt immediately.

ASSISTANCE GIVEN BY CIMMYT

CIMMYT is not directly involved in Ethiopia, but has provided training to five Ethiopian graduates in Mexico in wheat work under the FAO-Rockefeller Foundation Training Program. Also, CIMMYT has provided much wheat seed for experimental use.

The Mexican bread wheats used today are all derived from FAO/CIMMYT/USDA programs, reaching Ethiopia either directly or through Kenya.

In recent years, as a result of the Cooperative Regional Programs, the generous supply of bread wheat, durums and triticales of high yield and quality in the form of yield and screening nurseries as well as segregating populations has enabled workers to include very promising material in their programs. Much of this material will be the varieties of tomorrow.

The free and generous supply of material has enabled countries like Ethiopia to increase production even before being able to support a basic research program.

Wheat Improvement and Production in Egypt

Hassan Ali El-Tobgy
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Wheat Breeder
Ministry of Agriculture
Egypt

Wheat is the staple food grain for the urban population of Egypt. Because of the limited cultivated area of the country (about 2.4 million hectares), the wheat area is restricted and has decreased from 610,000 hectares in 1960 to 565,000 hectares in 1970.

During the same period, the population increased from 26 million to 34 million. The country is a wheat importer and with the present trend is population, wheat imports will continue to increase.

Although wheat yields averaged 3 tons/ha last season, it is imperative to increase wheat productivity per hectare.

All the wheats grown in Egypt are soft spring wheat, though they are sown in the early winter. They are all grown under irrigation. The cultivated area lies between 31° and 22° North latitude while its altitude lies at about sea level.

WORK DONE AND IN PROGRESS

Wheat Breeding

From 1920 onwards: Prior to 1920, breeding work was characterized by the survey and individual plant selection from local material which was mostly population mixtures.

In 1920, some wheat *(T. aestivum)* was introduced from India. As a result of intensified work on this material, varieties such as Hindi D, Hindi 62 and Tosson were developed. Varieties Beladi 116 *(T. pyramidale)*, Dakar 49 and Dakar 52 *(T. durum)* were selected from local material during this period. All these varieties succumbed to the attack of one or more rusts.

Since 1942: A hybridization program was initiated to develop varieties resistant to stem rust by bringing in new genetic stocks from Kenya. This resulted in Giza 139 (resistant to stem rust) in 1948.

With the release of Giza 139, the stem rust problem was almost solved but this variety was highly susceptible to leaf rust and moderately susceptible to stripe rust.

Since 1950: An expanded program of crossing was started, based on genetic diversity (Kenyan varieties, U.S.A. Regent, Mida Cadet, Newthatch and others) rather than more crosses of the limited and related parents. This work was stimulated by USDA and FAO nurseries.

During this period several varieties were developed for direct multiplication and breeding. As a result, the following varieties were released: Giza 144, Giza 145, Giza 146, Giza 147, Giza 148 and Giza 150.

All these varieties were resistant to stem rust while Giza 144 was also resistant to leaf rust and became more popular. Also, it focused attention on the problem of stripe rust. In 1967, Giza 144 was severely attacked by this disease in many parts of the Delta.

In the 1960's: More attention was given to the introduction of useful sources of genes for resistance. This resulted in the development of Giza 155, resistant to both stem and stripe rusts. Also, it had a high degree of tolerance to leaf rust, was early maturing and was moderately resistant to lodging. It had about 20% more yield potential than the earlier commercial varieties, comparing favorably with Mexican varieties.

Giza 155 seeds were first distributed to farmers in the 1968-69 crop season. In 1970-71, it occupied about 90% of the total wheat acreage. It yielded about 600 kg/ha more than Giza 144 and helped produce 300,000 additional tons of wheat.

Recently, another variety, Giza 156, has been developed which has better yield potential than Giza 155 but it is comparatively susceptible to stripe rust and is still under extensive study.

Concurrently, from 1962 onwards, semidwarf and dwarf genes were transferred to local cultivars from material introduced from Mexico with the help of CIMMYT and FAO programs.

As a result, several promising semidwarf lines were developed. These lines combine resistance to rusts, lodging and shattering with high productivity and better fertilizer response. Some of these lines (Lines 1567/4202, 1568/4478, 1571/4762, 17[illegible]048, 189/3137, and 191/3146) are now in an [illegible]anced testing stage The outstanding ones will be available for commercial planting.

At the same time, some of the high-yielding Mexican varieties are being extensively tested in the country. Also, many introductions and promising lines are being tested. Moreover, the cultural requirements of the new varieties are receiving more attention.

Wheat Disease

Considering the great importance of rusts and other diseases, pathologists have been closely collaborating with wheat breeders to determine the prevalent races of rust, appearance of new races, epidemiology of rusts, to screen several varieties against rusts and other diseases, and to identify genes for resistance to stem rust.

The present wheat disease situation is as follows.

Stem rust: Present but under control due to the development of resistant varieties. Races reported: 9*, 11*, 14*, 17*, 19*, 19A, 21, 24*, 24A, 42 (4 subraces), 53, 59, 69, 88, 117, 133, 186, 194, 196, 245, 279, 298 and E1.

Leaf rust: Present, but almost under control due to the development of field-tolerant varieties. Races reported: 10, 12*, 13, 17, 20, 26*, 31, 49, 57*, 67, 68, 77*, 86, 107*, 117, 129, 130, 131, 14[illegible]*, 158, 172, 184, 185 and 187.

Stripe r[illegible]: Present, more serious in the area. The [illegible]troduction of Giza 155 is likely to reduce its incidence.

Loose smut, bunt and *flag smut:* Present, but in minor importance and under control.

Septoria glume blotch: Not present.

Septoria leaf blotch: Not present.

Virus disease: Wheat mosaic present in traces.

Cultural Practices

Cultural requirements are one of the limiting factors in wheat production in Egypt. Cultural recommendations include:

1. Rotation: wheat is grown as a winter crop, usually after cotton and sometimes after maize or rice.
2. The best sowing time is: for Lower Egypt, November 10-25, and for Upper Egypt, November 5-15.
3. The recommended seed rate is 170 kg/ha. Sowing is done by hand broadcasting.
4. The optimum number of irrigation water applications is four or five, depending upon type of soil and the locality.
5. The economic fertilizer rate for the older varieties was 75 kg N/ha. Giza 155 stands up to 125 kg N/ha while semidwarf varieties respond economically to 150 kg N/ha.
6. Harvesting starts in early May in Upper Egypt and in mid-May in Lower Egypt.

Grain Quality

Work on quality testing has been in progress at the Grain and Bread Section, Giza. This section has been cooperating closely with the wheat breeders in testing the established wheats, new wheats and hybrids in early generations.

As a result, there has been a gradual increase in protein content. It was 7.5% in the old Beladi wheats and 8.5% in the varieties released in the 1950's. In recent varieties, the protein content is 10%.

Certified Seed Production

A good seed production program has been developed. The foundation and registered seeds are produced on Ministry farms under supervision of the Wheat Research Section staff. Certified seeds are produced throughout the country by contract growers under the the supervision of the technicial staff of the Seed Administration.

There are seed testing stations at Giza, Tanta and Minia which are responsible for the certification of the seed. All the seed is cleaned, treated with chemicals, certified, sealed in sacks and labelled before distribution to allow replacement of farmer's seed stocks every two or three years.

CONCLUSIONS

Due to efforts in the wheat research program to obtain higher yielding varieties, resistance to rusts and response to nitrogen fertilizer, the national average yield has reached 3 tons/ha (in 1971). This is quite high compared with other countries in the Near East.

* Prevalent races.

However, there is great potential for further increasing the yield level as is evident from results of recent experiments. For example, the average yield of Giza 155 was 5.3 tons/ha while yields of Siete Cerros and Super X were 5.5 and 6.1 tons/ha, respectively, with 150 kg N/ha. The only drawback of the Mexican varieties is their greater susceptibility to stripe rust and shattering.

To exploit the yield potential of the improved varieties, it is essential that farmers use improved cultural practices, especially proper levelling and seedbed preparation, combined seed and fertilizer drills, optimum quantities of fertilizers applied at the proper time, controlled irrigation and drainage, suitable mechanical-chemical methods for controlling weeds, and combines for harvesting and threshing

To popularize the use of such improved methods, it is essential that farmers be supplied with the machinery needed and guided in its proper use. This can be done through farmer cooperatives.

COOPERATION WITH CIMMYT

Cooperation between the Egyptian program and CIMMYT started in 1962 with the exchange of wheat material, the sending of trainees to Mexico and the provision of scholarships for two doctor of philosophy degrees in wheat breeding. In 1968, there was an extensive exchange of wheat material and planning of yield trials.

In 1971, an agreement was signed between the Egyptian government and the Arid Land Agricultural Development Program of the Ford Foundation with the technical support of CIMMYT. This will be a great step forward to meet the urgent demand for increased wheat production.

In addition to the technical assistance for the Egyptian Program, the Foundation will provide basic laboratory and field equipment to support and expand the research and production programs plus training fellowships for a limited number of young scientists in various disciplines.

An arrangement has also been made for a continuous supply of selected plant materials for use in wheat breeding and production programs. This includes exchanging varieties and advanced lines resistant to the three rusts and lodging as well as possessing high protein content and wider adaptability. CIMMYT will provide segregating generations as early as F_2 for direct selection under Egyptian conditions and will screen Egyptian segregating generations for stripe rust resistance in epidemic areas abroad.

Hopefully, an arrangement will be made to accelerate our breeding work by growing summer nurseries in Lebanon, México or elsewhere to overcome the present handicap of growing only one generation of wheat a year under Egyptian conditions.

Wheat in Kenya

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Kenya

Since 1966, the Canadian International Development Agency (CIDA) has provided aid to Kenya's wheat improvement program. CIDA provides funds for: salaries for Canadians stationed at the Plant Breeding Station, Njoro, Kenya; items such as growth cabinets, plot seeders, and laboratory and field equipment; and transportation and tuition costs for African staff members to take university training in Canada.

There are five Canadians at the Plant Breeding Station—a director, two plant breeders, a pathologist and an agronomist. There is also an FAO agronomist at the station. One Kenyan attended the CIMMYT wheat training course in 1970 and it is expected that others will be able to take advantage of this excellent training in the future.

The first commercial wheat was grown in Kenya in 1904. In 1907, stem rust appeared and completely destroyed the crop. Since that time, wheat improvement and production has been a constant struggle against the rusts. Until 1920, wheat breeding was largely financed by one of the original white settlers. The government established the wheat breeding station at Njoro in 1927.

Wheat is grown in the west-central highlands at altitudes of 6,000 to 9,500 feet. These highlands lie on the equator, so the period of daylight is almost constant throughout the year. Wheat matures in 3½ to 5 months at the lower altitudes and in 4½ to 6½ months at higher altitudes. A variety matures about 15 days later for every 1,000 feet increase in altitude. Rainfall in the wheat growing region averages 30 to 50 inches per year with most of it falling between April and July.

Table 1 shows wheat acreage, average yields, total production, and imports for 1956-70.

TABLE 1. Kenya's wheat acreage, average yields, total production and imports for 1956-70.

Year	Acres	Yield in bags per acre (200 lb. bags)[1]	Total production (200 lb. bags)	Imports (200 lb. bags)
1956	300,273	4.21	1,265,725	118,534
1957	251,061	4.42	1,110,104	113,574
1958	244,343	4.36	1,066,385	160,193
1959	259,806	5.43	1,411,948	117,729
1960	253,958	4.75	1,205,924	18,099
1961	230,544	4.03	929,034	93,190
1962	257,343	5.13	1,319,261	441,035
1963	291,670	4.91	1,432,698	75,389
1964	299,301	5.31	1,588,739	3,777
1965	324,435	4.53	1,468,202	Nil
1966	340,424	5.84	1,989,565	339,000
1967	374,744	7.12	2,653,850	Nil
1968	413,314	5.98	2,472,782	Nil
1969	406,442	5.69[1]	2,314,796[1]	Nil
1970	316,305	6.21[1]	1,965,238[1]	Nil

[1] Bags of 90 kilograms.

While the average yields appear low, they show a definite upward trend. Some of the better farmers obtain yields as high as 20 bags per acre.

In 1956, 13% of the wheat crop was produced by African farmers and this increased rapidly to 44% in 1969.

All wheat is handled in bags, but the wheat industry (farmers, Wheat Board, milling companies, railroads and others) is seriously studying the feasibility of converting to bulk handling.

In 1970, Kenya's domestic wheat requirements were about 1.34 million bags and demand is expanding at about 7% per year. In recent years, Kenya has exported wheat to Tanzania and Uganda and has exported wheat flour to other African countries and to countries in the Arabian Gulf area.

Kenya has about 1.2 million acres (about four times present acreage) suitable for wheat production.

WHEAT DISEASES

The rusts are the most important of the wheat diseases. Stem rust *(Puccinia graminis tritici)* is present most years at all altitudes. Because of the prevalence of stem rust and the changing race pattern, the average life of commercial wheat varieties has been about 4½ years although varieties such as Africa Mayo and Kenya Page, both possessing adult plant resistance, have been grown for about 10 years.

Nineteen stem rust races have been identified using a set of East African differentials. Currently, the most prevalent race is E.A. 5. It is similar to International race 34.

Stripe rust *(P. striiformis)* is prevalent at higher altitudes, usually 8,000 feet and above. This rust attacks leaves and ears. It causes considerable losses in susceptible varieties.

Leaf rust *(P. recondita)* causes some losses most years at all altitudes. It appears that the leaf rust population is comprised of very few races.

Blotch caused by *Septoria* species affects susceptible varieties most severely on poorly drained soils. Other diseases such as loose smut *(U. tritici)*, scab *(Fusarium graminium)* and take-all *(Ophiobolus graminis)* may cause losses some years but are generally considered not serious.

About 30 wheat varieties are grown each year and individual farmers often grow 5 or 6 varieties to spread the risk of rust losses. Growing several varieties with different maturities also spreads harvest work. The number of varieties grown is unrealistic for a total area of less than a half million acres. Fewer varieties will be essential if bulk handling is to become a reality. The objectives of the breeding program are to substantially reduce the number of varieties grown.

These objectives are to produce high-yielding varieties with: wide adaptability (fewer varieties required); shorter and stronger straw (to offset lodging losses under improved cultural and fertilizer practices); a broader base of rust resistance (variety life will be extended); and improved quality.

Parental material is available and is currently being used to meet these objectives. Many introduced varieties and lines from CIMMYT and elsewhere are being evaluated yearly. These introductions will no doubt continue to be a source of new commercial varieties as well as parental material. About 120 wheat varieties have been released in Kenya, 70 bred locally and the remainder are introductions.

Tobari 66, a Mexican variety, is being used extensively in the breeding program. This variety yields well at all altitudes, has good straw strength, is about the right height for Kenyan growing conditions and is satisfactory in quality. It is susceptible to a few stem rust races.

Romany (Colotana 261/51 x Yaktana 54A), also from Mexico, was one of the highest yielding varieties in Kenya for several years but had to be withdrawn because of its high degree of susceptibility to race E.A. 5 of stem rust. It was deficient in straw strength and quality, but its genetic yield potential and wide adaptability are being utilized in the breeding program.

Trophy (Timstein-Kenya[2] x Yaqui 50), another Mexican variety, has been the most widely grown variety for the past few years. However, in 1970 Trophy showed increased susceptibility to ear rust at high altitudes and it is susceptible to a new race of stem rust.

WHEAT QUALITY

In most years, Kenyan wheat produces a satisfactory flour without addition of imported hard wheats. The range of quality between the varieties currently grown varies from fair to very good, but in the future only varieties with fully acceptable quality will be released.

A new, well-equipped quality laboratory will be operating at Njoro in the near future. It will permit more extensive evaluation of many more lines. The Pelshenke Test has been used to screen the breeding material. Complete quality tests on advanced lines were conducted by a commercial milling company.

AGRONOMY PROGRAM

The agronomy program has been expanded recently. Emphasis is on fertilizer investigations and tillage practices.

Many fertilizer trials are being conducted which will permit more definite recommendations considering type and amount of nutrients in relation to soil type, rainfall pattern, varieties and so forth. Now, fertilizer recommendations are based mainly on history of the land and are: new land (previously in grass or in cereals for less than 3 years) 15-20 kg N/ha and 60-80 kg P_2O_5/ha; old land (in cereals for 3 years or more) 30-40 kg N/ha and 60-80 kg P_2O_5/ha.

Extensive trials on cultivation methods are now underway. These trials compare tradition-

al (burning straw, deep ploughing and several disc harrowings) with surface (retention of trash near soil surface, use of sweep or blade type cultivators, chisel ploughs and so forth) cultivation methods.

These trials aim to determine if cultivation costs can be substantially reduced, if weed control can be improved, if moisture penetration can be improved and if water erosion can be reduced.

Wheat Production in Turkey

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Turkey lies between 36° and 42° North latitude and is surrounded on three sides by seas. Mountain ranges parallel the coasts, separating the warmer coastal areas from the higher, dryer central plateau.

So, wheat is grown under two conditions. One is an area of limited rainfall (less than 400 mm/year), moderately cold winters and little irrigation water. These conditions characterize much of the Anatolian Plateau where winter wheat is grown under a fallow-wheat cropping sequence.

The second set of conditions includes generous rainfall, mild temperatures and, in many areas, available irrigation water. These conditions are found along the coastal areas where varieties with spring habits are sown in the fall. It is in these areas that Mexican varieties have made a great contribution. Eastern Turkey is a rugged, mountainous area where winter varieties are sown in the fall or spring varieties are planted in the spring.

Turkish agricultural production is dominated by cereals, wheat in particular. Turkey's total cultivated area is about 24 million hectares with about 1.5 million irrigated. About 8.7 million hectares are fallowed each year. Of the 15.4 million hectares sown annually, winter cereals occupy 12 million hectares. Wheat is the most common winter cereal with about 8.5 million hectares planted annually.

During the 1970-71 wheat season, Turkey produced a record 13 million metric tons of wheat on about 8.6 million hectares, an average yield of 1,500 kg/ha. About 1.5 million hectares were fall-seeded to spring varieties and the remainder was winter wheat.

VARIETIES GROWN

Triticum aestivum is the major species grown, accounting for 40% to 50% of the area. *T. durum* and *T. compactum* are also important, occupying 30% to 40% and 20% to 30% of the area, respectively.

The spring wheat area is dominated by Penjamo 62, first imported in quantity in 1967. Some Lerma Rojo 64 and Super X are grown, but the area in these varieties is small. Several Italian and Mexican varieties are being tested in the spring wheat area.

Winter varieties include improved Turkish varieties 220/39, 111/23, 1593 51, 4/11 and imported varieties Bezostaya and Wanser. Newer winter varieties 406, Bolal and 093/44 may replace the older varieties.

Important durum varieties are Akbasak, 073/44, Berkmen and Karakilcik 1133.

WHEAT DISEASES

In the winter wheat regions, *Puccinia striiformis* is the most important disease, sometimes causing heavy looses. *Puccinia recondita* can also be a serious problem in some locations during favorable years. *Puccinia graminis tritici* is less important in the winter wheat areas but can cause serious losses under favorable conditions. Common bunt (*Tilletia* sp.) and *Ustilaga tritici* are widespread and can cause serious losses.

In the spring wheat areas, *Puccinia striiformis* and *Septoria tritici* are serious problems, especially on the recently introduced varieties from Mexico. Cultivation of Lerma Rojo and Super X has almost been abandoned because of susceptibility to these two diseases. In some areas, *Puccinia recondita* develops almost every year, especially in the Sea of Marmara region, and *P. graminis tritici* can cause serious losses in susceptible varieties.

In addition, *Erysiphe graminis* is a serious problem in areas of higher rainfall. *Ustilago tritici* is also a widespread problem.

CULTURAL PRACTICES

Most wheat in Turkey is grown under dryland conditions (300-400 mm rainfall per year) which necessitate a fallow-wheat sequence. Cultural practices are adapted to a livestock economy that depends on stubble and weeds coming up in the fallow as a main source of feed.

These are not good moisture conservation practices since weeds remove most of the moisture. Consequently, the fall-sown wheat depends on rain after seeding for germination. Very often there is not enough early rainfall and the wheat germinates in early winter or the next spring, thereby missing the favorable period for root development and tillering with a resulting sharp yield reduction.

It is necessary to develop a management system for these soils that will permit more moisture conservation, earlier planting and more fertilizer use.

RESEARCH PROBLEMS

The Mexican variety Penjamo 62, besides being very susceptible to *P. striiformis* and *Septoria tritici,* is a short-duration, light-insensitive variety which, when planted at the desired time of November 1-15, will flower in early spring. As a result, it is often partially sterilized by frost. Longer-duration, high-yielding varieties with adequate disease resistance are needed for the coastal areas of Turkey.

Another problem facing wheat research efforts in Turkey is the lack of well-trained scientists with training beyond the bachelor of science degree engaged in wheat improvement.

Steps are being taken to solve the problems outlined above. An interdisciplinary wheat research project has been organized and is developing with the assistance of CIMMYT and the Rockefeller Foundation. This project operates at 10 research stations representing the major ecological areas of Turkey. The foundation of strong breeding programs in both spring wheat and winter wheat will increase in intensity and scope in the future.

Agronomic research is being conducted on tillage practices and other aspects of crop management. This agronomic research is a cooperative effort involving the wheat research project, scientists from Oregon State University supported by USAID funds and other Turkish research organizations.

A research program in plant pathology has been initiated. A field disease survey and a series of disease trap nurseries were begun in 1970-71. A vigorous field screening program is being initiated this season.

In future years, facilities for race identification of pathogens of particular interest to the Middle East will be created. Other research disciplines, such as economics, will be added in the future.

Also, eight Turkish students are studying abroad for the master of science degree and four trainees are at CIMMYT headquarters. Soon these young men will return to add their impetus to Turkey's increasing research efforts in wheat production.

A Summary of Wheat Production and Research in Lebanon

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Wheat area stays relatively constant (about 70,000 hectares) and yields have been static.

In 1967-68, large-scale tests with Mexipak and Super X began. In 1970-71, about 10% of the acreage was planted with these higher yielding varieties. Procurement under government subsidy policy in 1971 shows an increase of 30,000 tons—mostly Mexican varieties.

Research on cereal improvement has greatly intensified since 1967-68. Mexipak is standard for selection to improve disease reactions and yielding ability. Laboratory equipment is now available for cereal technologists to improve the quality of spring wheats, durum wheats and barley. Next season the laboratory becomes active.

Cooperation with CIMMYT, FAO, and the Rockefeller and Ford foundations is very close to stimulate regional cereal improvement work. Disease and yield nurseries are prepared in Lebanon for screening and testing in 40 countries. Some outstanding durum and barley varieties are being increased for widespread release.

Wheat Research and Production Programs in the Near East

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Wheat is by far the most important basic food and is to the people of the Near East what rice is to people of the Far East.

The Near East and Mediterranean countries were net exporters of food grains until the early 1950's, but the situation changed with the upsurge in population, stagnant crop yields (500 to 600 kg/ha in rainfed areas and 1.24 to 1.47 tons/ha in irrigated areas) and mounting pressure on land and water resources.

Food imports, of which cereal made up 52% during 1960-64, had been rising rapidly and increased from 1.2 to 12 million tons from 1955-57 to 1965-67. This adversely affected the economic condition of many countries and brought some serious problems (Table 1).

HELP RENDERED TO THE REGION

Noting this serious situation, FAO organized a meeting in 1952 in Turkey which was also attended by representatives of Iran, Iraq and Pakistan. At this meeting it was decided to establish a committee on wheat and barley to determine the possibilities of starting a coop-

TABLE 1. Average area, production and yield of wheat in member and associate member countries of FAO-NE Cereal Improvement and Production Project.*

Country	1952-56			1964-68		
	Area 1,000 hectares	Production 1,000 metric tons	Yield 100 kg/ha	Area 1,000 hectares	Production 1,000 metric tons	Yield 100 kg/ha
MEMBERS						
Afghanistan	2,113	2,162	10.2	2,407	2,212	9.2
Algeria	1,912	1,305	6.8	2,021	1,183	5.9
Cyprus	77	68	8.8	59	71	12.0
Ethiopia	856	508	5.9	992	735	7.4
Iraq	1,259	726	5.8	1,784	972	5.4
Iran	2,438	2,270	9.3	4,220	3,533	8.3
Jordan	277	176	6.4	247	193	7.8
Kenya	122	121	10.0	124	140	11.3
Lebanon	70	57	8.1	70	60	8.6
Libya	145	13	0.9	197	51	2.6
Morocco	1,599	1,097	6.9	1,716	1,571	9.2
Nigeria	—	—	—	—	—	—
Pakistan	4,224	3,147	7.5	5,427	4,728	8.7
Saudi Arabia	43	59	13.8	97	140	14.4
Somalia	—	—	—	—	—	—
S. Yemen	2	4	17.8	5	10	20.0
Sudan	13	19	14.3	60	66	11.0
Syria	1,366	845	6.2	1,127	870	7.7
Tunisia	1,110	553	5.0	884	400	4.6
Turkey	6,653	6,649	10.0	8,114	9,300	11.5
Egypt	679	1,471	21.7	537	1,409	26.2
Yemen	13	16	12.3	13	15	11.5
ASSOCIATE MEMBERS						
India	10,721	7,901	7.4	13,490	12,100	8.9
Nepal	125	123	9.8	132	163	12.4

* Source: F.A.O. Production Year Book, 1969.

erative program in the Near East countries. Since then, the number of participating countries has increased from 5 in 1952, to 12 in 1962 and to 24 by 1971.

The main objective is to improve varieties and production techniques in order to achieve self-sufficiency, raise the nutritional and living standard of the people, save huge sums of foreign currency spent on the import of food grains and even release areas from wheat and barley production for other crops like oilseeds, legumes, forages and pastures, allowing diversification of agriculture and improving the overall economy of the countries.

Various research and production activities were greatly expanded due to the positive and practical support of the Rockefeller Foundation (CIMMYT) since 1961. Similarly, useful cooperation and coordination was also developed with other agencies such as the Ford Foundation, Swedish Agency for International Assistance (SIDA), Netherlands Help under FFHC (NOVIB), USAID, USDA and research institutes of many advanced countries.

Some of agencies like CIMMYT, the Ford Foundation and USAID also started concentrated country-subregional programs in India, Pakistan, Lebanon, Turkey and Tunisia.

From 1955 to 1967, many screening nurseries (regional and international) and segregating materials were supplied for testing under local conditions. Improvements were made in the breeding program, agronomic trials, pathological studies and grain quality work as well as in the testing program. Some of the equipment needed for conducting experiments was introduced.

Several persons were trained in national, regional (through SIDA) and international training centers (particularly, through the FAO-Rockefeller training center in Mexico) apart from sending selected persons for postgraduate studies to the United States and Sweden Most of these trained persons are now engaged in wheat improvement work in their respective countries.

In addition to maintaining good follow-up, several meeting-seminars were arranged and regular visits were made by the cooperating scientists to different countries. Several publications giving the results of various nurseries and topics of special interest were produced and distributed by CIMMYT while FAO regularly published its quarterly information bulletin, giving results of work in progress in various countries. In order to use the varieties identified as high yielding, help was provided many countries in launching accelerated wheat production programs.

ACHIEVEMENTS

The standard of research programs and extension has shown a marked improvement with better facilities, trained personnel, laboratory and field equipment, seed production and distribution, a better price structure, credit facilities for farmers and an improved balance of input-output prices.

From these activities, many high-yielding, disease- and lodging-resistant, and fertilizer-responsive varieties have been developed or identified and released for commercial plantation. Many countries have launched successful accelerated wheat production programs.

Thus, high-yielding varieties are being used in several countries in the region and wheat production has been increased. During 1968-69, about 7.9 million hectares were sown to high-yielding varieties in the region (including India) providing an estimated 7.9 million additional tons of wheat worth US$553 million.

Hopefully, if such accelerated production programs are pursued, it will be possible to achieve self-sufficiency in almost all the countries and surpluses in some of them. The present success has been due to the combined efforts of the participating governments, FAO, CIMMYT, the Ford Foundation, USAID, USDA, SIDA and other agencies. It is hoped that this cooperation is further strengthened to allow more progress.

RESEARCH

The research program consists of testing introductions, screening varieties against major diseases for good agronomic characteristics and for yield potential, hybridization and selection of suitable plants, yield nurseries (preliminary, national, regional and international), agronomic studies to determine optimum cultural requirements, including fertilizers, pathological studies on rusts and other important diseases and pests, grain quality tests, extensive testing of the promising varieties and laying out demonstration plots. This also includes suitable arrangements for controlling seed production and distribution.

To carry out all this work effectively, necessary facilities comprising trained personnel, well-equipped experiment stations with adequate laboratory and field facilities (including transportation) and cooperation between different disciplines are needed.

Table 2 shows approximately the present position regarding availability of various es-

sential facilities in several countries. Although there has been a marked improvement in various directions, there are many shortcomings and deficiencies which need to be overcome.

Training

There is a need for training more personnel in different disciplines as well as selecting the outstanding ones for postgraduate studies to provide future leaders of the programs.

There is also a lack of technicians and field assistants. Special practical training courses, if arranged within the region, would be very useful for these persons.

National Cereal Improvement and Production Committees

Work on wheat improvement and production relates to many disciplines and can best be coordinated and carried out through a cereal improvement and production committee representing breeding, agronomy, pathology, soils, grain technology, seed production, agricultural engineering, grain legumes, fodder and pastures, extension service and so forth.

Such committees should be established in various countries. These committees should meet twice a year to evaluate the results of experiments and prepare annual plans.

These committees should also advise the ministries of agriculture on matters relating to policy issues such as release of new varieties, supply of inputs (seeds, fertilizers, machinery, water, electricity, fuel and lubricants) and suggest priorities on projects relating to cereals. This will not only help improve the overall programs, but will also create a team spirit with healthy competition and cooperation among workers in various disciplines.

Research Facilities

In many countries the research stations and laboratories are not well-equipped to cope with the increased work. Stations must be laid out properly and supplied with facilities for field experiments and for laboratories. Much useful equipment was introduced in the past, but due to shortage of foreign exchange, the countries could not meet growing demands.

TABLE 2. Size of wheat programs and facilities available for participating countries.

Countries	Research stations + substations	Facilities available	Trained researchers, Mexico + postgraduate	Testing program	Breeding program	Summer nursery	Agronomy studies	Pathology studies	Grain quality	Seed Production	Demonstration plots
Afghanistan	1+10	I	4	M	P	—	F	P	—	M	M
Algeria	1+3	I	—	S	P	—	M	P	—	F	S
Cyprus	1+5	I	1+1	M	P	—	F	P	P	G	S
Ethiopia	2+8	I	4+1	M	P	—	F	M	—	F[1]	S
Iraq	1+6	I	5	M	S	—	M	P	—	G	S
Iran	1+12	A	6+1	L	L	S	M	M	M	M-G	M
Jordan	1+9	I	4+1	M	S	—	F	P	—	M	S
Kenya	2+14	A	1	L	M	S[1]	M	G	M	G	S
Lebanon	2+5	A	3+1	L	L	S	M	M	M	G	S
Libya	1+4	I	3	M	—	—	P	P	—	M	—
Morocco	1+3	I	—	S	—	—	P	P	—	M	S
Nigeria	1+5	I	—	S	—	—	P	P	—	P	P
Pakistan	1+15	A	29+10	L	L	M	G	G	M	M-G	M-L
Saudi Arabia	1+8	I	1	M	—	—	M	P	—	P	S
Somalia	1+3	I	—	S	—	—	—	—	—	—	—
S. Yemen	1+2	I	—	S	—	—	P	—	—	P	—
Sudan	2+7	I	3+1	M	P	—	M	P	—	M	S
Syria	1+4	I	5	M	P	—	M	P	—	M	S
Tunisia	1+6	A	M	L	L	—	G	G	M	M	M
Turkey	5+4	A	11+5	L	L	—	M[2]	M[2]	M	M-G	M
U.A.R.	1+8	A	6+2	L	L	—	G	G	G	G	M
Yemen	1+2	I	—	S	—	—	P	—	—	—	—
India	8+21	A	L	L	L	M	G	G	G	G	M-L
Nepal	1+7	I	1	S	—	—	M	M	—	M	S

I, Inadequate; A, Adequate but needs to be improved; P, Preliminary; S, Small; F, Fair; M, Medium; L, Large; G, Good; N.A., Not available.

[1] Growth chambers.

[2] Likely to be enlarged.

[3] Only in some localities.

Hence, all agencies helping these countries should try to supply the needed equipment. This also should include transportation facilities for research workers. Similarly, equipment for carrying out yield trials and establishing demonstration plots is also needed for accelerating the testing programs and for educating farmers in modern production techniques.

Improved Methods of Testing in Dryland Areas

Due to defective methods of testing and screening in dryland areas, large quantities of material have built up because of carry-over from year to year.

Since screening under rainfed condition is very difficult due to poor soil and variable rainfall patterns, it is necessary to evaluate the material under irrigated (approximating good rainfall) and well-fertilized conditions so the differences among all varieties and lines will show. For ultimate screening, the promoted varieties can be intensively tested under specific rainfed conditions. This will accelerate the testing program since much material will be dropped earlier.

Some of the high-yielding varieties like Pitic 62 and Mexipak (originally developed for irrigated areas) have done well under rainfed conditions in many countries, including Cyprus, Syria, Lebanon and Iraq.

Breeding Programs for Dryland Areas

Good breeding programs are underway in some countries, but in many countries it has not been possible to start due to various reasons, particularly lack of competent, trained persons.

Until recently, the breeding programs were more active in irrigated areas and little work was done for rainfed areas. It is important that breeding work in rainfed areas be strengthened, making use of indigenous varieties resulting from natural selection and highly adapted to local climates. The local varieties are usually tall and susceptible to lodging and diseases. Varieties selected for dryland areas should not be shorter than one-gene dwarf varieties because their size is likely to be much reduced under low rainfall (Senator cappelli is reduced from 130-135 cm to 75-80 cm).

Also, in most dryland areas, durum varieties are more important than bread types. Hence, durums require special attention in breeding programs for dryland areas. Similarly, work needs to be intensified on breeding drought-resistant and cold-resistant varieties suitable for rainfed areas of highlands.

Intensified research efforts on dryland crops would help ease sociopolitical strains.

Growing Two Generations in a Year

Except in two countries (Iran and Pakistan, neither of which is satisfactory), no arrangements have been made to grow two generations in a year. Kenya is using growth chambers while some locations are being tried in Turkey and Lebanon. In other countries, either suitable locations for growing summer nursery do not exist, or they have not been explored or developed.

To accelerate breeding, selection and initial seed increase, it is highly desirable to grow two generations in a year. This may be done in various ways. Establish two or three subregional stations (one ideal place is Bamian, Afghanistan), make arrangements for raising summer nurseries in Ethiopia and Kenya (where the normal wheat season is June to October) or provide growth chambers to countries with reasonably developed breeding programs. This problem needs careful and immediate attention.

Pathological and Grain Technology Studies

Few countries in the region have facilities for pathological studies although some efforts have been made on a regional basis for screening varieties against serious diseases (under artificial or natural inoculation conditions), for determining physiological races and for epidemiological studies on rusts. This has helped provide useful material to breeders and helped determine the race spectrum.

Presently, much material resistant to stem rust is available but there is need for thorough screening for leaf rust, stripe rust, *Septoria* and mildew. These diseases are quite serious in many countries. This need will be partly fulfilled through the trap nursery, started in 1970.

The pathological studies could be done better by dividing the region into subregions, each served by a well-established laboratory. A similar arrangement can provide for testing grain quality, which is quite important in this region. Well-equipped grain quality laboratories exist in two countries and laboratories are planned for three other countries. Arrangements should be made so that these laboratories would also help the other needy countries.

Recently, SIDA sanctioned a project for evaluation of 30,000 samples of cereals to determine protein and lysine content. This project will be of great help in the long run.

Cultural Experiments and Crop Diversification

Apart from high-yielding varieties, cultural practices are important in increasing production, particularly in rainfed areas. Some good work is underway on cultural practices in the irrigated areas, but little is being done for the rainfed areas which constitute a major sector in this region.

Therefore, it is important that intensive research and extension programs be initiated to encourage dryland farmers to keep fallow lands free of weeds by using suitable cultural practices and proper implements and rotations, in order to replace the present system of wheat-fallow-wheat. The introduction of legumes (grain or forage) will be highly beneficial in various respects. This will help diversify agriculture and integrate crop and animal production, improve soil fertility, stabilize cereal production, and enhance and ensure the income of farmers.

Seed Production and Distribution

Controlled seed production and distribution programs, so essential for making use of the high-yielding varieties, are lacking in many countries. These countries should be helped to develop suitable programs to meet the requirements of the farmers. This will streamline the production system of different categories of seed by the breeders and by government contract seed growers, field inspection, laboratory testing and certification, seed processing, bagging, storing and distribution.

This requires immediate attention because it will become more dificult with the release of increased numbers of improved varieties.

PRODUCTION

As mentioned earlier, many countries started impact programs on increased wheat production through the release of some high-yielding varieties and distribution of fertilizers with encouraging results (Table 3).

In India and Pakistan, where this program was followed on an extensive scale, it revolutionized the economy of the farmers. They have increased fertilizer use, installed thousands of tube wells for irrigation, purchased many wheat threshers manufactured within the countries, and obtained many tractors, combines and other machines in addition to purchasing many consumer goods. Increased wheat production also had a great impact on the gross agricultural product of the two countries. In the three years ending 1969-70, the value of the wheat crop was US$2,700 million above the value of the record 1965 wheat crops.

All these activities have infused farmers with a spirit of enthusiasm. This also produced multiple effects on agricultural production, giving confidence to farmers, scientists and government officials in adopting new technology, including double cropping on irrigated lands.

Yield trends of high-yielding varieties generally indicate that farmers harvested four or more tons per hectare in the beginning, but yields decreased steadily with increased acreage under these varieties.

This yield decrease can be attributed to many factors but the most important factor is lack of knowledge about how to exploit the full potential of the high-yielding varieties through proper cultural practices. If this deficiency can be overcome, it is possible for farmers to increase production 40% to 50% with existing varieties.

To exploit the yield potential of the improved varieties, farmers should use improved cultural practices such as proper levelling of fields, proper seedbed preparation, timely and proper seeding, sowing with combined seed and fertilizer drills, applying optimum quantities of fertilizers at the right time, controlled irrigation and drainage, suitable mechanical-chemical methods for erradicating weeds, timely harvesting and proper storage. To popularize use of these methods, farmers must be supplied with the essential machinery and guided in its proper use.

This is possible if the agricultural cooperative societies are provided help by the governments. It is, therefore, suggested that sets of essential field equipment be supplied for demonstration purposes and for use by farmers in pilot areas. This will help increase production and reduce the cost which is comparatively higher than the world market price of wheat.

It is also essential to train many persons from different countries in production agronomy, the type of training now being contemplated by CIMMYT. Help should also be provided to those countries which have reached the stage of launching successful impact programs.

This should be done by scheduling the provision of technical information and material (seeds, fertilizers and so forth), on a precise, time-phased basis and by excercising price interventions—input subsidization and output price support. The countries should also be helped to implement proper grain storage.

TABLE 3. Areas sown to high-yielding varieties in several Near East countries in recent years and projections.

Country	Initial Program		Following Program(s)		Varieties
	Year	Hectares	Year	Hectares	
Afghanistan	1966-67	1,215	1967-68	2,633	Mexipak, Indus 66, Sonora 64
			1968-69	202,511	Lerma Rojo 64A, Penjamo 62
			1969-70	688,538	Tascosa
Algeria	1969-70	5,500	1970-71	140,000	
			1971-72	600,000	Inia 66, Tobari, Mexipak Local improved and Italian varieties.
Cyprus	1970-71	8,500	1971-72	15,000	Keny x Yaqui 48
Ethiopia	1969	13,500	1970	32,500	Pitic 62
			1971	71,500	
					Mindum x A10 (durum)
Iraq	1967-68	6,400	1970-71	125,000	
			1973-74	750,000	Mexipak 65
Iran	1968-69	35,000	1970-71	130,000	Lerma Rojo 64A, Penjamo 62, Inia 66, Tobari, Bezostaya, Omid, Roshan
Jordan	1968-69	2,000	Small programs in selected areas.		Deiralla 1 (Gabo x C250) Deiralla 2 (F8 x Horani 21) Pitic 62, Mexipak 65
Kenya	1963	Most area.	1962	104,091	
			1969	164,618	Africa Mayo, Trophy, Kenya Kudu, Kenya Hunter, Kenya Page, Bonny, Bounty Token, Goblets, Romany.
Lebanon	1967-68	60	1968-69	400	Indus 66, Mexipak 65, Jori 69
			1969-70	2,500	
			1970-71	7,000	
			1971-72	12,000	
Libya	1969-70		A very limited program.		Sidi Mesri 1 (selection from Mexipak 65), Inia 66, Tobari.
Morocco	1967-68	200	1968-69	5,000	Siete Cerros, Inia 66,
			1969-70	10,000	Tobari, Penjamo 62
			1970-71	20,000	Mara, BT-908
Nigeria	1969-70	Small area.	Indus 66 is being tested and multiplied.		
Yemen	1969-70	Started identification of high-yielding varieties and their multiplication.			
India	1964-65	6	1965-66	2,835	Lerma Rojo 64A Sonora 64
			1966-67	283,516	S 227 (Kalyansona) and PV 18 S 307 (Safed Lerma)
			1967-68	2,440,000	S 308 (Sonalika) S 331 (Chhoti Lerma)
			1968-69	4,880,000	H.D. 1941 (Hira, triple dwarf) Narbada 4 (for rainfed areas)
			1969-70	5,670,000	A9-30-1-durum
Nepal	1966-67	7,000	1967-68	33,000	62, Kalyansona, Chhoti Lerma
			1968-69	18,000	Lerma 52, NP 852, C 306, Sonora 64, Pitic
			1969-70	63,000	
Tunisia	1968-69	12,000	1969-70	53,000	Inia 66, Tobari,
			1970-71	100,000	Penjamo 62.
			1971-72	200,000	
			1972-73	300,000	
Turkey	1967-68	170,000	1968-69	800,000	Penjamo 62, Lerma Rojo, Pitic 62, Inia 66,
			1969-70	540,000	Tobari, Super X
			1970-71	479,000	Bezostaya, Wanser, 220/39,
			1970-71	1,048,285	1593 and 4-11.
U.A.R.	1968-69	Most area.	Giza 155 was released in 1968-69 and occupied 90% of the local wheat acreage (526,529) in 1970-71.		Giza 144, Giza 148, Giza 150 Giza 155
			1970-71	Small areas under Mexican varieties.	Siete Cerros, Super X Mexipak.

It is most encouraging to note that all the agencies which have helped are maintaining good coordination and cooperation in their respective programs. It was only through these joint efforts that some tangible results have been achieved and it is hoped that the same spirit will continue in the activities of all the organizations concerned.

Wheat Production in Chile

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As the first paper discussing wheat production in South America, Table 1 is presented to provide a perspective—very little recent progress in wheat production or productivity in South America.

TABLE 1. Wheat area, yield and production averages of world regions for 1948-1952 and 1968.

Region	Area Million hectares		Production Million metric tons		Yield 100 kg/ha	
	1948-52	1968	1948-52	1968	1948-52	1968
World	173.3	227.5	171.1	332.5	9.9	14.6
Europe	28.0	28.8	41.2	72.9	14.7	25.3
Africa	6.5	8.4	4.6	8.5	7.0	10.2
Oceania	4.7	10.9	5.3	15.1	11.3	13.9
Asia	25.9	41.4	21.4	44.4	8.2	10.7
N. + C. America	38.9	35.0	45.1	62.5	11.6	17.8
S. America	6.9	8.5	7.4	8.7	10.7	10.3

Wheat is the most important cereal in Chile. It occupies about 60% of the surface planted to annual crops and it provides 40% of the calories and 15% of the total protein consumed by Chileans.

Until 1940, Chile was self-sufficient in wheat and small amounts were exported. After 1941, the annual wheat production deficit increased and in recent years it was necessary to import 15% of the total consumption (about 300,000 tons per year). The rapid increase in population and demand for foodstuffs, stabilization of the cultivated area and slow increases in yield per unit area are some of the factors aggravating the problem (Table 2).

TABLE 2. Total wheat demand in Chile, 1965.

Demand (1,000 metric tons)	
Human consumption	1,203.7
Per capita[1]	137.0
Animal feeding	71.5
Seed[2]	108.8
Other uses	37.9
Total	1,403.4
Production	1,276.0

[1] Kilograms per person.
[2] Estimated at 160 kg/ha.

Chile has excellent soil and climatic conditions for intensive cultivation of wheat with high yields. More than 85% of the area has adequate soils and sufficient rain or irrigation to produce wheat. Still, the average yield is low (1,730 kg/ha in 1970), especially if compared with some European countries or Mexico (Tables 3 and 4).

Growing wheat in areas of insufficient rainfall in the northern region and low quality soils in other regions contributes to low yields. Also, efforts by state institutions, universities and private enterprise on fertilization programs, formation and use of improved varieties and of other technological factors have not been reinforced by simultaneous and aggressive communication and extension of the results obtained by the researchers.

Likewise, there has been neither a definite system of price regulation to stimulate the

TABLE 3. Area, average yield and production of wheat under dryland and irrigated conditions, Chile, 1965.

	Area hectares	Average Yield kg/ha	Production metric tons
Dryland	536,900	1,310	701,200
Irrigated land	190,000	2,180	414,600
Total	726,000	1,540	1,115,800

TABLE 4. Area, production and average yield in the three wheat growing regions of Chile, 1970-71 crop year.

Region	Area		Production		Average Yield kg/ha
	Hectares	% of country	Tons	% of country	
North	225,190	28.99	461,707	34.36	2,050
Central-South	253,320	32.61	361,889	26.93	1,428
South	298,130	38.38	520,150	38.71	1,744

wheat producer nor the operation of efficient mechanisms to provide a timely, low-cost supply of inputs necessary for cultivation.

Other limiting factors are some diseases such as the rusts of stem, leaf and glume, *Puccinia graminis*, Pers. f. sp. *tritici*, Ericks. et Henn., *P. recondita* f. sp. *tritici* Rob ex Desm., and *P. striiformis* West, respectively. Other pathogens contributing to losses are *Linocarpum* sp., *Fusarium* sp., *Ustilago* sp., *Tilletia* sp., *Septoria* spp. and *Erysiphe* sp. Also, entomological problem arise due to aphids, root maggots and insects of stored grains.

Wheat improvement is carried out mainly by the *Instituto de Investigaciones Agropecuarias* (INIA) of the Ministry of Agriculture and, on a smaller scale, by the universities and some private institutions. The state, through several dependencies of the Ministry of Agriculture, determines the policies of prices, commercialization and other economical aspects of the crop. It also deals with extension and communication through the Department of Agricultural Extension.

In general, research covers: (1) development of improved varieties; (2) determination of optimum dosages of fertilizers; (3) control of weeds; (4) disease problems; (5) entomological problems in the crop and in the stored grains; (6) soil preparation and crop rotations; and (7) irrigation problems.

Until now, it has not been possible to cover all these areas of research with equal intensity. The greatest efforts have been in developing improved varieties and in fertilization. We believe that in order to accelerate the improvement of wheat production, we should apply jointly and simultaneously several measures that will allow us to:

1. Intensify research in all aspects of wheat productivity.

2. Apply efficient techniques of agricultural extension on a broad scale with adequate personnel and resources, and develop a more effective relationship among extension workers and research workers. Productivity contests are receiving much attention (Table 5).

TABLE 5. Wheat production contest, South-Central Region, 1969-70.

Number of participants:	185 (74 were small farmers or land reform centers).
Total area covered:	10,338 hectares.
Farm size:	2-10 ha (14.5%); 10-50 ha (38.8%); 50 ha + (3: %).
Technical assistance by:	13 extension and local crop agents. 6 crop research workers.
Sponsoring Institutions:	INIA and Crops Division, M. of Agriculture.
Educational efforts:	Meetings, direct contact, demonstrations, field days, tours, mass media communication, field trials.
Average fertilization:	N = 63.9 kg/ha; P_2O_5 = 113.0 kg/ha.
Top yields obtained:	7,500-5,000 kg/ha (19 cases). 5,000-3,500 kg/ha (70 cases). 3,500-2,500 kg/ha (68 cases).

1969-70 National average yield: 1,770 kg/ha.
1969-70 Regional average yield: 1,650 kg/ha.

TABLE 6. Protein percentage and bread loaf volume of spring wheat cultivars released for the northern region of Chile.

Cultivar	Cross	Protein %	Loaf volume cc	Year released
Menflo	Mt x F1	10.4	646	1954
Vilufén	K117 x Mt	10.0	645	1956
Orofén	(N-M) (K-Mt) Fn	10.8	655	1959
Rulofén	Men sib x My48	11.6	696	1960
Huelquén	Md-McM-Ex	10.7	625	1963
Platifén	Th-Sta Cat x My54	14.1	722	1964
Centrifén	Y53-Nor 10/Br x LR^2	11.5	710	1965
Collafén	(C14)^1/4160//Yt54-Nor 10/Br x Ofn	11.4	749	1967
Yafén	Y50 (Fn-K58/N)^2	12.6	850	1967
Toquifén	(C14)^1/4160//Yt54-Nor 10/Br	12.6	780	1969
Mexifén	Son 64 x (Sk^{0}E-An^{3}E)	11.3	745	1970

TABLE 7. Average yield of 6 bread spring wheat cultivars and 3 advanced experimental lines, northern regional tests, 1965-70, at 37 locations.

Cultivar or line	Yield kg/ha
Menflo	3,032
Yafén	4,332
Huelquén	4,548
Centrifén	4,569
Collafén	4,789
Toquifén	4,947
Mexifén	5,510
[(908-Fn)[2]/4160//Yt54-Nor 10/Br] C14[2]	5,180
Rfn2 x (Fn-KIN x Nor 10/B)	5,220
Lee[2]-KF x Yt54-Nor10/B24-1c[1]	6,590

[1] Average of 2 years over 9 locations, 1969-70.

TABLE 8. Average yield of 4 durum wheat cultivars and 3 advanced experimental lines, northern regional tests, 1965-70, at 37 locations.

Cultivar or line	Yield kg/ha	Year released
Capelli	3,973	1940's
Candealfén 5, Cp[3]-Gz	4,332	1958
Alifén, Cp x Ethiopia 464	4,747	1965
Quilafén, Yt54[2]-Nor 10/B//Ld 357 x Tc	5,597	1968
Cfn x (Lan. dwarf-Lan)	5,202	——
(Yt54-Nor 10/B21) BY x Tc[2]	5,177	——
Cp-St464 x (Yt54-Nor 10/B21-1c x Cp[3]-Gz) Tc	6,830[1]	——

[1] Average for 1 year, 3 locations.

TABLE 9. Average yield of 4 bread winter wheat cultivars and 7 advanced experimental lines, southern area, 1965-70.

Cultivar or line	Yield kg/ha	Year released
Cappelle Desprez	4,660	1950's
Lilifén, Nd.D-WW x Lee-Fn/N, N° 2357	5,510	1967
Hosbignon	5,712	1961
Manella	6,836	1967
CAR 463, Vg8881 x Hn IV[1]	7,300	——
CAR 487, Vg 8058 x I. de F.[1]	6,700	——
CAR 853, Hn IV x (Kt54A-Nor 10/B21-1c x Kt54B) Nar 59[1]	8,700	——
(14 x 53) x Odin 2X CI 13431, S 6425, WA 004877[2]	9,040	——
WA-64207, CI 13431 x CI 7805 2X CI 13447[2]	10,100	——
CAR 681, Sambo x Hn IV[2]	10,100	——
CAR 831, Pj62 x Hn IV[2]	9,875	——

[1] Average 1967-70 yield trials.
[2] 1970 yield trials.

3. Design a price policy to stimulate good production.

4. Provide, at low cost, the inputs that the farmer must use with the new technology.

5. Create a system of agricultural credits channeled to stimulate wheat production.

6. Intensify the international cooperative programs designed to determine new genetic sources for yielding, disease resistance, wide adaptation, nutritional value, industrial quality and so forth.

7. Increase cooperation between the programs of wheat improvement in different countries to achieve a greater interchange of germ plasm, of technical personnel and of ideas, particularly among research workers dealing with common problems.

In the last 10 years, several improved varieties of wheat (winter, spring and intermediate habits) have been given to Chilean farmers. Between 1966 and 1970, INIA has provided farmers of the north-central area with the first semidwarf varieties of bread and durum wheats. They have been planted extensively in this area. The germ plasm obtained in the interchange with CIMMYT and its predecessor, the

TABLE 10. Average yield of 4 bread spring wheat cultivars and 4 advanced experimental lines, southern area, 1970 yield trials.

Cultivar or line	Yield kg/ha	Year released
Heine - Koga	3,692	1960
Pumafén, MD x Col 266/51	4,230	1967
Panguifén, MD[2] x Fn-K58/N	4,233	1969
Lilifén, ND-WW x Lee-Fn/N, N° 2357	5,874	1967
Likafén, Vg 8316 x Lee-KF	6,966	——
Ofn (Yt54-Nor 10/B) LR-Mfo x Vil 53-Vg 9139	6,758	——
(Kt54-Nor 10/B-21-1c x Kt54B) Nar 59 x Hn IV[2]	6,577	——
Pch x (Kt54-Nor 10/B-21-1c x Kt54B//Nar 59)[2]	6,516	——

Office of Special Studies, and with other international cooperative programs, has been of great importance in obtaining practically all of the new varieties.

For these reasons, we believe that CIMMYT can help and influence directly or indirectly in the achievement of the measures we already mentioned above and consequently contribute to a faster increase in the production of food in our countries.

Improving Wheat Production in Argentina

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Argentina's main wheat area is in the humid, subhumid and semiarid Pampa areas between latitudes 31° and 40° South and longitudes 48° and 65° East. The area's annual precipitation is between 500 and 1,000 millimeters and the mean annual temperature is about 15°C.

The wheat region can be divided into seven ecological subregions. Also, new areas in the North have been opened to wheat in the last three years.

Argentina's wheat crop is grown under rainfall rather than irrigation. The yield is a function of the distribution of the rains and of the soil-stored water rather than of total rainfall.

EVOLUTION OF WHEAT PRODUCTION

Wheat cultivation in Argentina was started in 1856. In the last quarter of the past century, the production of this cereal was very important. There were 73,000 hectares of wheat in 1872, 815,000 in 1888 and 3,250,000 hectares in 1899.

In the first 30 years of this century, the wheat area increased to a maximum of 9.2 million hectares in 1928. This area decreased in 1941 (7.3 million hectares) and continued to decrease slowly until it stabilized at approximately 5.5 million hectares.

The smallest area in the last 65 years was planted in 1970 (4.11 million hectares). Something similar has happened to production. In 1964 production set a record with 11.26 million tons and in 1970 production was the lowest during the last 18 years with 4.23 million tons.

Three stages of yield increases can be observed. These are related to the varieties that were planted. In the first stage (before 1930), the average yield was about 700 kg/ha. In the second stage (1931-1955) when the first varieties developed in the country were planted, the average yield increased to 1,100 kg/ha. The present average yield is 1,400 kg/ha.

Between 1950 and 1969, the area planted was 5.7 million hectares with an average annual increase of 25,467 hectares. The average annual production in the same period was 6.24 million tons with an average annual increase of 77,772 tons. The average yield was 1,268 kg/ha with an average annual increase of 8 kg/ha.

The variation of the area planted has had some influence on the fluctuations of production, but the big changes are mainly due to climatic factors.

EVOLUTION OF WHEAT BREEDING

Wheat cultivation in Argentina was initiated with populations and varieties from different parts of the world. These wheats were generally of low productivity, susceptible to lodging and shattering, and were very susceptible to diseases, especially the rusts.

Due to the heterogeneity of these populations, it was possible to select superior biotypes and after 1912, wheat improvement was based on selection from populations. These selections became the first improved varieties and later served as valuable progenitors in the crossing program.

When no more variability was obtained from these populations, hybridization among the selections and varieties started. In 1925, the first resultant varieties were obtained (38 M.A.). Hybridization continued, but using closely related progenitors reduced genetic variability. This has been a factor limiting yield increases. All the Argentinian varieties of bread wheat (about 35) are the product of selections in hybrid populations and were developed by private or government breeders.

In 1935, with the new grain law, objectives were changed to obtain varieties with higher yielding capacity, good industrial quality, good agronomic performance and good resistance to rusts. Good industrial quality and good resistance to the rusts have been achieved. How-

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ever, with respect to stable, high yielding and good agronomic types, the desired levels have not been reached and the average annual increase in yield has been very low.

The New Breeding Program

These problems were discussed with Dr. Borlaug in 1959 and, as a result, a cooperative breeding program was started. Several experimental stations of the *Instituto Nacional de Tecnología Agropecuaria* are involved. This new program has been functioning since 1961 and is carried out with technical assistance from CIMMYT.

The main feature of this new stage is the introduction of genetic material. This has considerably increased genetic variability with respect to new sources of resistance, stiffer straw and yield capacity. The interchange of genetic material has been not only with the local experimental stations but also with CIMMYT.

Results

Local and foreign markets require wheats with good industrial quality and are very strict in some aspects. But, the diverse growing conditions require that the varieties have special characteristics for their adaptability. These two factors are precluding substantial increases in yield per hectare and are delaying the release of new varieties. However, there are several promising new lines with better yields, resistance to lodging, resistance to diseases and responsiveness to larger amounts of fertilizer.

Release of new varieties is controlled by the *Tribunal de Fiscalización de Semillas.* Last March this organization registered the variety Precoz Paraná Inta. It was selected from the cross Sonora 64A x Knott No. 2 (II 18893-12P-3B-3P-1B-1T).

Also, another line selected from the cross Sonora 64 x Klein Rendidor (II 19975-68Y-1J-6Y-1J-4Y-1J-0B) has been considered for release with the proposed name of Marcos Juárez Inta. The present plan of the breeding program for bread wheats is to release new varieties every year.

Aspects Needing More Attention

The different conditions of the wheat areas and the variation of the planting season require more emphasis in the selection of varieties with broad adaptability.

Also, biological studies of aphids *(Schizaphis graminium* and *Microlophium evahsi)* should be started because these insects have been increasing in the wheat areas. Sources of resistance to these insects need to be found.

Varieties with resistance to frost should be selected to avoid frost damage when the wheat is flowering.

Ear and root rots are becoming a serious problem in most of the varieties and should be studied.

Physiological studies should be started to understand and overcome premature ripening of some of the varieties. This causes shriveling of the grain.

The different fertility levels in the soils in the wheat areas should be considered in the distribution and adaptation of the new varieties and in fertilizer recommendations.

Studies on the use of hybrid vigor should be made.

Durum Wheats

Durum wheats constitute about only 6% (400,000 tons) of total annual wheat production and most of this is exported. The Argentinian durum wheats are highly appreciated in the foreign market for their quality, protein content, semolina yield and good cooking characteristics. Production of these wheats is restricted to the southeastern part of the wheat area.

Breeding should be started to improve resistance to lodging, increase yields, and improve resistance to stem rust and *Fusarium* while retaining the quality characteristics.

Through cooperation with CIMMYT, efforts are being made to introduce the short stem, the high yielding ability and the resistance to stem rust of the Mexican varieties into Argentinian varieties. Breeding efforts in nontraditional durum areas such as Paraná and Pergamino aim to introduce durum cultivation into these areas where current varieties are not well adapted. Some advanced selections have higher yield and better resistance to disease and lodging. However, their quality is untested.

Triticales

The experiment stations at Bordenave and Anguil are selecting and testing triticales. This work is oriented to the use of triticales for forages. This cereal has shown good resistance to drought and has been considered for the semiarid regions. The material being used was received from CIMMYT.

THE ORGANIZATION PLAN

The provisions of the organizational plan (1971-75) for wheat include:

1. Intensify development and distribution of high-yielding varieties, as well as the application of better cultural practices.
2. Increase the protein content to assure better quality for the foreign market.
3. Keep a stock of about one million tons to be in a good position for transactions in the international market.

The objectives can be reached through intensifying the breeding and extension program. It is for this reason that we consider it very important to maintain a close cooperation with CIMMYT.

The Brazilian Accelerated Wheat Program

John Gibler
Technical Director
Ricardo Matzenbacher
Research Director
Joao F. Sartori
Plant Pathology Director
Brazilian Accelerated Wheat Program

For many years wheat importation was the primary drain on Brazil's foreign currency reserves. This started to change in 1969 through the efforts of farmers' wheat cooperatives, their federation (FECOTRIGO) and the wheat policy of the federal government.

Production increased from approximately 300,000 tons in 1966 to an estimated 2.5 million tons in 1971 (Table 1).

TABLE 1. Wheat area, yield, production and imports in Brazil for 1966-71.

Year	Area (million has)	Yield (kg/ha)	Production (million tons)	Imports (million tons)
1971 (Est)	2.40	1,040	2.50	1.20
1970	1.82	1,000	1.80	1.93
1969	1.22	960	1.17	2.24
1968	.78	920	.71	2.40
1967	.56	670	.38	2.50
1966	.38	795	.30	2.43

Some of the factors that contributed to this increase are discussed.

Establishment of FECOTRIGO's wheat research organization in cooperation with Rio Grande do Sul's Secretary of Agriculture helped. This is the farmers' own program financed by a levy on their production.

The program has created confidence in the future. Farmers are willing to risk capital and expand production knowing that they will have varieties and information coming from their research program.

By 1970, the cooperatives in Rio Grande do Sul had about one million tons of storage capacity plus 280,000 tons of storage capacity in state and federal granaries. More is being constructed. This storage space has allowed the government to release wheat to the mills as needed, stabilizing marketing.

Another plus factor is improved quality. The milling industry informs us that Brazilian wheat, after storage for 5 to 6 months, improves in quality and is as easy to mill as imported hard red winter.

The government, through the Bank of Brazil, buys all wheat delivered to the cooperatives by farmer members at a price established by the Federal Monetary Commission. Each year, FECOTRIGO gathers statistics from its more than 60 cooperative members to establish production costs. These data are used by the Monetary Commission in setting the official wheat price.

Table 2 lists the official wheat prices paid to farmers during the last six years.

TABLE 2. Official wheat prices paid to Brazilian farmers (1966-71).

Year	Cruzeiros Per Ton	Equivalent in US Dollars	Value of Wheat Crop (US$1,000,000)
1971	$546	$ 97	$242.5
1970	$490	$ 99	$178.2
1969	$450	$103	$120.5
1968	$383	$100	$ 71.0
1967	$317	$116	$ 44.1
1966	$265	$119	$ 35.7

Farmers receive a warehouse receipt that can be exchanged immediately for cash at the local branch of the Bank of Brazil.

The Bank of Brazil provides credit for farmers. The formula is complex with varying percentages of interest. Seed, fertilizer, insecticide and herbicide purchases are charged 7% interest and remaining purchases are charged about 15% for the small farmers and 18% for the larger farms.

The federal government passed a law requiring that part of all funds rediscounted through

the central Bank of Brazil by private banks be set aside for agricultural loans on the same basis mentioned above. This provided a great credit stimulus and agricultural loans became readily obtainable.

With credit available, mechanization increased rapidly. By 1970, 71% of the wheat farms, by area, were mechanized. These farms produced 76% of the total production.

With the discovery that lime application helped neutralize aluminium toxicity, yields started increasing. FECOTRIGO estimates that about 325,000 hectares of land were limed with an average of 3.7 tons/ha in 1970.

Fertilizer usage has also increased dramatically. By 1970, about 80% of the land was fertilized with an average of 230 kg/ha. Average price was about US$0.95/kg.

Present wheat varieties have normal straw height and are fairly unresponsive to fertilizer. They are soft wheats, generally low in quality.

The varieties and the percentage of the total area grown to each are: Cotipora-C3, 34%; Albatroz-IAS 51, 14%; Frontana, 13%; Iassul-IAS 20, 10%; Alvorada-IAS 50, 9%; Erechim-S 18, 3%; IAS 52, 3%; Toropi-S 1 3%; and others (14 varieties), 11%.

Most are rather old varieties. One, Frontana, was released about 34 years ago. It still occupies 13% of the area.

WHEAT PRODUCTION LIMITATIONS

The main limitations to wheat production are lack of fertilizer responsive varieties and the highly acid, aluminum-toxic soils.

Diseases are also important in limiting production and may become more important with increasing acreage. Although the epidemiology of diseases in southern South America has not been adequately studied, there are no physical barriers to spore movement between countries.

Given favorable climatic conditions, a build-up of inoculum reaching epiphytotic proportions of stem and leaf rust could occur on the older, susceptible varieties. All of the varieties listed above are susceptible to one or more Brazilian races of stem and leaf rust.

Scab, caused by the fungus *Gibberella zeae*, attacks all parts of the plant but is especially severe in the spike. If temperatures and humidity are relatively high at flowering, scab can become severe. There are no sources of absolute resistance but most of the older varieties are tolerant.

Conditions that favor scab also favor *Septoria nodorum* development. This fungus is espe ially severe on the nodes, causing strangulation and doubling over of culms. Most varieties are susceptible, but the variety Lagoa Vermelha (C17) is tolerant.

Mildew caused by *Erysiphe graminis tritici* can also cause losses. In 1970 it was especially severe, appearing early in the season. The growing season was humid, favoring further disease development. Culms and spikes were hard hit, causing heavy loss on susceptible varieties. Siete Cerros and Lagoa Vermelha were among the tolerant varieties.

Resistance to change, long considered characteristic of farmers, has proven unirue. News of the Green Revolution spread rapidly to Brazil. The farmers wanted to be part of this revolution so they instructed their federation, FECOTRICO, to establish a wheat research program. The program started in 1969. Agribusiness also contributed. Massey-Ferguson made available to FECOTRIGO the senior author as technical director of the program. The milling industry contributed funds to help establish the wheat quality laboratory.

Experimental wheats from CIMMYT and associated programs in Ecuador, Colombia and Argentina were planted on about 35 hectares. This genetic material represented many thousands of lines, including a large crossing block from CIMMYT's program, F1's from Mexico, Mexican, Colombian and Ecuadorian F2's, Frocor and Bonza multilines from Colombia, fixed lines from Mexico, Colombia, Ecuador, Argentina, Israel and other countries, international yield trials from CIMMYT, and triticales. Most were planted on limed plots, but the multiline and fixed lines were planted on nonlimed soils, also.

An on-the-job training program started through seminars, field preparation and layout, liming, fertilizing and leveling, making field books, maps, establishing systems of planting, weed control, erosion control and drainage, making tags, taking agronomic and disease notes and making crosses. More than 2,800 crosses were made to train agronomists in the new "Go-Go" crossing system and to furnish the base for the new expanded program.

In general, Brazilian varieties are tall, low yielding and poor quality but they have tolerance to scab *(Giberella zeae), Septoria nodorum* diseases and to excess soil alumninum. They were crossed with introduced rust-resistant, semidwarf varieties having high yields and good quality but poor tolerance to aluminum toxicity. This combined the best features of all varieties.

The practical field training that started with the Massey-Ferguson fellowship grant to Alfeu E. Campos in 1968 to train at CIMMYT headquarters was expanded. Ten scientists have trained or are now in training at CIMMYT's headquarters.

In 1969, the first large-scale summer planting was made. Ten tons of lime were applied one month before planting. This was not enough time for the lime to neutralize soil acidity and aluminum toxicity. Also, high soil temperatures might be affecting plant development.

Stem and leaf rust attack was severe. Every commercial Brazilian variety was susceptible. Because of this threat, a plant pathologist was added to identify races involved and to test the advanced lines. Biotypes of races 11, 15 and 17 were identified.

Also, many commercial varieties from other countries were carefully checked for resistance. A Mexican variety, Azteca, and a Colombian variety, Samaca, were fairly well-adapted to limed soils and resistant to stem rust.

Root penetration was shallow. There appeared to be a hardpan developing at plowsole level. Consequently, every experimental field was subsoiled to a depth of 65 to 80 centimeters. The amount of phosphorus in the applied fertilizer was increased. All fields were leveled.

Additional genetic material from Ecuador, Mexico and other countries was introduced for further screening. The first preliminary yield trials started with the best introduced and selected Brazilian lines. The large crossing program continued.

Three hundred kilograms each of the high-yielding, good-quality, stem rust-resistant commercial varieties, Azteca and Samaca, were imported from Colombia and Mexico. They were planted on a semicommercial scale in seven locations throughout Rio Grande do Sul.

Also, the first regional trial was started with the best lines screened from the program. The objectives were: (1) get a broad test in as many locations as seed quantity permitted on adaptation and disease resistance; and (2) train personnel to carry out regional trials.

Plant development was exceptional, nearly as good as in the CIMMYT nurseries. Some of the lines produced nearly 6 tons/ha despite severe attacks of mildew, scab and *S. nodorum*.

The good yield appeared due to the improved agronomic practices mentioned before: about one year between lime application and seeding, subsoiling, leveling, and increased phosphorus application at about 325 kg/ha.

The F2, F3 and F4 lines were outstanding, and more than 150,000 plants were selected. The grain was visually graded and more than 80% was discarded.

A biochemist was hired and sent to CIMMYT headquarters for training in wheat quality testing methods. Equipment for a complete experimental quality laboratory was imported.

The second summer nursery was seeded in late 1970 on limed and nonlimed field with the above material. Diseases were severe—first an attack of mildew then *Septoria tritici* and *S. nodorum*. Plant development was poor due to high soil temperatures and it was necessary to harvest most lines in bulk. For this reason, it will be necessary to look for another place for future summer nurseries.

Part of the quality laboratory was put into operation. Micropelshenke tests, protein analysis and Alveograph tests are being run on the wheats from the preliminary regional trials at Herval and Sao Gabriel.

Problems are being encountered in getting a stable yeast source. Fluctuations in results occur with the local yeast. Tests are being run on other brands but it may be necessary to import yeast.

The Cruz Alta center was limed, prepared and marked into fields. The 1971 planting of about 80 hectares was divided between the center and the Julio de Castilhos substation.

Because of a lack of facilities and trained assistants at Cruz Alta, the crossing program remained in Julio de Castilhos along with some advanced material. The plantings on nonlimed soil were expanded at the center to produce varieties for traditional farmers who use no lime. If plant development is satisfactory, plant generations will be rotated from nonlimed to limed soil and from limed to nonlimed soil to develop more flexible varieties.

It is not known if tolerance to aluminum toxicity is linked to low yields, but there is evidence that such a linkage exists. For this reason, part of the program will continue selecting varieties on limed soils to provide high-yielding wheats for progressive farmers using lime.

Regional variety tests are being conducted at five locations. Construction has started at the Cruz Alta center. Great technical progress has been made since the program started. A high-quality research program has been established. Advanced training for the M.S. degree has started but needs to be expanded. Scien-

tists with the ability to handle many breeding lines efficiently and successfully have been field trained. Many thousands of crosses were made combining the best genes or factors available to science. Information on how to grow wheat with fertilizer, proper cultural practices, etc., has been and is being developed and tested.

Progress depends on an economically sound farming community. The information and varieties developed by research need to reach more farmers quickly.

Only through increasing unit yields can local prices remain competitive with world trends. If wheat is profitable, more farmers will grow the crop. This will narrow the gap between consumption and production, reducing the massive foreign currency drain. Improving quality of locally produced wheat offers the consumer a better product and an easier handling wheat at the mills.

To achieve these objectives, Phase Two of our program contemplates creating an extension service with a sound, practical approach to solving farmers' problems. The service would be staffed with center-trained agronomists working in the cooperatives.

CIMMYT has already played a vital role in the establishment of the Accelerated Wheat Program by furnishing germ plasm to start the program and training the research staff. Four of our staff scientists are presently in Mexico in the training program. We are receiving important new germ plasm every semester. We hope that CIMMYT will continue these programs of training and supplying elite germ plasm.

Wheat Improvement Progress in Southern Brazil

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Project, "Increase and Development
of Wheat Production"
Brazil

Brazil is an importer of wheat. But, because of increases in wheat area and productivity, wheat imports are steadily diminishing.

The Ministry of Agriculture has nine regional institutes for agricultural research. Of these, two are in the main wheat areas. These are IPEAS, for the states of Rio Grande do Sul and Santa Catarina, and IPEAME, responsible for research at the federal level in Paraná and Sao Paulo.

Besides these institutes of the federal government, the state secretaries of agriculture have experiment stations which, especially in Rio Grande do Sul, are involved in wheat investigations.

Recently, to promote wheat production, the UNDP/FAO Project was commenced. Five specialists are working with national scientists at the Passo Fundo experimental station of IPEAS, Rio Grande do Sul.

The experimental results have been widely applied by farmers. Some of these results which have stimulated wheat production in southern Brazil will be discussed.

Varieties

Since 1934, the experiment stations have been distributing their own improved varieties. With the exception of Frontana, all the presently recommended varieties were distributed after 1963. Despite some disadvantages, these varieties still have many positive attributes—tolerance to aluminum, resistance to stem rust and some tolerance to *Septoria* and *Gibberella*.

Most of the increase in wheat production is due to these varieties. The majority of the varieties are tall, but IAS 54 and IAS 55, distributed in 1970-71 and bred by IPEAS, are short. They come from crosses between Brazilian material and Mexican lines.

Fertilizers

Most of the wheat in Brazil is fertilized according to official recommendations. There are big responses to phosphorous and nitrogen applications but, on most Brazilian wheat soils, the response to potassium is small.

Another serious problem in some wheat soils is a low pH and a high content of free aluminum. Lime application helps solve this problem.

Cultural Practices

As a result of research, recommendations concerning the date of sowing and the quantity of seed are made to farmers.

Seed Production

The Bank of Brazil finances only wheat production which uses seed certified by the government and produced under supervision of state scientists. All of the certified seed is treated with the recommended doses of fungicide.

THE FUTURE

Despite recent progress, there is still much to do before Brazil is self-sufficient in wheat. The high production of the last three years was partly due to climatic condition that limited *Septoria* and *Gibberella*. Since the current varieties possess only limited tolerance to these diseases, climatic conditions favoring the pathogens would seriously reduce production.

Thus, the main problem facing Brazilian breeders is to combine resistance to *Septoria nodorum* and *Gibberella* sp., adequate tolerance to high soil aluminum, short straw and high yield. Scientists of the state and federal institutes are carrying out extensive investigations to achieve this objective. Hopefully, CIMMYT can collaborate effectively in this task.

The Wheat Situation in Perú

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STATISTICS OF PRODUCTION AND DISTRIBUTION OF VARIETIES

Since wheat production in Perú is almost static, the increasing demand causes an increasing deficit, making wheat imports almost 34% of food imports and 7% of Perú's total imports (Table 1).

TABLE 1. Production and consumption of wheat in Perú.*

Year	Cultivated Area (hectares)	Production (Metric tons)	Apparent Internal Demand (Metric tons)	Deficit Importations (Metric tons)
1960	153,690	146,140	505,008	358,868
1961	153,420	153,910	579,514	425,604
1962	153,800	152,830	564,673	411,843
1963	153,100	152,610	513,967	361,357
1964	149,300	143,150	535,189	392,039
1965	153,150	146,720	609,521	462,801
1966	156,710	145,002	637,974	492,972
1967	159,850	152,180	644,593	492,413
1968	160,000	148,000	777,751	692,571
1969	155,000	139,500	751,166	611,666

* Source: Programa de Incremento de la PRODUCCION DE TRIGO, Work group report, La Molina, 1970.

With these trends, Perú will soon be nearly totally dependent on imports if some measures to solve this situation are not taken. Thus, the government has started a national program to reduce imports by encouraging use of better varieties and better land management. At the same time, the program will promote use of substitute food crops to reduce dependency on wheat.

Peruvian wheat varieties have large, soft grains which are preferred in the home and in small industry. *Triticum durum* varieties are planted in the temperate-to-cold areas above 2,500 meters elevation. At lower altitudes, *T. aestivum* varieties are planted, mainly Florence Aurore, Pusa, etc.

The National Wheat Program is introducing improved varieties and is promoting these varieties in the high productivity areas (coastal regions). The Cereal Program of Universidad Nacional Agraria is undertaking studies that should allow production of improved wheat varieties on the northern coast near Ecuador. The impact of these new varieties will be felt in future years.

LIMITING FACTORS FOR WHEAT PRODUCTION

Climate

Climate is a serious limitation, especially above 3,000 meters elevation. Drought and sudden temperature changes cause important losses some years.

Universidad Nacional Agraria is trying to develop or isolate varieties tolerant to cold temperatures and drought for these areas. If this is achieved, Perú could become self-sufficient.

Soils

The topography is extremely rugged. This limits use of machinery in most wheat producing areas.

However, wheat production is completely mechanized along the coast and in some high valleys.

Diseases

Rusts are the major limiting factor. The diversity in ecological conditions allows serious infection and frequently destruction of the old varieties. Stem and leaf rust are the most important diseases along the coast and in valleys up to 2,500 meters altitude.

In valleys above 3,000 meters, stem rust gradually looses importance and conditions for the development of stripe rust are more favorable.

Sociological Aspects

Wheat production has important social implications in Perú. Much of the rural population uses wheat as the main foodstuff and will continue growing it under any circumstances. Increased wheat production would mean an improvement in income for an important sector of the population.

Economic Aspects

Perú spends much money to import wheat, limiting the nation's capacity to buy other goods necessary for development. The government has established wheat prices which are higher than the price of imported wheat. This should stimulate wheat production and benefit the local producer.

THE ROLE OF RESEARCH PROGRAMS

Under the government measures to stimulate production and enhance commercialization of wheat, the responsibility for increasing production was given to the Ministry of Agriculture.

The Ministry created a permanent commission for the coordination and execution of the wheat program. In the initial phase, the program is readjusting and preparing a broad approach to the problem.

Other institutions, such as Universidad Nacional Agraria, are helping to achieve definite goals for certain areas of the country.

THE ROLE OF CIMMYT

There is an agreement between CIMMYT and the Peruvian government to establish projects (Puebla type) whose center of operations will be in Agrarian Zone III.

The new genetic material from CIMMYT is very helpful and is used intensively. This material is playing a very important role in the development of new varieties for the northern, warmer part of Perú.

A closer relationship with CIMMYT is highly desirable.

The Wheat Situation in Ecuador

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Ecuador has a permanent wheat production shortage. This forces Ecuador to import about 45% of its total requirements.

Before any research and improvement through plant breeding was started, Ecuador produced about 38,000 tons annually on approximately 63,000 hectares in the inter-Andean area with an average yield of a little more than a half ton per hectare.

As a result of plant breeding research, increased mechanization and use of fertilizers, average annual production increased to 80,000 tons from about 80,000 hectares. However, despite the national increase, wheat importations also climbed because population growth demanded more wheat.

There are six principal commercial wheat varieties in Ecuador. In crop year 1970-71, Napo and Crespo accounted for 62% of the area sown. Ten percent was sown with Amazonas, Atacazo and Bonza. Less than one-half percent was sown with Rumiñahuia. The remaining 28% was sown with other improved wheats and native varieties.

WHEAT PRODUCTION LIMITATIONS

The main factors which limit wheat production in Ecuador are climate, diseases and marketing problems.

The distribution and quantity of rainfall are a constant threat to the producer. For example, during the 10 months of the crop year in Santa Catalina, the rainfall in the past 3 years exceeded normal by 89, 234 and 438 millimeters, respectively.

There have also been years with similar variations in the opposite direction. The rainfall distribution often does not allow planting at the proper time and causes delays at harvest, lowering grain quality.

The most important wheat disease in Ecuador is stripe rust. During the last few years. leaf rust attacks have increased, leading to the search for genetic resistance. Stem rust is also a serious problem.

Although wheat has an officially supported price, storage shortages, cash buying of the crop and tranportation difficulties leave the smaller producers at the mercy of the middlemen who pay notably less than the prices on official list.

The National Institute of Agricultural Research Wheat Improvement Program is trying to solve some of these problems by developing higher yielding varieties which are rust resistant and earlier maturity. The central government is seeking solutions to the transportation and marketing problems.

CIMMYT has united with our efforts to improve the wheat situation by making available practical training for our staff, periodically sending us capable researchers and generously donating valuable genetic stock.

Wheat Production in Colombia

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Production Statistics

Table 1 shows Colombia's area, production, yield and importation of wheat. Production has been declining drastically since 1966 while imports increased considerably.

TABLE 1. Area, production, yield and imports of wheat for Colombia, 1958-69.

Year	Area (1,000 hectares)	Production (1,000 tons)	Yield (tons/ha)	Imports (1,000 tons)
1958	140	160	.88	91
1959	145	166	.87	97
1960	142	160	.89	92
1961	142	160	.89	137
1962	162	150	1.08	125
1963	90	113	.80	103
1964	85	100	.85	184
1965	110	120	.92	188
1966	125	110	1.14	221
1967	80	68	1.18	186
1968	93	69	1.35	268
1969	68	58	1.18	193

For example, in 1966 the area was 125,000 hectares yielding 110,000 tons while in 1969 the area was only 68,000 hectares producing 58,000 tons. The average yield over this period remained static at about 1.2 tons/ha. Wheat imports in 1969 reached nearly 200,000 tons.

Varieties

The wheat program distributed 13 improved varieties between 1950 and 1968 (Table 2). These varieties have occupied almost 70% of the wheat area of the country.

The varieties are: Menkemen 52, Bonza 55, Nariño 59, Crespo 63, Bonza 63, Napo 63, Tiba 63, Tota 63, Miramar 63, Miramar 64, ICA-Sugamuxi 68, ICA-Samacá 68 and ICA-Zipa 68. The experimental yields of these varieties during several seasons at Tibaitatá and Surbatá appear in Table 3.

FACTORS LIMITING WHEAT PRODUCTION

The following factors limit wheat production in Colombia.

Climate

The climatic factor which most affects yield is frost in December and January.

Soils

Heavy soils with poor internal drainage reduce plant vigor and yield. Also, these soils often provide favorable conditions for root rot and ear rot.

Most soils require nitrogen, phosphorus and calcium application. The recommended NPK application rate is 30-150-30.

Diseases

Rots are the main disease problem in the provinces of Cundinamarca and Boyacá. Rots can reduce yield and grain quality drastically.

Selection is being carried out for material resistant or tolerant to rots under conditions

TABLE 2. Improved wheat varieties developed by the Instituto Colombiano Agropecuario (ICA) from 1950 to 1968.

Variety	Altitude adaptation (meters above sea level)	Yield (tons/ha)	Maturity (days)
Menkemen 52	2,000-2,700	3.8	150
Bonza 55	2,400-2,800	4.0	165
Nariño 59	2,400-2,800	3.9	160
Crespo 63	2,400-2,800	4.3	165
Bonza 63	2,400-2,700	4.3	165
Napo 63	2,500-3,000	4.5	155
Tiba 63	2,200-2,700	4.4	155
Tota 63	2,200-2,700	4.3	155
Miramar 63	2,400-2,800	4.2	150
Miramar 64	2,400-2,800	4.2	150
ICA-Sugamix 68	2,300-2,700	4.5	165
ICA-Samacá 68	2,300-2,700	4.5	165
ICA-Zipa 68	2,300-2,700	4.4	165

of 1,500 millimeters of precipitation, high soil content of organic matter and low soil pH (4.5). Severe ear rot reduced grain yield of Samacá 68 by 37% in 1970.

Rust of the glumes and stem rust are common and they affect yield most.

In southern Colombia, there is a virus disease called *Enanismo* (dwarfism) which is transmitted by an insect *(Cicadulina pastusae).* Its distribution is not widespread and we have sources of genetic resistance.

Economic and Social Aspects

The average unit for wheat production is only five hectares. Approximately 20,000 families depend on wheat.

Farmers have very little machinery, roads are bad and there are many difficulties with storage.

Credit is scarce, not very flexible, difficult to obtain and usually covers only 50% of production costs.

The costs of production are high due to a continual increase in input prices—fertilizers, herbicides, machinery and transport.

Marketing is slow, with a limited capacity to handle grain and few buying locations.

There is no program for increasing production which integrates credit, marketing, technical assistance and extension.

Imports are made at unsuitable times, disrupting the internal marketing of wheat.

THE WHEAT IMPROVEMENT PROGRAM

Twelve new varieties were distributed to farmers between 1950 and 1968. We have several promising new varieties for 1972. Among these are three dwarf varieties. All these varieties give high yields and good profitability (Tables 4 and 5).

The use of fertilizers and herbicides, and the density of sowing has been studied, leading to recommendations for maximum yield. Poor soil preparation (omitting one cultivation and levelling) reduced yield 25% in a 1971 trial.

Our quality laboratory has allowed the selection of varieties with excellent bread making quality—very similar to the quality of imported wheat.

The program has established adaptability and demonstration trials in the three principal zones of production. At these trials, field days for farmers are presented. Short courses for farmer groups are organized, also. Each year there are field days at each field station for the wheat program.

The National University of Colombia provides studies to the level of *Ingeniero Agronomo* and Master in Agriculture.

TABLE 3. Average yields in tons/ha of improved varieties and promising lines and races of wheat in yield trials at Tibaitatá (1968-70) and Surbatá (1970).

Variety	Tibaitatá				Surbatá		Overall		
	1970-A	1969-A	1968-A	70A, 69A, 68A	1970-A	1970-B	1970-A 1970-B	Average	Bola Picota
Menkemen	4.6	1.9	4.4	3.7	3.7	2.1	2.9	3.2	165
Bonza 55	4.3	3.0	4.4	3.9	4.6	2.8	3.8	3.9	194
Nariño 59	3.1	1.7	3.5	2.8	4.1	2.1	3.1	2.9	147
Tiba 63	4.8	2.3	4.7	3.9	3.0	2.6	2.8	3.4	170
Tota 63	4.7	2.0	4.0	3.6	3.4	2.5	4.0	3.3	164
Crespo 63	4.7	2.8	5.5	4.3	4.9	3.3	4.1	4.2	212
Napo 63	4.7	2.3	5.3	4.1	4.9	2.5	3.7	3.9	197
Bonza 63	5.4	3.8	5.2	4.8	6.0	3.7	4.9	4.8	243
Miramar 63	4.2	2.3	4.0	3.5	4.2	2.6	3.4	3.4	173
Miramar 64	3.6	2.4	4.3	3.4	3.7	2.4	3.1	3.3	164
ICA-Sugamuxi 68	4.9	3.1	5.5	4.5	4.1	3.4	3.8	4.1	208
ICA-Zipa 68	3.7	3.4	4.9	4.0	4.9	3.0	4.0	4.0	200
ICA-Samacá 68	5.4	3.7	6.0	5.0	4.5	3.7	4.1	4.6	230
PM. 67-A (Sug. Sib 1)	4.3	2.8	5.1	4.1	5.4	3.2	4.3	4.2	209
PM. 7 Sel 5xK58/NxFr	3.8	2.4	4.5	3.6	4.3	2.8	3.6	3.6	179
ICA-Coconuco	4.4	2.3	4.4	3.7	4.1	4.0	4.1	3.9	195
PM. 9 Sugamuxi Sib 2	5.0	3.5	6.0	4.8	5.9	3.7	4.8	4.8	242
PM. 11 Af-MyxFn-Y	5.5	3.8	4.9	4.8	4.7	4.1	4.4	4.6	231
PM. 12 (Sugamuxi sib 3)	5.3	3.8	5.0	5.0	5.9	4.0	4.9	5.0	250
PM. 23 (Pasta)	4.9	3.1	5.5	4.5	5.5	3.2	4.4	4.4	222
Tiba (Sel 67)	5.3	2.0	4.8	4.0	4.0	2.5	3.2	3.6	183
Va. 150	1.3	1.5	1.0	1.3	4.0	1.6	2.8	2.0	103
Bola Picota	1.2	1.8	0.9	1.3	4.1	1.2	2.7	2.0	100
Mentana	4.0	2.0	3.5	3.2	4.3	2.1	3.2	3.2	160
Palmira 2	3.9	2.5	3.1	3.2	3.8	2.2	3.0	3.1	155

TABLE 4. Yields in tons/ha of promising new varieties from trials and small plots at Tibaitatá and Surbatá in 1970-A, and comparing these varieties with Samacá 68.

Names and pedigree	Tibaitatá		Surbatá		Average	% Samacá
	Trials	Small Plots	Small Plots	Trials		
Fr^4(Bg-S/K x E/T-Fn) x Toca 59 II-17811-1B-5T-1B	6.3	6.7	6.7	4.5	6.1	151
Son. 64-Sk^0 (E)An^3 (E) x Napo 63 II-20844-26B-4B	5.5	6.0	5.3	4.6	5.3	132
Fr-K. 58/N-Bza. 55 II-12193-7T-1B-4T-1B-1T	5.2	6.1	4.3	5.5	5.3	130
My54-N.10B/Gb x Gb 56) Son. 64 MII-18995-101M-110T	5.6	5.4	5.3	4.2	5.1	127
Yt. 54/N. 10B. 21.1c x Kt. 54B MII-8187-5T-13B-1T-1B	5.0	5.0	5.5	5.1	5.1	127
Crespo 63	5.0	5.2	4.3	4.5	4.8	118
Lee-Fn x (K. 58/N-Fr)^2 II-15910-10T-2B-4T	5.0	6.0	3.5	4.5	4.7	117
Zipa 68	5.1	4.4	4.8	4.1	4.6	113
Son. 64A-TzPP/Y. 54 x R-Rw^2-Bza. 55 II-20899-12B	4.7	5.3	3.5	4.1	4.4	109
Samacá 68	4.4	3.8	3.5	4.5	4.1	100
Menkemen	3.3	2.5	4.0	4.4	3.5	87
Son. 64A-Sk^0 (E)/An^3 (E) x Napo 63 II-20844-114B-1B	4.5	3.8	2.4	3.3	3.5	86

TABLE 5. Yield, quality and other characteristics of some promising varieties (Tibaitatá, 1971-A).

1971 Variety Number	Name and Pedigree	Height cm	Yield kg/ha	Yield %	Weight kg/hl	Loaf Volume cc
12	Lee-Fn x (K. 58/N-Fr)^2	120	5,752	126	78.90	1,045
9	Fr-K. 58/N-Bza. 55 II-12193-7T-1B-4T-1B-1T	115	5,580	122	80.30	760
11	Son. 64-Sk^0 (E)An^3 (E) x Napo 63	105	5,366	117	80.10	740
3	(My. 54-N. 10E/Gb x Gb. 56) Son. 64 MII-18995-101M-110T	85	5,062	111	78.50	920
10	Crespo 63	115	4,989	109	79.30	780
41	Yt. 54/N. 10B. 21.1c x Kt. 54B MII-8187-5T-13B-1T-1B	80	4,680	102	74.65	760
33	Son. 64-A-Sk^0(E)/An^3 (E) x Napo 63 II-20844-114B-1B	100	4,586	100	76.45	780
6	ICA-Sacamá 68	110	4,573	100	78.05	1,030
21	Fr^3 (Bg-S/K x E/T-Fn) x Toca 59 II-17811-1B-5T-1B	115	4,492	98	77.25	900
4	ICA-Zipa 68	110	4,401	96	79.10	1,020
17	Son. 64A-Tz.PP/Y. 54 x M-Rw^2-Bza. 55 II-20899-12B	85	4,041	92	80.30	910
1	Menkemen	105	3,468	76	78.50	500
	Hard Red Winter				84.50	780

TABLE 6. Wheat yields, costs and profits with and without 10-30-10 fertilizer at several seed densities, Tibaitatá.

Fertilizer kg/ha	Seed kg/ha	Yield kg/ha	Weight kg/hl	Costs US$/ha	Value US$/ton	Value US$/ha	Profit US$/ha	Return %
			Zipa 68, 1970-A, LOTE 18 [1]					
0	110	3,070	71.5	188	95	291	103	55
0	140	3,410	72.5	197	96	327	130	66
0	170	3,560	71.0	207	94	335	128	62
300	110	2,380	71.0	210	95	227	17	8
300	140	3,510	71.0	234	91	319	85	36
300	170	3,580	71.0	242	94	336	94	39
			Samacá 68, 1970-B, LOTE 19 [2]					
0	130	3,512	68.0	153	87	307	154	101
300	130	4,072	68.5	193	93	379	186	96
0	160	3,761	67.5	163	92	345	182	112
300	160	3,829	67.5	195	92	351	156	80
0	175	3,291	66.0	158	90	295	137	87
300	175	3,903	69.0	198	94	366	168	85

[1] High rainfall and poor drainage reduced yields.

[2] This growing season had normal rainfall distribution.

The plan of production of the *Instituto Colombiano Agropecuario* is making progress at the experiment station level and with some farmers, production, yield, costs, profitability and so forth are being determined. The plan collaborates in the promotion of wheat production, using demonstration trials at a commercial level in farmers fields (Table 6).

ROLE OF CIMMYT

CIMMYT has collaborated with the wheat program in Colombia in the following areas:

1. Interchange of germ plasm includes: the International Spring Wheat Yield Nurseries; segregating F_2 material, especially dwarf Mexican varieties crossed with Colombian wheats (this material gives very good results in our program); screening nurseries; triticales; and specific genetic material like early genotypes. The Mexican material has good agronomic type, for example, dwarfism, vigor combining ability, quality and resistance to stem rust. However, they are moderately susceptible to stripe rust and are susceptible to root and ear rots. Also, they are rather late and have somewhat shrivelled grains and low bushel weights.

2. Training of technical personnel.

3. Interchange of publications.

4. Support to attend international conferences.

5. Visits of CIMMYT staff to the Colombian program.

Wheat Production in México

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The area sown to wheat in México has increased from 550,000 hectares in 1925 to 859,000 hectares in 1968 (Table 1). Since 1949, when the first improved varieties were obtained from our wheat breeding program, production increased from 400,000 to 2.38 million tons and average yields increased from 727 to 3,065 kg/ha.

Along with the new varieties, improved agricultural practices like fertilization, irrigation, and weed and pest control have played an important role in increasing yields. The average yield has increased 300% in the last 22 years.

About 90% of the area grown to wheat is under irrigation. National consumption has increased from 500,000 tons in 1925 to 2 million tons in 1971.

México became self-sufficient in wheat production in 1956 and not until this year have we had to import grain (about 260,000 tons). This shortage in grain production originated from a reduction of the area sown to wheat in northwestern México.

México has exported much wheat seed, mostly varieties Siete Cerros T66, INIA F66, Pénjamo T62, Lerma Rojo S64, Sonora F64, Jori C69 and Tobari F66 to many countries in the Middle East, Far East and North Africa.

Commercial varieties are distributed in the wheat growing regions of México as shown in Table 2. The most widely grown are INIA F66, Siete Cerros T66 and Lerma Rojo S64. Next season (1971-72) there will be small quantities of the new varieties Yécora F70 (Bluebird 2), Saric F70 (Bluebird 3), Nuri F70 (Bluebird 1), Cajeme F71 (Bluebird 4) and Potam S70 (INIA x Napo) available to farmers. These varieties have shown a wide adaptability to our conditions and to conditions in other countries where they have been tested. Three of these have been classified as triple dwarfs (75 to 85 cm)—Yécora F70, Saric F70 and Cajeme F71.

TABLE 1. New varieties, area sown, production and yield of wheat in México, 1925-71.

Period	New Varieties	Area (ha)	Production (tons)	Consumption (tons)	Yield (kg/ha)	Yield % 1925-48
1925-48	B. Yaqui, B. Bajío, Ramona, Mentana	550,000	400,000	500,000	727	100
1949-52	Y48, Kt48, My48, Y50, L52, Kt52	604,000	534,000	800,000	893	122
1956	Y53, Ch53, Y54, Yt54, Kt54, Gb54, Gb 56	770,000	1,040,000	1,040,000	1,350	186
1965	L.Rojo, Nai60, Pi62, Pj62, Son63, Son64, LR64, To60	666,000	1,600,000		2,402	330
1966	Nai60, Pi62, Pj62, Son64, LR64, Ovi65	683,000	1,609,000		2,355	323
1967	INIA 66, Tob66, No66, S.Cerros 66	857,000	2,400,000		2,800	385
1968	CIANO F67, Nor M67, AzF67, BjF67	859,000	2,200,000		2,607	358
1969		839,911	2,381,826		2,836	390
1970	Jori C69	723,199	2,216,369		3,065	421
1971*	Yécora F70, Nuri F70, Saric F70, Potam S70, Cajeme F71	660,000	1,800,000	2,000,000	2,727	375

* Estimated data.

TABLE 2. Distribution of varieties grown in the wheat growing regions of México.

Region	States	Area* hectares	Varieties
Northwestern		435,095	
	B. California	76,413	L. Rojo 64, INIA 66, S. Cerros T66.
	T.S. B. California	14,000	Tobari F66, INIA 66, Azteca F67, CIANO F67.
	Sonora	303,272	INIA F66, S. Cerros T66, Azteca F67, Jori C69.
	Sinaloa	41,410	INIA F66, Azteca F66, Tobari F66, CIANO F67, Noroeste F66.
North-central and northeastern		139,090	
	Chihuahua	61,800	L. Rojo 64, Pénjamo T62, INIA F66.
	Coahuila	54,249	L. Rojo 64, Nadadores M63, Pénjamo T62, INIA F66.
	Nuevo León	10,390	" " " " " " " " "
	Durango	7,751	" " " " " " " " "
	Tamps.-Zac.	4,907	Pénjamo F62, L. Rojo 64, Norteño M67, Azteca F67.
Central and southern		149,014	
	Michoacán	47,044	Azteca F67, Tobari F66, Bajío M67, CIANO F67.
	Guanajuato	46,517	" " " " " " " "
	Oaxaca	17,600	" " " " " " " "
	Jalisco	14,486	" " " " " " " "
	México	7,000	" " " " " " " "
	Querétaro	6,000	" " " " " " " "
	Hidalgo	5,000	" " " " " " " "
	Puebla-Tlaxcala	2,332	" " " " " " " "
Total		723,199	

* Data from 1970.

Factors limiting wheat production in México are climatic, sociological and economic. The state of Sonora has the record in production and average yields. Good climate, good soil, available water, improved varieties, improved agricultural practices and organized farmers have been responsible for the success. However, there is still much opportunity in this region for greater improvement.

The rest of México, where 60% of the wheat is grown, has inadequate climate and soil, and lacks water, improved varieties, modern agricultural practices, financing and farmer organization. Since most of the farmers involved in these problems are *ejidatarios* and *colonos*, the government is making a big effort to reach solutions through offices like Water Resources, Seed Production, Seed Certification, Banks and Extension. The Agricultural Extension Office was created this year.

The Mexican wheat breeding program (INIA) and CIMMYT have worked cooperatively for many years. Great achievements have been accomplished nationally and internationally through improved varieties and agricultural practices developed in Mexico and then exported to other countries like India, Pakistan, Morocco, Tunisia and Turkey. Also, many young scientists from several countries have been trained. The interchange of much genetic material is another achievement of the program.

The exportation of seed of improved varieties like Sonora F64, Lerma Rojo S64, Pénjamo T62, Siete Cerros T66 and INIA F66 along with improved agricultural practices was a major component in the recent achievement of outstanding results in India and Pakistan. Similar results are now being observed in countries like Tunisia, Morocco, Algeria and Turkey.

The Canadian Wheat Program

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Although vast in total area (almost 10 million square kilometers), Canada has relatively little agricultural land (approximately 50 million hectares).

Most of the cereal crop land is in the western prairies, beginning 750 kilometers inland from the Pacific Ocean and extending almost 1,600 kilometers east along the United States border. The area forms a triangle 950 kilometers from north to south on the west side. Winnipeg is on the east point of this triangle and is the center of the major grain handling and merchandising companies.

Wheat occupies 8 to 12 million hectares of crop land annually and 95% of the total wheat production is hard red spring varieties grown on the western prairies. The remainder is winter and white varieties, and durum.

Normally, the spring crop is planted in May and harvested in August, approximately 100 days after seeding. Yields average about 1.7 metric tons per hectare but under good management and with a reasonable rainfall, double this average yield is easily achieved.

Almost all wheat is grown under dryland conditions. During the growing season, 25 to 35 centimeters of rain falls. Frequently, lack of water seriously limits yields.

The average farmers owns 300 hectares of land, is highly mechanized and often carries on a livestock enterprise with his grain production.

Canada has long had a reputation for producing a high quality wheat for the export market. Of the 13 to 20 million metric tons produced annually, about 75% is available for export. The overall average protein level is 13.6% but normally ranges from 12% to 16%, depending on the location and the fertilizer program used by the farmer.

Until recently, all breeding programs have been geared to produce wheats of high quality. In the eastern prairies, resistance to leaf and stem rust is also necessary since each summer the rust spores blow north from the winter wheat areas of the central United States and pose a major threat to our crop. Only resistant varieties are grown. In the western prairies, breeders have to incorporate drought and saw fly resistance. In the northern regions, early varieties are essential.

Breeders at the Canada Department of Agriculture Research Station at Winnipeg have utilized the winter nursery facilities at the CIANO Station at Cd. Obregón since 1953. This nursery has been invaluable in accelerating varietal improvement in the eastern region. Our department of the University of Manitoba has grown a winter nursery in Obregon since 1964.

High quality has been the first criterion for licensing a wheat variety in Canada. Licensing of varieties is under the jurisdiction of the Canada Department of Agriculture. It is illegal to license or grow any variety in Canada with a quality inferior to the standard variety—Marquis—unless it has clearly distinguishable seed characteristics. Thus, it is only within the last few years that breeding for high yield as the prime criterion has started.

We have now broadened the genetic base in this program by utilizing Mexican and other foreign varieties in complex crosses. Also, we have developed a system of early generation testing for yield and quality starting with full-fledged trials in F_3. We now retain and concentrate on the few top-yielding lines from a cross for further selection and testing, and eliminate most inferior material.

In our program, which started six years ago, we have advanced strains that outyield current varieties by 20% to 40%. These strains can be identified by seed size and seed color. They should pose no licensing problem even though the quality is considered inferior to our standard. Such varieties will probably be used

widely for livestock feed and could even find a place in the export market in blends. Our first "feed" wheat licensed in western Canada was Pitic 62. The introduction of this variety in 1968 was a milestone in the evolution of the Canadian licensing system because it was the first nonquality variety or feed variety to be licensed in western Canada in recent years. Pitic 62 has not done well since its introduction because it is late, weak-strawed and leaf rust-susceptible.

However, it served its purpose in broadening the horizons of the Canadian government grading and marketing agencies to the extent that a real interest has developed in the feed wheat breeding program. Ways and means of incorporating feed wheat varieties into our traditional handling system are well advanced.

On August 1, 1971, Canada introduced a protein grading system to replace the antiquated grades we had used for the past 60 years. We are now in a better position to compete on the export market with other countries —Australia, the United States and Argentina— that have sold a guaranteed-protein wheat for several years. Our new grades (1, 2 and 3) offer a guaranteed protein from 12% to 15% in 1% intervals.

One of the major problems facing the Canadian wheat industry is lack of seaports and extreme distances to seaports. Only two major ports exist, Vancouver on the west and Thunder Bay on Lake Superior at the beginning of the St. Lawrence Seaway system. Vancouver is open to shipping all year but the Seaway is closed for about 3 or 4 months each winter.

A third port is Churchill in northern Manitoba on Hudson's Bay. In this subarctic region shipping is open only three months of the year and a relatively small percentage of the total is exported through this port.

At all three ports, there are large terminal elevators owned by farmers cooperatives and private grain companies. Each elevator has a capacity of from one to eight million bushels (up to 200,000 tons) with sophisticated facilities for boxcar unloading and cargo loading.

In summary, Canada is a major producer and exporter of hard red spring wheat varieties and maintains a reputation for a high quality product. Breeding programs have been influenced by the need for maintaining high protein quality and only recently have there been new efforts in breeding for high-yielding feed varieties. A variety with quality inferior to Marquis can only be licensed if it can be identified by seed sample. Protein grading has just been introduced in Canada and probably many of our licensing difficulties may be overcome through routine protein quality analysis with the new grading system.

Wheat Production in Afghanistan

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The total cropped area of Afghanistan is estimated at 4.1 million hectares with about 2.3 million hectares sown to wheat. Wheat is the most important agricultural crop in an agriculturally oriented economy.

There are 1.3 million hectares under irrigation and 1.0 million hectares grown on rainfed lands. This produces a yield of about 2 million tons on the irrigated area and 500,000 tons on the dryland for a total of 2.5 million tons. Consumption is still marginably above this level but these production figures represent a marked advance over previous levels.

Wheat is grown under variable conditions at altitudes from 300 to 3,000 meters. Much of the irrigated area is small developments in valleys of snow-fed rivers. However, there are concentrated development areas such as the Helmand Valley and Jalalabad irrigation projects.

The dryland wheat is confined to the areas north of the Hindu Kush and the high mountain meadows where rains are sufficient to grow a crop. Most of the area south of the Hindu Kush receives little rainfall and desert or near-desert conditions persist in most of the South and West.

Wheat is used as flour for making "nan." This is relatively thin bread baked on the inside walls of a clay oven. Tea, kabob and nan are staples of the Afghan diet.

Wheat improvement started in 1966 under a joint program of the Afghan government and the United States Agency for International Development. The program's main thrust has been the extension of new varieties and practices to farmers.

Formerly, very few demonstrations had been placed on farms. There are now nearly 3,500 each year. As a result, the rising shortage was arrested despite a population increase of 1.9% per year.

Associated with the extension program, several research stations were set up. The central station, Darul Aman, is near Kabul. Most of the provinces are represented by a station. Trained personnel are few, salaries are very low, there is need for increased mobility to facilitate coordination and facilities are fairly limited. Yet, several dedicated young men are doing a creditable job of selecting and testing new materials.

Among the diseases, stripe rust is probably the most damaging. The cold growing season is conducive to its development. Leaf and stem rust, although of less importance, can be damaging in local areas, particularly in the South. *Cercosporella* is present in the North but the extent of damage is not known. There is not one plant pathologist in the program and this must be rectified as soon as possible.

Extensive tests indicate that Mexipak is the most widely adapted of the fall-sown, spring-type varieties and Bezostaja is best adapted for the winter areas. In certain sections, Sonalika does very well and it appears to have better stripe rust resistance than Mexipak.

Several other varieties in test appear promising and are under limited increase. These include E 1314, Line 17778, Ephrat, Pénjamo 62 and other unnamed lines. In areas where somewhat more hardy types are needed, Kenya-Mentana is successful. There is a need to intensify varietal research and to establish a higher level of stripe rust resistance.

Agronomic tests have been conducted for several years. This makes it possible to recommend the best planting date for different areas.

Fertilizer recommendations have been worked out. In general, recomendations include about 100 kilograms of nitrogen and 40 kilograms of P_2O_5. At some higher stations, there is a marked carryover of phosphorus and this masks the response. On farm fields nearby, the response is marked.

Although many farmers use fertilizers, I received the impression that some farmers con-

sidered fertilizer as fertilizer rather than by content. For example, one farmer I talked to was using DAP but had he used some additional urea, the response would have been excellent.

There are other soil problems. One problem is the high boron content in the water of the Helmand River which could lead to future toxicity problems.

Seed production has moved ahead vigorously. In 1966, only 690 tons of seed were produced in the entire country. By 1969, production had jumped to 15,000 tons and has been rising since. It was my impression that seed production is being placed on a sound footing.

Many problems are still outstanding. It is difficult to make improved seeds and fertilizers available to the farmers. In the concentrated irrigated areas and near highways, this has largely been overcome, but in mountainous regions of a country without railroads, distribution problems are acute. There is need for credit facilities on a wider scale.

Breeding and testing along with research on cultural practices need to be intensified and facilities need to be made available to the research people. Close coordination between stations is necessary.

There are virtually no threshing machines in Afghanistan and storage facilities, particularly on the farm, need to be improved to reduce grain losses.

However, the government is making a real effort to increase production through fertilizer and seed subsidies. Also, it is providing a floor price for grain in the market.

In late 1969 or early 1970, Afghanistan and India made an agreement of assistance. India undertook to provide a wheat breeder and a wheat pathologist for Afghan wheat research. Appointees are now in Afghanistan and will be assisting through the coming crop year.

This year Afghanistan had its second major drought year. In much of the nonirrigated areas, the crop was a complete or near failure. In May, the government was reported to have already signed contracts for 50,000 tons from both the United States and the USSR to alleviate the hunger problem. Also, prices had increased sharply in the shortage areas.

Beyond this, it is essential that seed be brought into these areas for fall planting this year (1971) to avoid widespread hardship. Government officials are, of course, working to accomplish this.

Over the past few years, personnel from country programs closely associated with CIMMYT have visited the Afghan program to discuss problems. There has been a regular supply of seed from CIMMYT nurseries, both from the spring program in México and Dr. Rupert's program in California. Several trainees have returned from CIMMYT and now hold responsible position in the Afghan organization.

I am sure that as the irrigated area becomes covered with improved varieties and as better communications and distribution is established, Afghan dependence on the vagaries of the climate will be much reduced. Buffer stocks can then be established.

Wheat Improvement in India

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Wheat has a special significance in Indian agriculture. This is primarly due to its nutritious quality, high-yielding ability, wide adaptation, cultural acceptability and production stability as a result of its reasonable freedom from devastating diseases and insect pest damage.

Though second in national cereal production (23 million tons), wheat ranks behind rice and sorghum in area (16 million hectares). It is the most important crop of northern and central India.

Wheat improvement work dates back to 1905 when work was initiated at the Indian Agricultural Research Institute. Early attempts aimed at isolation of superior lines in yield and quality characteristics. Hybridization with exotic varieties, notably from Australia, resulted in improved disease and lodging resistance. Outstanding tall and medium-tall varieties have been developed, particularly at the Indian Agricultural Research Institute and in the Punjab.

We were asked to draw up a scheme for increasing wheat production by 1 to 2 million tons in 1961. By the time we started planning the details, this order was increased to 5 million tons.

The country had not developed its irrigation and fertilizer production resources to any appreciable extent. Whereas, in the beginning we thought that we could increase fertilizer use with the existing varieties (particularly in the limited irrigated wheat area), this was inadequate for meeting the increasing need.

Fortunately, due to the availabality of seeds of four Mexican commercial dwarf varieties in the country, we could plan a few trials of these in 1963-64. These seeds and samples of another 613 experimental lines were supplied by Dr. Borlaug and the Mexican government.

We had already initiated dwarf wheat breeding work using Italian varieties in crosses with Indian ones. Also, no one could predict the suitability of Mexican material for direct introduction into India. This Mexican material proved to be superior in standing ability and had substantial rust resistance against Indian races, but it was inferior in drought tolerance, grain appearance and *chapati*-making quality.

In 1964, I proposed importing seeds and conducting trials at several locations but the proposal could not be pushed through due to inadequate testing of the Mexican varieties under Indian conditions.

In 1965, Dr. M.S. Swaminathan obtained permission for the import of 200 tons of Sonora 64. I got an additional order for 50 tons of Lerma Rojo pushed through.

Due to the prevailing low level of soil fertility in India at the time, the performance of Lerma Rojo was not convincingly superior, even with 135 kilograms of N/ha, to the then available tall Indian varieties. Production of Sonora 64 was inferior. However, Dr. R. G. Anderson and I got approval for importing more Lerma Rojo seed.

The first extensive trials and national demonstrations on farmers' fields in Delhi State in 1965 showed the usefulness of this variety and others. Approval for 18,000 more tons of Lerma Rojo was obtained. Help from Dr. Borlaug in planning the procurement of seeds from Mexican farmers at less than half the Mexican government price paved the way for our getting started on dwarf wheat cultivation on an extensive scale some four years ahead of schedule.

Increase in area was again very abrupt because we had by now simultaneously removed farmers' and consumers' major objections—the red-grain color of Lerma Rojo—by selecting new strains from the original segregating breeding lines and populations sent to us by Dr. Borlaug in 1963.

It should be carefully noted here that the four semidwarfs first selected in India (Kalyansona, Sonalika, Safed Lerma and Chhoti Lerma) were not received in a finished, identified varietal stage, but as breeding lines and were

selected from segregating progenies by the pure-line method. The selections made were seed-increased during the normal and off seasons, field tested for three years, approved through the All-India Coordinated Wheat Improvement Project and released by our Central Varietal Release Committee in 1967.

These four varieties and a little sprinkling of Sharbati Sonora (Sonora 64 amber grained induced-mutant) and dwindling Lerma Rojo, now constitute the extensively grown (about 7.5 million hectares) dwarf wheats in India (1970-71). The increasing area of these varieties, total wheat area, production and per hectare yields are summarized in Tables 1 and 2.

TABLE 1. Extension of area under irrigated dwarf-wheats in India.

Year	Area in hectares
1963-64	4
1964-65	100
1965-66	5,200
1966-67	360,000
1967-68	2,400,000
1968-69	4,000,000
1969-70	4,400,000
1970-71	7,500,000

The rapid spread of the dwarf wheats has almost saturated the entire irrigated wheat area and has increased the average per hectare yields from about 800 kg/ha to 1,293 kg/ha (Table 2).

TABLE 2. Area, production and average yield of wheat in India during 1960-61 to 1970-71.

Year	Area (1,000 ha.)	Production (1,000 tons)	Average yield (kg/ha)
1960-61	12,927	10,997	851
1961-62	13,570	12,072	890
1962-63	13,950	10,776	793
1963-64	13,490	9,853	730
1964-65	13,460	12,290	913
1965-66	12,656	10,424	824
1966-67	12,838	11,393	857
1967-68	14,917	16,568	1,111
1968-69	15,958	18,651	1,169
1969-70	15,834	20,400	1,263
1970-71	16,800	23,250	1,293

The farmers are finding it increasingly profitable to invest their profits in permanent farm improvements such as tube-wells, pumping sets, tractors and other farm machinery. Irrigated area increased from about 26% to about 50%. This is resulting in better living standards for the farming community and general industrialization of the country, leading to economic growth.

Wheat improvement has thus spearheaded increasing production of other crops by providing for the required essentials.

COORDINATED ALL-INDIA WHEAT IMPROVEMENT PROJECT

I would like to briefly discuss technical aspects of wheat improvement in India, particularly the recently adopted coordinated approach.

Wheat production in India is now being extended to almost all states. In northwestern and central India the environmental conditions are a real asset. Bread wheats are grown on about 90% of the area and the remainder grows macaroni wheats in central and peninsular India. *Turgidum* and *compactum* cultivation has become practically extinct. About half the area is irrigated, where mostly only dwarfs are grown, while "talls" are still grown under rainfed conditions.

Although more than 50 races of rust attack wheat, serious epidemics have been rare. Smuts are also of general occurrence. Bunts, *Alternaria, Helmintrosporium, powdery* mildew, *Septoria* and nematode diseases may be of local significance, particularly during certain seasons. More than 90% of the crop is grown in plains areas.

Wheat breeding has been done at more than 24 centers under state and federal control. During 1961, the Indian Council of Agricultural Research suggested countrywide coordination of wheat improvement. We have pooled the resources of qualified personnel and the varieties bred at the centers for coordinated testing under all crop production conditions.

Technical work under the project has been carried out with the willing cooperation of many wheat workers in India for their mutual good.

Every year we evaluate about 800 to 1,000 varieties entered by the centers. We test their adaptability to each of the available crop production conditions and to different areas in India under the coordinated trials series. These are planned for each of the five agroclimatic zones in the country and include material at all stages of varietal development.

Zonal meetings of breeders are organized by the coordinator during the crop season to make an on-the-spot study of the promising varieties.

Aggressive breeding and coordinated testing programs have been developed since the early 1960's. During the late 1960's national demonstrations, agronomic and pathological testing work in coordinated series were also initiated.

Dwarf wheat culture needs precision farming for best results. Pressure is being exerted on the government for rapid modernization through mechanization, improving transportation, marketing and storage, and for increased industrial use of grain.

Recent multidisciplinary attacks on wheat problems aim at improving grain quality, disease and lodging resistance, etc. A triple dwarf, Hira, was released last year. It is a marked success in grain-setting in this plant-type. This will come into production during 1971-72.

Others are undergoing advanced testing for adaptation. It is hoped that the new varieties, to be released in a year or two, will fulfill expectations of diversity in disease resistance besides contributing to stability in crop production. Being shorter, the triples promise to be better suited to denser planting, thereby increasing yields per unit area without extra inputs.

PROBLEMS

While total wheat production and per hectare yields continue to increase, there is still considerable scope for increasing these appreciably by extending existing technology and by developing irrigation resources, multiple cropping and mechanization. Crop losses after harvest should be minimized. Timely distribution of fertilizers and providing credit will help further boost yields and production, also.

Insuring the continuity of the wheat workers, particularly the breeders, and their encouragement will go a long way in insuring more and better quality food for the expanding Indian population.

Data from the 400 to 500 coordinated wheat varietal trials and from the additional coordinated agronomic trials are collected, analyzed statistically, summarized and discussed at the annual All-India Wheat Workshops. At this workshop, the program of the next year's work is also chalked out.

CIMMYT AND OTHER AGENCIES

My talk should have given ample evidence of our close linkage with the CIMMYT program in México since Dr. Borlaug's visit to India. Dr. Anderson has been closely associated as our co-worker during August 1965 to May 1971.

We express our sincere gratitude to CIMMYT, the Rockefeller Foundation in India and its scientists, particularly Drs. Borlaug, Anderson, Krantz, Wright and others, who have helped us in planning and executing the wheat work carried out during the 1960's. This association is our proud privilege and we greatly value it. It has brought the people of the United States, México and India closer together. There now exists free exchange of materials with CIMMYT. Similar cooperation has also been developed recently with the FAO and the Ford Foundation. We want to further intensify these bonds of cooperation.

Also, I want to thank the organizers of this very useful workshop and the government of India for this opportunity for participation.

Economic and Social Aspects of the Wheat Revolution

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Economists' comments on the wheat production breakthrough and the Green Revolution are very controversial and mainly critical. For example, Gunnar Myrdal of Sweden completely ignored it as long as possible and later tried to belittle its importance. (See his recent books: *Asian Drama* and *The Challenge of World Poverty).* He was in New Delhi during the initiation of the Green Revolution. Still, he was not able to recognize it.

Other economists, like Walter P. Falcon of Pakistan, mainly concentrate on problems related to the Green Revolution. He writes about three generations of problems without using many words on the benefits and positive impacts.

Some of the leftist economists conclude that the Green Revolution is wasting time by delaying social reforms.

Professor Boulding has deduced a theorem saying that if you cannot assume effective population control, an increase of food production may result in a greater total amount of human suffering in the future.

On the other extreme, writers in *Time,* June 13, 1970, and September 13, 1971, indicated, under reference to the Green Revolution, that there are more or less unlimited possibilities for increased food production and that 150 billion persons can be fed on this planet.

ECONOMIC AND SOCIAL BENEFITS IN THE INDIAN SUBCONTINENT

The achievements have already been commented upon in the country reports and there is no need for me to go into details. Roughly, we can conclude that wheat production in India and Pakistan nearly doubled over a six-year period. This spectacular result has mainly been achieved by us of high-yielding varieties on approximately 10 million hectares of irrigated land in combination with large quantities of fertilizer and improved cultivation practices.

The benefits of the wheat revolution cannot be discussed on the basis of wheat production alone. The introduction of the improved wheat technology can be considered a vehicle or a catalyst for initiation of a Green Revolution, for general rural development and for an increased rate of economic growth. The importance of this can clearly be seen from the development in India and Pakistan.

Farm Income

During the past four wheat harvests (1968-71), about US$3 billion and US$1.1 billion has been added to the gross agricultural production value of India and Pakistan, respectively, above the value of the record 1965 wheat crop.

Part of this, say 20% to 25%, is used for inputs such as fertilizers, pesticides and tractor fuel. Most, however, is accounted for by inputs from the agricultural sector itself, covering the cost of family labor, hired labor, draft animals, seed, water, management and so forth.

The increase of farm income has greatly stimulated capital investments in farming and consumer demand among the rural population. Of the resulting farm investments, the private development of irrigation systems is most striking and has the greatest impact.

Irrigation Development

The wheat revolution has greatly stimulated investments in tubewells in the fresh groundwater areas. The number of tubewells sunk annually in the subcontinent is approaching 100,000. This is a development of utmost importance. Also, it is occurring in the canal-irrigated areas to increase irrigation intensity and to make better timing of irrigation possible.

Tubewells help maintain water levels at optimum depths, helping prevent soil waterlogg-

ing and salinity. This results in increased fertilizer use, higher yields of wheat and other crops, and rapid agricultural development.

The Green Revolution in the subcontinent can only be fully understood against a background of increasing water availability, mainly through private investments in pumping. The parts for private tubewells are made locally. The increasing demand has greatly stimulated development of small rural industries.

Farm Mechanization

The Green Revolution has greatly stimulated use of tractors and tractor equipment threshers, grain drills and other equipment. Timeliness of sowing is important for the Mexican varieties. Tractor cultivation, providing deeper tillage, also contributes to higher yields. Studies show a 25% yield difference compared with cultivation by draft animals.

Mechanization, tubewell development and more intensive farming seem to result in increased labor employment. Combines represent an exception, so use of combines has been controlled by the governments through import controls. Small mechanical threshers have been introduced and are becoming widespread. Combined grain and fertilizer drills are important for high yields.

Farm mechanization, like tubewell development, has greatly stimulated local agroindustrial development which supplies the tools of modern agriculture.

Modernization of the Villages

The increasing income from the Green Revolution is also beginning to show in improved housing in the rural villages. Brick houses are replacing mud houses, new storage structures are being built and the use of electricity, where available, is increasing.

Modernization of villages represents a tremendous scope for labor intensive investments with a small foreign exchange component.

Effect on Consumption

The increasing farm income is having a marked effect on demand for durable consumer goods. The number of transistor radios in rural areas is increasing rapidly, opening new prospects for educational programs.

Industrial statistics illustrate the growing demand for radios, sewing machines, bicycles, motorcycles, textiles and so forth. Thus, the Green Revolution represents a great stimulus, not only for agroindustrial development, but also for the consumer goods industries, and for general industrial and economic development.

Indirect Effects on Other Crops

Through the wheat revolution, farmers became more interested in new technology. They started to use improved varieties (if available), more fertilizer and improved cultural practices for other crops.

The relationship between the farmers and research scientists and extension agents improved greatly. Farmers in great numbers started to visit agricultural research stations, asking for advice and improved varieties of various crops.

Often they got so interested that they became a nuisance. For example, they picked up seed from the research plots of varieties not yet released and started to multiply them. Seed of these varieties was sold from farmer to farmer at high prices.

Research scientists now have to work hard to keep up with farmers' expectations.

The Green Revolution has created respect and understanding for agricultural research among administrators and politicians. The importance of rural development has become more obvious to economists and planners.

Food Consumption and Nutrition

Both observations and statistical data indicate that as a result of the changes in agriculture, farm families and farm labor families eat more and better food.

The wheat revolution has gradually benefitted all farmers. It is mainly based on new varieties and fertilizer. These factors are divisible and can be used on small as well as on big farms.

The farm laborers have benefitted, also. Employment and wages have increased. Even seasonal laborers, representing the poorest rural group, have benefitted. They usually get their pay as a percentage of the crop, often acquiring most of their annual food grain supply. Therefore, these laborers directly benefit from the higher yields.

There is no evidence that any group has become poorer through the Green Revolution.

Increased wheat consumption does not only provide a more satisfactory level of calories but also provides more protein. For the wheat-eating rural masses, wheat often supplies about 70% of the total protein intake.

Nutritional experts have found that a satisfactory level of wheat intake, under most circumstances, will provide sufficient protein. This effect will become still more important when wheat varieties with higher protein content and quality are developed.

Expansionary Fiscal and Monetary Policy

Lack of adequate food supplies and fear of rising food prices, which could lead to inflation, has been limiting the possibilities for an expansionary economic policy in many developing countries. The rapid increase in wheat production, at less cost per unit than previously, is likely to result in self-sufficiency in several countries.

Thus, the prospect for expansionary policies becomes much brighter. A more expansionary policy, for example, through labor intensive public projects like the Rural Work Program in the subcontinent will increase demand for food grain so a still higher production can be sold and the production increase can continue after the scope for import substitution has been exhausted.

So, food production increases can be converted into useful investments such as drainage, irrigation and road projects. For countries approaching a food grain surplus, this can become an important element of development strategy.

Additional Benefits

The list above could be considerably extended by adding benefits like facilitating multiple cropping, making small farmers more market oriented and changing attitudes of the farm population.

THE MAIN PROBLEMS

Limitations of the Green Revolution

According to Falcon, the first-generation problem is simply the main limitation on the great production successes as he sees them. He points out that only 23% of the total Asian wheat land in 1968-69 was in improved varieties and concludes that continued rapid rates of adoption on additional areas are unlikely.

His conclusion is based on the assumption that the most severe constraint is adequate and controllable water supplies. Since expansion of the irrigated areas is a time-consuming and costly process, the wheat revolution will likely be limited to irrigated land and to higher rainfall areas. This would lead to regional disparities.

However, when Falcon wrote his paper, it was already clear for the persons more closely involved that the wheat production breakthrough would spread to the larger rainfed areas.

Marketing and Pricing Problems

Marketing and pricing are the second generation problems. For example, the wheat production breakthrough in India and Pakistan resulted in difficult storage problems. The marketed quantities increased at a greater rate than production. The production increase from 1967 to 1968 of 40% to 50% resulted in a large increase in marketed wheat. The government storage capacity was far from sufficient and wheat had to be stored in schools, sport stadiums and in the open covered by plastic.

Storing capacity has been expanded. However, the capacity for India is still inadequate for storing the seven million tons needed to reduce the annual fluctuations in wheat prices. The prices are already remarkably stable during the heavy postharvest arrivals. This is important to stimulate farmers to greater efforts.

Transportation bottlenecks have often been a problem, partly because of physical limitations and partly because of restrictions on grain movement by trucks. Deficiencies in grading and milling have lead to difficulties, also. The production beakthroughs for wheat and rice have made it urgent to overhaul and modernize the whole marketing system.

The price policies for wheat in India and Pakistan during the period of production breakthrough can only be understood on the basis of a total approach which Borlaug has called "The Kick-Off Approach."

This approach includes well-adapted packages of new, high-yielding technology, demonstrations of yield differences in farmers fields and economic incentives through favorable product-factor price relationships and reduction of price uncertainties, both for factors and products. Price uncertainties for wheat in India and Pakistan were reduced through guaranteed minimum prices and government procurement at these prices. Fertilizers were supplied in time and the credit situation improved. In Pakistan, prices were guaranteed by the government for the harvests of 1967, 1968 and 1969.

Many economists are criticizing these price policies, mainly on three accounts: (1) the structure of relative prices did not have a close enough relationship to world prices; (2) the prices were too high, in some cases, at the official exchange rates, double the world prices; and (3) the prices should have been lowered early in the period of production breakthrough.

Everybody agrees that agricultural price setting has to be an integrated part of a sound,

total economic policy. However, there have been and will continue to be differences between what can be deduced from textbook theorems and practical policies. Also, common sense and understanding of farmer psychology are needed.

The guaranteed price levels for India and Pakistan were fixed so that the market prices were often higher. Guaranteed prices reduce the risk of a price fall after harvest. The world market price is largely a fiction because of the distorting effects of dumping programs by developed countries. Also, because of the overvalued exchange for many developing countries, a fair comparison between internal and world market prices is extremely difficult.

For West Pakistan, the wheat prices in 1968 (f.o.b. Karachi) were 170% of the world market prices, using the official rate. According to the so-called free exchange rate, the difference nearly disappeared.

Falcon illustrates his point about necessary adjustments with a story about a price cut for wheat in Pakistan at harvest in 1969, which after a brief time was reinstated. However, he forgets to mention that the main question was one of farmers' confidence in the government-guaranteed price for that harvest. As Borlaug has stressed, it was mainly a question about the worth of confidence which nobody can put a price tag on. Borlaug and co-workers, as early as 1965, noted that it was urgent to take steps to facilitate a diversification of the cropping pattern and a reduction of the wheat acreage by millions of acres when West Pakistan approached self-sufficiency.

We always argued that rigid price support policies, which tend to freeze cropping patterns, should be avoided and after the new cost-reducing technology had been widely adopted, the time would come to consider a price reduction for wheat, making other crops relatively more profitable and facilitating diversification of agriculture.

The difference of opinion between Falcon and us in 1969 arose because we strongly felt that the new government should honor the previous government's guarantee since the farmers had planted their wheat with extra efforts under the assumption that the guarantee would be honored. Furthermore, we were not sure that the cost-reducing technology had been widely enough adopted to make a price reduction feasible at that time.

In answering such a question, the scientists, without whom there would have been no Green Revolution, should also have their say.

Social Problems

The third-generation social problems of the wheat revolution have been defined as problems of social forces and uncertain consequences. They have to do with welfare, equity, employment, land reforms, other social reforms and institutional changes generally. There is a marked trend towards growing interest in these problems.

The Green Revolution suddenly came to the forefront in the discussion of these problems partly because it was concomitant with a growing understanding of the following factors.

1. A population explosion which started 15 to 20 years ago and continues with population growth rates of 2.8% or more in many already overpopulated, developing countries.

2. A labor force explosion, because of limited opportunities for nonfarm employment, will result in an increased agricultural population, labor force and number of landless laborers.

3. The possibilities of a technological dedevelopment in agriculture that would reduce the need of labor.

4. Low average incomes in most developing countries are prevalent.

5. Great regional and personal disparities in distribution of income, wealth and political power in the rural areas is widespread.

6. There is a need for combining a high economic growth rate with the fostering of equity and social justice.

Some economists criticize the Green Revolution as if it had been sold as a panacea for all the social ills listed above and many more. This is simply nonsense. I have never met anybody involved with the Green Revolution with any such illusions.

The Green Revolution was sold simply as a means for rapid increase of food grain production. Nothing more was needed to sell it. Criticism of such a narrow objective is valid only if people are not facing starvation.

To conquer hunger is a large task. To ensure equity and social justice is another large task. To a degree, these two aims must be pursued by separate actions. Complementarities should be exploited. But if production increase is made subordinate to social aims, the results may be dismal, as proven by experience.

An agricultural policy primarily aiming at social justice, would most likely, when implemented, turn out to be more unpredictable than most previous agricultural policies in devel-

oping countries. The goal of increased food production would be so conditioned by social objectives of higher priority that it would be lost as a focus for action and there would be no effective strategy for eliminating hunger.

It is possible that the pendulum has swung too far in the direction of overemphasizing total agricultural production and aggregate economic growth. Some adjustments may be sound. But, it would not be sound policy to let the pendulum swing widely to the side of income distribution and social reforms. It is necessary to use common sense and try to strike a sound balance.

Regarding the labor force explosion and employment problem, the effect of introduction of new varieties and supporting technology varies according to the circumstances. Generally, the new varieties appear to create more employment directly and indirectly. However, this tendency is not nearly strong enough to solve the gigantic employment problems created by the labor force explosion.

According to UN-FAO estimates, the developing world, excluding Mainland China, will need to increase agricultural employment opportunities during the second development decade by about 20%, or 89 million jobs more than the 1970 level. Improvements in agricultural technology alone *can not* solve this problem. During the same period, nonagricultural employment is expected to increase by 52%, or 119 million jobs.

Indirectly, as stressed above, abundant, low-cost production of food may help solve the employment problem if it is used as a basis for an expansionary, employment-creating economic policy.

Introduction of new technology has often lead to an uneven regional growth, especially between irrigated areas and rainfed areas, and between irrigated areas with effective water control and areas without proper water control. This can be partly corrected by research supporting the less favored regions.

The relative impact on big and small farms is less clear. The relative effects will depend to a high degree upon proper support of small farmers through effective credit, extension programs and government policies to prevent increasing inequality of incomes within agriculture.

The Green Revolution has bought time to make changes for fostering equity and social justice, and to stop the population explosion. Without the Green Revolution, the situation today in many developing countries would be much more difficult, maybe unmanageable.

The basis for employment of the growing labor force and social reforms can be created only through an increased economic growth rate, which will be facilitated by a high agricultural growth rate. Social and institutional reforms can most easily be implemented concomitant with sound economic development.

The new agricultural technology is doubtless a positive factor for an attack on poverty and on the social imbalances, which are man-made issues of long standing. Modernization of agriculture in the less-developed countries should include new technology geared to higher production and policies for improvements in the institutional framework to benefit the rural areas where overpopulation is a threat.

CHALLENGES OF THE FUTURE

Generations of Wheat Revolutions

While the first generation of the wheat revolution has been characterized by introduction of high-yielding varieties on 10 to 12 million hectares of irrigated land, the main challenge is to develop and introduce high-yielding varieties on 35 to 40 million hectares of rainfed land. The potential breakthrough for bread-wheats on rainfed land with fuller use of the potential on irrigated land will represent the second generation of the wheat revolution.

The third generation will most likely be a breakthrough for high-yielding varieties of durum wheat and barley, and adaptation and introduction of wheat-legume rotations while grain content and quality is significantly improved.

Much of the rainfed area is in the Middle East and North Africa, including Afghanistan and Turkey, with 25 million hectares of wheat and 10 million hectares of barley. Like India and Pakistan, these areas have a wheat deficit which can be eliminated through import substitution. Doubling the present wheat production of approximately 20 million tons will be necessary to fill this deficit of 6 to 8 million tons and to meet the increasing demand through 1980.

Self-sufficiency is not a relevant target for all countries of the region. Some are rich oil countries and can easily afford to import wheat. However, a green revolution is necessary in these countries to improve the economic and social position of the farmers.

The Depressed World Market

Various projections of total world wheat production have been made. There are consid-

erable variations among them. However, they all include a reduced growth of import demand and abundant supplies in major exporting countries.

This will lead to downward pressure on world market prices, greater use of wheat for feed and probably concessional sales by some major exporters. Unless the major developed wheat producing countries come to grips with their production problems, the supplies may be too bountiful.

It has been argued that fertilizer recommendations for wheat should be based on the world market prices. However, adjusting national wheat prices down to the depressed world market level would most likely bring the wheat revolution to an early halt. The developing wheat producing countries need to keep the wheat revolution rolling, higher and more stable wheat prices than the fictious and fluctuating world market prices.

Also, the probable increased use of dumping programs by developed countries may seriously limit export possibilities for developing nations which generate export surpluses. For these countries, adjustments of relative prices of agricultural products will be necessary to stimulate diversification and decrease wheat acreage to avoid unmanageable surpluses.

With growing population and demand, there will generally be a need for increased production of alternative crops like grain legumes, oil seeds, fodder crops for livestock, winter vegetables and potatoes. It will be sound policy to increase wheat yields per hectare as rapidly as possible to release land for production of other products needed.

Even for poor countries with foreign exchange difficulties, a self-sufficiency policy should not be defined as meaning no import at all. Because of the great yield fluctuations for rainfed wheat and the relative high cost of storage from good years to bad years, it may be most economical to aim at 90% self-sufficiency and to import significant quantities in serious drought years.

Cheap Fertilizer Needed

To provide a favorable product-factor price relationship, it will be very important to supply cheap fertilizer. A technological revolution in fertilizer production is underway. However, the developing countries have not yet been able to reap many benefits. This would require large, modern factories which often have to be based upon economic cooperation between several countries. Efficient distribution systems for fertilizer and other inputs are important to facilitate favorable benefit-cost ratios, also.

Subsistence Farmers

It is extremely important to reach the subsistence farmers at a cost the developing countries can afford. This will be a main challenge for the second generation of the wheat revolution, entering the vast rainfed areas with less total yield potential and higher risks than the irrigated areas.

Millions of farmers in these areas are barely making a living. Wheat and barley are usually the main crops. According to experiences in Tunisia and other rainfed areas, the main requirements are: suitable varieties and packages of improved technology; cheap fertilizer available on credit with easy terms; and more efficient extension through well-trained production agronomists.

In some countries, the subsistence farmers are located on the more hilly and unfertile land, and are using draft animals and primitive tools while the big units are mechanized. Special packages of improved technology may be needed for them. In countries where fertilizer is readily available on credit, as in Egypt, the small farmers are brought into the main stream of development. This seems to be an absolutely necessary precondition and it seems to be a main contributing factor to success under the Puebla Project for corn.

In the main parts of the rainfed areas, there is a growing deficit of meat, especially sheep meat which is strongly preferred. This represents a great challenge which only can be met through increased feed production. Livestock development with a wheat production breakthrough is also needed for sufficient improvement of the economic and social conditions of the small farmers.

Such a development can take place through: future reduction of the wheat acreage in favor of fodder crops; introduction of wheat-legume rotations; and improvements of grazing lands.

From an economic and social viewpoint, CIMMYT's interest in adaptation and introduction of wheat-legume rotations is highly welcome. It may become a very important aspect of the Green Revolution for the rainfed wheat areas and for support of the small farmers.

However, the introduction of such rotations may run into some difficulties. In many parts of the rainfed areas, for example the Anatolian Plateau, there are communal grazing rights for all farmers on the wheat land after harvest.

This implies that we have to work with whole villages as a unit and have to convince all the

farmers of a village to change rotations at the same time. Research is needed to be prepared for such a situation.

In the irrigated areas, we found that all farmers were ready for change. I am convinced the same will happen in the rainfed areas. The peasant farmer is shrewd enough to change whenever it is clearly demonstrated that advances in technology make large increases in yields possible. This assumes that the new inputs required are made available and that there is ample margin for a reasonable profit.

I do not agree with Myrdal that the ambition is often missing and that an educational effort of staggering dimensions is needed. The same was said about the farmers in India and Pakistan.

Wheat Research in Pakistan

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Pakistan grows about six million hectares of wheat, an increase of about one million hectares over the pre-dwarf period. Almost all of the wheat is grown in West Pakistan where about 60% is grown under irrigation and 40% under rainfed conditions. East Pakistan has only recently begun to grow wheat in the winter season and acreage is still small.

The principal wheat growing areas are in the provinces of Punjab, Sind and North West Frontier. A small acreage is sown in Baluchistan in areas adjacent to the Sind and near the city of Quetta in the West. Rainfall in the southern part is very low. Thus, all of the wheat grown in Sind and much of that grown in Punjab is under irrigation. Water for irrigation is supplied by the Indus River and its tributaries which rise in the Himalayan regions of Kashmir.

In northern Pakistan, areas of northern Punjab and the Northwest Frontier Province grow rainfed wheat. Moisture is conserved from the monsoon season when rains fall until the end of September (in a good year) and occasional nonpredictable rains occur during the winter months.

In the irrigated areas, little attention was paid to drainage when the land was put under irrigation. The result has been a gradual build up of salt in the soil. This is a major problem of Sind and large water-logged areas of Punjab. In Punjab, large reclamation projects are bringing the land back into production. Many wells were drilled and through judicious application of well water and river water, it has been possible to lower the water table and wash salts down in the profile where they do not cause deleterious effects on the crops. There is still a vast need for drainage and land reclamation in the country.

When the British were in India and until the beginning of World War II, this portion of the subcontinent was a surplus area and exported much grain to the United Kingdom and other countries. However, demands of an increasing population rose above supply and the country was forced to import wheat to feed its people. Production in the region remained more or less static at 3.5 to 4.0 million tons.

THE ACCELERATED WHEAT IMPROVEMENT AND PRODUCTION PROGRAM

In 1964 Pakistan launched its Accelerated Wheat Improvement and Production Program with the aim of reaching self-sufficiency in the shortest time possible. In 1965 the country imported 350 tons of Mexican wheats. Research was stepped up. Microtrial test plots were grown at many locations and farmers demonstrations were presented throughout the country. As an integrated research team was developed, the program operated from three major centers at Lyallpur, Tandojam and Tarnab.

In 1967, 42,000 tons of Mexican wheat was imported and the 1968 production jumped to about 6.2 million tons compared with the previous high of 4.6 million tons in 1965. As the new varieties and technology spread, production continued to advance, reaching a high of 7.3 milion tons in 1970.

In 1971, several factors resulted in a drop in production to an estimated 6.5 million tons. Rains were absent in the dryland production areas until late February and water in the canals was low because of poor rainfall in the Indus headwaters during the preceding monsoon period. Lower rates of fertilizer were applied because of partial failure of the rice crop preceding wheat and national elections coinciding with the sowing season interfered with timely operations. Examining the sales figures for fertilizers in the various years, it is evident that fertilizer sales were made about a month later than normal so that the full benefit would not be gained through late application.

One of Pakistan's perennial fertility problems has been the low use of phosphorous in relation to nitrogen. Much agronomic work has shown that the desirable level is 2N:1P. How-

ever, in Pakistan it has never exceeded about 6N:1P and this year slipped to 7N:1P. This low application rate of phosphorus leads to inefficient use of nitrogen applied. Also, some shortages of trace elements, such as zinc, may be becoming limiting in the lighter-textured soils.

DISEASES

The rusts are the principal diseases of Pakistan. Stripe rust is potentially the greatest hazard as it can cause damage on susceptible varieties in the North West Frontier Province and Punjab. A new race(s) capable of attacking Mexipak appeared in the 1969-70 crop. In the past year, because of extremely dry conditions, this disease was of little importance. It is, however, necessary to diversify the varietal picture at an early date to avoid possible losses in the coming years.

Stem rust appears in Sind each year. Usually losses are minimal but if it appears early, it can cause damage. Leaf rust is present but damage is light.

A nematode-associated disease caused by *Anguina tritici* is fairly widespread in Punjab but can be readily controlled by good seed production practice.

Loose smut is a problem with susceptible varieties. Mexipak is essentially immune to this disease and its culture has lowered the incidence appreciably in the northern areas where the disease is usually more prevalent.

Common bunt is a problem only in the hill areas of the North.

VARIETIES

Mexipak remains the principal variety. In the beginning, Pénjamo 62 was used extensively. This was replaced by Mexipak and Indus 66, two varieties derived from the cross 8156. Chenad 70 (C271 x Willet(E)-Sonora 64), a new variety, is now becoming more widespread. It is somewhat more resistant to disease than Mexipak and has shown a widely adapted yield potential.

Barani 70 (Pitic-Gabo x C271) was released last year for rainfed areas. It has shown promising results in the dryland areas as well as under low fertility and restricted irrigation. Blue Silver (Sonalika) and C271² x Lerma Rojo-Sonora 64 are two early varieties which yield well under late planting due to late harvesting of the preceding crop. One or two of the Bluebird varieties are also promising.

THE FUTURE

The original coordinated program ceased to exist after West Pakistan underwent political division into the four provinces already mentioned. This resulted in the formation of four separate agricultural ministries with wheat research and production the responsibilities of provincial governments. Despite this fractionation, research has continued in an integrated fashion through very close collaboration among the scientists of the different provinces. A summer nursery has been established at Kaghan which will service the different breeding programs. This promises to provide more rapid advances in the breeding of new varieties. Very dynamic programs are being conducted and new varieties are now moving out of the research stations.

It can be expected that, with aggresive government policy to encourage wheat production, Pakistan's self-sufficiency in wheat can continue for some years.

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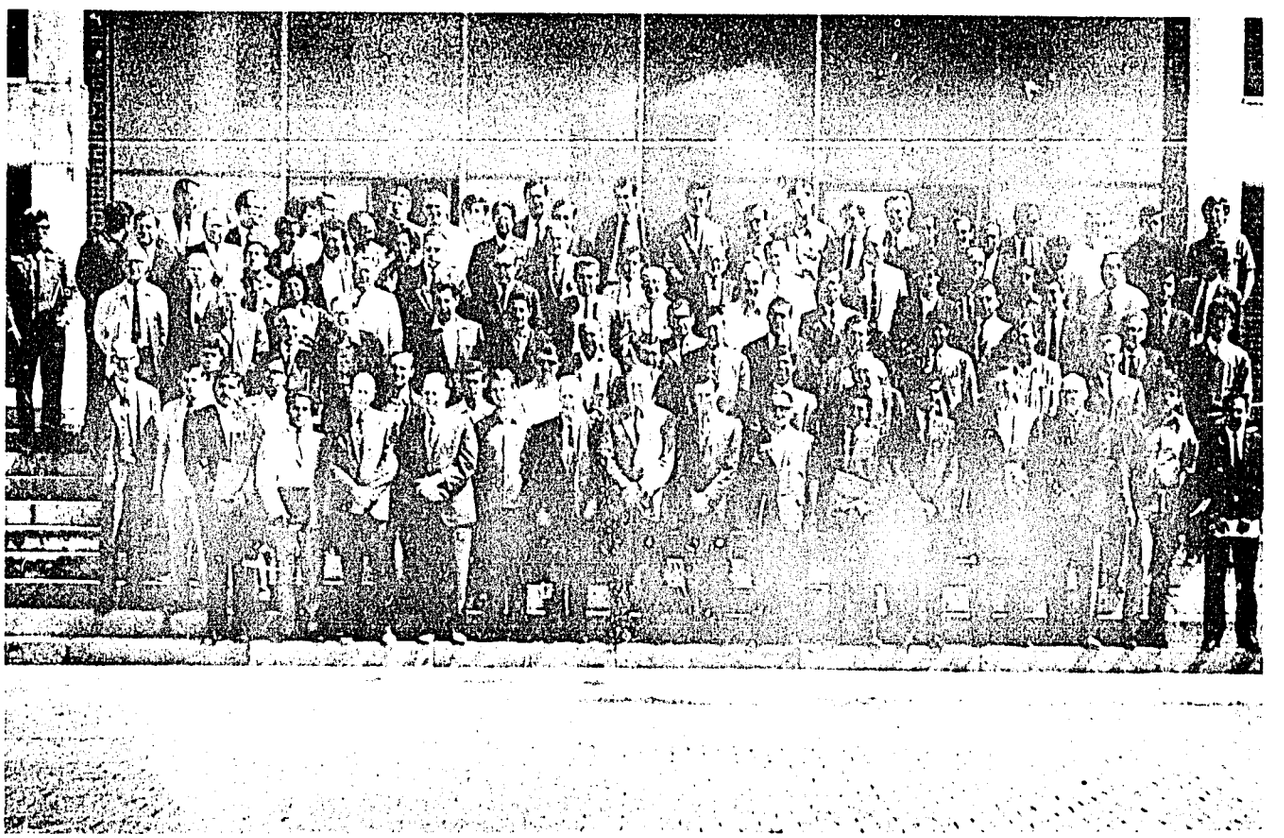

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