CEREAL IMPROVEMENT IN DRY AREAS

A Report on the Tunisia Cooperative Cereal Improvement Project

Ministry of Agriculture
Republic of Tunisia

International Center for Agricultural Research in the Dry Areas, ICARDA

CEREAL IMPROVEMENT IN DRY AREAS

COOPERATIVE CEREAL IMPROVEMENT IN TUNISIA (1980-1985)

MINISTRY OF AGRICULTURE
REPUBLIC OF TUNISIA

INTERNATIONAL CENTER FOR AGRICULTURAL RESEARCH IN THE DRY AREAS (ICARDA)

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FOREWORD

This document highlights ICARDA's impact in Tunisia since the inception of the Tunisia-ICARDA collaborative project on cereal improvement in 1980. It also reflects the coherent relationship between ICARDA and the Tunisian national programs, particularly the Institut National de la Recherche Agronomique de Tunisie (INRAT). The project considers three aspects; barley improvement, cereal pathology, and training.

In my foreword to the ICARDA Annual Report of 1983 I drew attention to the fact that the work of ICARDA has helped to strengthen the Tunisian barley improvement program so that the national program now conducts research on barley with only limited support from ICARDA. As a result, the Tunisian Government has requested us to transfer the major part of our own research efforts on cereals in Tunisia to pathology.

In early 1985, three barley cultivars were officially released for Tunisian farmers, thus fulfilling one of the aims of the project. This will increase the national barley production by over 20% in both low and high rainfall areas. Intensive testing against various diseases, and identification of wheat and barley lines with high yield potential and multiple disease resistance should help to replace, if necessary, commercial varieties susceptible to the prevailing diseases. Two bread wheat and one barley varieties are now at the stage of prerelease testing and multiplication. The findings of the project indicate that the national program is making full use of the genetic variability existing in the cereal program of ICARDA as well as elsewhere.

Training in different categories as is reflected in this document has been given high priority from the start of the project, to further strengthen the research programs in trained manpower. The aim is to strengthen the capacity of national programs to carry out their own crop research.

Although research is a never-ending process, the initial objectives of this project have been successfully accomplished. However, research on production packages is needed to maximize and stabilize barley production in the low rainfall areas of Tunisia.

The results of this work and the methodologies developed for rainfall areas in general are detailed in this document. I hope this will be of interest and use to others who are working to improve barley and wheat production in dry areas.

Mohamed A. Nour,
Director General

ACKNOWLEDGEMENTS

This work was achieved through collaboration between Tunisian and ICARDA scientists. Our principal partner in this project is the Institut National de la Recherche Agronomique de Tunisie (INRAT). However, other Tunisian institutions have actively participated, such as the Office des Cereals and the Institut National Agronomique de Tunisie (INAT). The project, funded from ICARDA core budget from 1980 through 1986, was initiated in response to a specific request from the Government of Tunisia. It's aim was to strengthen winter cereal research and production capabilities with particular emphasis on barley improvement and pathology.

Thanks are due to His Excellency, Mr. Lassad Ben Othman, Minister of Agriculture, Government of Tunisia, Mr. Mohamed Fadel Khalil, ex-Director of International Cooperation, Ministry of Agriculture, and Drs. Mohamed A. Nour, Director General, and H.S. Darling, ex-Director General of ICARDA, for developing this project.

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Several others, both scientific and support staff, from Tunisia and ICARDA have contributed to the sucess of the project, to whom we owe sincer gratitude.

J.P. Srivastava

Srivastava

Leader
Cereal Improvement Program

HIGHLIGHTS

BARLEY BREEDING:

1. Three barley lines Roho, Taj (WI 2198), and Faiz (ER/Apm) were identified from the ICARDA international nurseries, and in 1985 were released by the Tunisian National Program. They had consistently high yields under Tunisian conditions. The three varieties were tested for yield performance in areas with 220-400 mm and over 350 mm seasonal rainfall. Roho and Taj had improved yields over local varieties in the 220-400mm rainfall areas, and Faiz in areas receiving over 350mm rainfall.

2. A promising barley line, Rihane 's' (sel. 2L-1AP-3AP-0AP), is now under large-scale testing, for possible release, at several sites in Tunisia. This line is a 6-row type which is preferred by farmers, is more tolerant to disease than local varieties, and gives better yields than the newly-released varieties under both low and high rainfall conditions.

CEREAL PATHOLOGY:

1. Sources of multiple disease resistance were identified in bread wheat lines with good grain quality and high yield potential. In Tunisia, lines Sunbird's' and Bobwhite 1 are tolerant to septoria leaf blotch, yellow rust, and tan spot. Averaged over two and three years, they had yield increases of 20% and 12% , respectively, over the improved local check (Tanit). They are presently being tested in large-scale verification/demonstration trials at several locations.

2. A practical method was developed for screening against barley stripe disease. Plants of the F1 nursery, encircled by a spreader of Helminthosporium gramineum, are continuously subjected to a source of inoculum at the different stages of head development. This technique allows effective selection of plants resistant to the disease.

3. The level of resistance to Septoria tritici has improved in ICARDA germplasm selected under Tunisian conditions. During the 1982-85 crop seasons, the percentage of resistant and moderately resistant entries increased from 8% to 42% in the KLDN-D, from 24% to 49% in the DON, and from 41% to 58% in the WON.

4. Thousands of new wheat and barley entries from national, ICARDA, and CIMMYT germplasm were evaluated for resistance to diseases prevalent in Tunisia using artificially created epidemics or natural inoculation. Sources of resistance were also identified.

TRAINING AND WORKSHOPS:

1. Training was a major component of the project. During 1979-85, 10 junior support staff attended residential training courses on cereals at ICARDA. The main objective was to improve their technical and practical knowledge in the different aspects of cereal improvement. Simi'arly, 10 technicians were trained in various aspects of cereal improvement either through short specialized courses or through individual training for periods of two to four weeks.

2. A scientist was trained in barley breeding for three years (1980-83) in Tunisia and has now assumed full responsibility for the barley program at INRAT.

3. Three national scientists are supported by the project for their Ph.D. research and six students for M.Sc. degrees.

4. Support was given to national scientists to participate in several seminars and workshops held in the region or elsewhere.

ACRONYMS

ABYT	- Advanced Barley Yield Trial
AYT	- Advanced Yield Trial
B	- Barley
BD	- Ble Dur
BON	- Barley Observation Nursery
BT	- Ble Tendre
BW	- Bread Wheat
BYDV	- Barley Yellow Dwarf Virus
BYT	- Barley Yield Trial
CB	- Crossing Block
CIMMYT	- Centro International de Mejoramiento de Maiz Y Trigo
CRG	- Collection des Resources Genetique
D	- Durum
DERV	- Direction de l'Enseignement, Recherche et Vulgarisation
DON	- Durum Observation Nursery
DON-RF	- Durum Observation Nursery-Rain-Fed
DST=DSN	- Durum Septoria Nursery
EBYT	- Elite Barley Yield Trial
GM	- Grand Mean
HYV	- High-yielding Varieties
IBON	- International Barley Observation Nursery
IBWSN	- International Bread Wheat Screening Nursery
IBYT	- International Barley Yield Trial
ICARDA	- International Center for Agricultural Research in the Dry Areas.
INAT	- Institut National Agronomique de Tunisie
INRAT	- Institut National de la Recherche Agronomique de Tunisie
ISEPTON	- International Septoria Nursery
KLDN	- Key Location Disease Nursery
LBA	- Lima Bean Agar
LR	- Leaf Rust
MR	- Moderately Resistant
MT	- Metric Tonne
MS	- Moderately Susceptible
NB	- Net Blotch
OR	- Orge
PBDN	- Preliminary Barley Disease Nursery
PM	- Powdery Mildew
POT	- Pepiniere d'Observation Tunisienne
PYT	- Preliminary Yield Trial

R	- Resistant
RCBD	- Randomized Complete Block Design
RSP	- Regional Segregating Populations
S	- Susceptible
'S'	- Sib or Sister
SD	- Stripe Disease
SC	- Scald
SW	- Specific Weight
T/E	- Tenacity/Elasticity
TU	- Tunisia
TYC	- Top Yielding Category
WST=WSN	- Bread Wheat Septoria Nursery
YMA	- Yeast Extract Malt Agar
1000 KW	- Thousand Kernel Weight

I. INTRODUCTION *

A. Overall Cereal Situation in Tunisia:

Cereals are very important crops in Tunisia. They occupy over 1.6 million hectares of the arable area and are important to the food security of the country.

1. Agroclimatic Conditions in Tunisia

Tunisia is characterized by a Mediterranean climate and can be divided into three zones (Figure 1).

a. Northern zone: the annual rainfall is 350-600 mm and on average, 75-90% of Tunisian cereal production is in this region. Despite high rainfall, average yields are only a little over 1 t/ha. Most of the country's wheat is cultivated in this zone.

b. Central zone: annual rainfall is 200-350 mm. However, year-to-year variation is large and this discourages farmers from using improved inputs for cereal production. Both barley and durum wheat are grown in this zone.

c. Southern zone: annual rainfall is less than 200 mm. Barley is grown almost exclusively in this zone but productivity is very low.

Rainfall at the main experimental sites and a general description of the cropping seasons are shown in Table 1.

2. Constraints to Cereal Production in Tunisia

Cereal production in Tunisia is limited by different constraints which can be summarized as follows:

a. Inadequate and irregular rainfall in all cereal growing areas.
b. Heat, a combination of heat and drought during spring in some seasons, and low temperatures in certain areas.
c. Lack of appropriate fertilizer and herbicide application in small holdings, which represent about 30% of the cereal area in the northern region.
d. Absence of barley varieties adapted to the lower rainfall areas.
e. Lack of adapted production technologies for the semi-arid areas.

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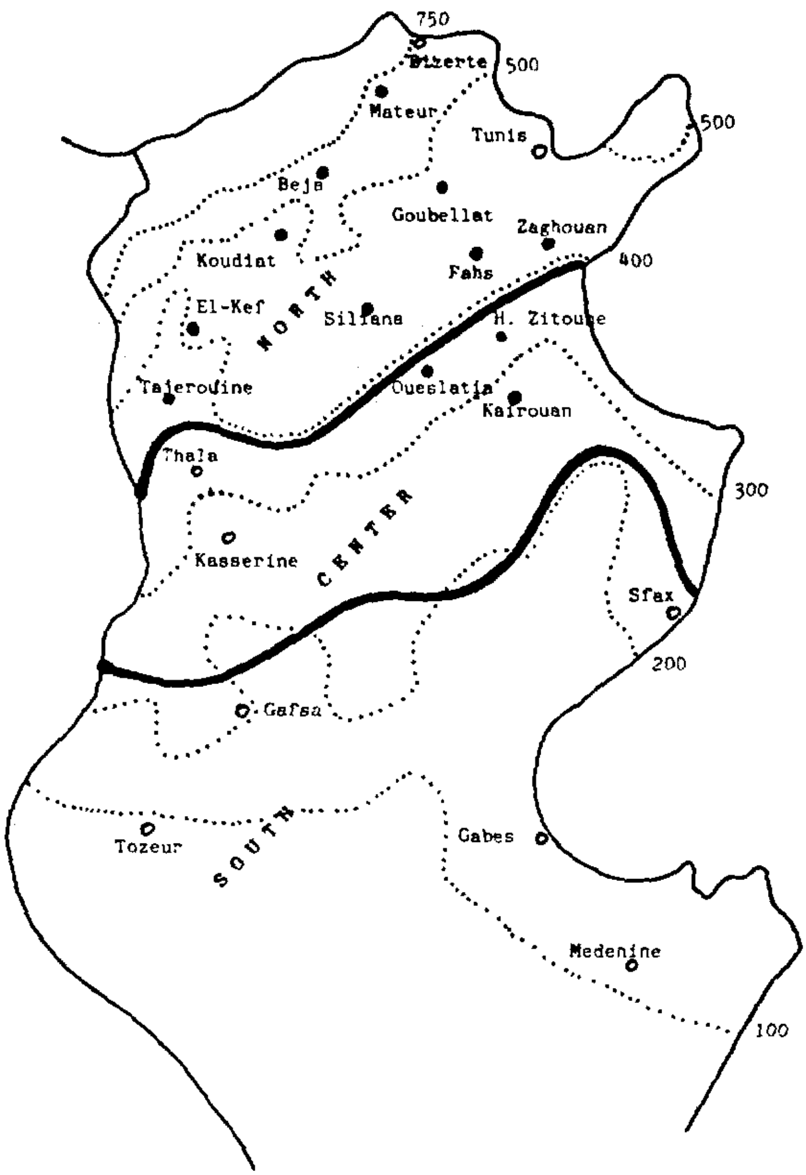
* For the statistics of this section:
Evaluation Retrospective des Realisations du VI eme Plan en Cerealiculture. (Decembre, 1985), Ministere de l'Agriculture, Republique Tunisienne.

FIGURE 1 : BIOCLIMATIC MAP OF TUNISIA



● EXPERIMENTAL SITE

Table 1. Total rainfall (mm) for the period September-June at Beja, Koudiat, Boulifa Hindi Zitoun and Tajerouine, during the cropping seasons 1980/81 to 1984/85.

	SITE AND RAINFALL					
Crop season	**Beja**	**Koudiat**	**Boulifa**	**H.Zitoun**	**Tajerouine**	**General description of the season.**
1980/81	590	431	382	200	-	Well distributed rainfall with occasional snow in January
1981/82	609	575	372	267	224	Irregular rainfall. From 1 November to 15 January it was almost dry in the north and dry in the center and south. Late rainfall, and a hot spring.
1982/83	544	481	363	482	-	70%-90% of the total rainfall occurred during 22 October-15 January. Dry in February-April in the center and south and less than normal in the north. Hot spring.
1983/84	562	374	372	194	223	Center, south, and Fahs area were dry. Normal rainfall in the North.
1984/85	368	389	411	414	-	Very favorable climatic conditions in the country as a whole.

3. Area Under Cereals

The area under cereals in Tunisia is about 1.6 million hectares and is divided into 800,000 ha (50%) of durum wheat, 150,000 ha (10%) of bread wheat, and 650,000 ha (40%) of barley. Of this, about 85-95% is harvested (Table 2).

In the north, the area under cereal crops is 750,000-850,000 ha and durum wheat is the dominant crop (58%), followed by barley (30%), and bread wheat (12%).

The area under cereals in the center and south varies from year to year depending on rainfall from September to January. The average is 780,000 ha with large variations between years (418,000 ha in 1982 compared to 1,090,000 ha in 1985). In these regions, barley is the dominant crop (52%), followed by durum wheat (43%), and bread wheat (5%).

The area planted to durum wheat in the center and south is still rather high in spite of government efforts to reduce it in favor of barley. The area grown to bread wheat is low despite continuous encouragement from the government, which in certain years gives prices equal to those from durum wheat.

4. Cereal Production in Tunisia

Average cereal yields in Tunisia are irregular and always depend on prevailing climatic conditions. However, average annual production has increased by about 47% in the last two decades (0.77 million metric tonnes (mt) in 1966-1975 to 1.13 million (mt) in 1976-1985.

During 1984-85, average national production was about 1.3 million mt. This consisted of 57% durum wheat, 30% barley, and 13% bread wheat, with yield averages of about 1020 ,688, and 1542 kg/ha, respectively (Table 2). In the north, average yield was about 1315 kg/ha, but was only 413kg/ha in the center and south. In 1985, Tunisia harvested a record cereals crop (2.1 million tonnes) which was mainly due to favorable agroclimatic conditions and the adoption of new production technology packages.

5. The Production-Consumption Balance

The evolution of cereal production has helped to reduce the deficit between supply and demand. National consumption is higher than production, and national production during the past four years (1982-85) could meet 69% of the total needs as shown below.

Table 2: Harvested area, production and yield of cereal crops in Tunisia during the 1980-81 through 1984-85 cropping seasons

		NORTH			CENTER & SOUTH			TOTAL		
		Area 1000 ha	Production 100 MT	Yield Kg/ha	Area 1000 ha	Production 100 MT	Yield Kg/ha	Area 1000 ha	Production 100 MT	Yield Kg/ha
Durum	80-81	495	7296	1774	200	748	374	695	8044	1157
	81-82	471.4	6924.1	1469	156	604.5	388	627.4	7528.6	1200
	82-83	454	4054.2	893	364.8	1040.7	285	818.8	5094.9	622
	83-84	463.5	5133.5	1108	190.4	709.2	372	653.9	5842.7	894
	84-85	450.3	7222.2	1604	407	3471.5	853	857.3	10693.7	1247
Bread Wheat	80-81	77	1530	1987	11	60	545	88	1590	1806
	81-82	74.5	1584.3	2078	12.2	83.3	683	86.7	1631.6	1882
	82-83	78.8	956	1213	32.7	131.5	402	111.5	1087.5	975
	83-84	83.5	1217.1	1458	18.2	54.5	299	101.7	1271.6	1250
	84-85	117.7	2688.9	2285	58.1	422.9	728	175.8	3111.8	1770
Barley	80-81	170	1862	1095	273	838	307	443	2700	609
	81-82	212.1	2774.3	1308	182.6	611.6	335	394.7	3385.9	858
	82-83	208.3	1829.4	878	422.9	1204.5	285	631.2	3033.9	481
	83-84	243.8	2290.6	940	245.6	830.3	338	489.4	3120.9	638
	84-85	243	3216.6	1324	577.6	3647.7	632	820.4	6864.3	836
Total	80-81	742	10688	1440	482	1645	340	1226	12334	1006
	81-82	758	11246.7	1484	350.8	1299.4	370	1108.8	12546.1	1132
	82-83	741.1	6839.6	923	820.4	2376.7	290	1561.5	9216.3	590
	83-84	790.8	8641.2	1093	454.2	1594	351	1245	10235.2	822
	84-85	811	13127.7	1619	1042.7	7542.1	723	1853.7	20669.8	1115

	Needs (100 mt/year)			
	Production	Consumption	Seeds	Production as percent of needs
Durum	7290	8826	675	77
Bread wheat	1775	6156	109	28
Barley	4101	3020*	342	122**
Total	13,166	18,002	1,126	69

* 16% for human consumption, 84% for animal feed.
** This figure is unusually high, because 1984/85 was such an exceptional season. In most years, barley production does not meet demand.

The 1984/85 season was especially favorable for barley production. Favorable autumn rains encouraged farmers in the dry areas of central and southern Tunisia to increase the amount of acerage planted in barley. In addition, favorable rains, which continued throughout the growing season, lead them to harvest a higher than usual percentage of the crop. As a result, barley production in 1985 exceeded the country's needs.

This one unusually good harvest, however, does not mean that Tunisia is now self-sufficient in barley. In 1981, a more typical year, production as a pecentage of needs for durum wheat, bread wheat, and barley was 85, 28, and 77% respectively. During the first four years of the project, Tunisia imported approximately 40,000 mt of barley per annum

Average annual human consumption during the same period (1982-85) was 226 kg per capita, of which 129 kg was durum wheat, 90 kg bread wheat, and 7 kg barley.

6. Ways of Increasing Cereal Production in Tunisia

The maximum area suitable for cereal production was planted during the favorable 1984/85 season, and the unusually good growing season lead farmers to harvest about 1.9 million ha, an increase of about 0.3 million harvested ha over more typical years. Further production increases must come through yield improvement. The following components are considered valuable for increasing yields in Tunisia.

a. Suitable seedbed preparation.

b. Optimum use of fertilizers. The quantities of fertilizers used for cereals during 1981-85 were (in 1000 t)

	1981/82	1982/83	1983/84	1984/85
Superphosphate 16%	15	10	10	11
Superphosphate 45%	61	68	72	76
Ammonium nitrate 33%	75	63	80	95

In general, most fertilizer was used in the northern areas of the country. The average annual quantity used is equivalent to an average application rate of 40 kg P_2O_5/ha and 32 kg-NO_3/ha, which is below the optimum rate recommended for the north; this should be about 60-70 kg/ha for both P_2O_5 and NO_3.

c. Adequate use of herbicides. On average, during 1981-85, 30% of the area grown to cereals in the north was sprayed each year with herbicides. As shown below (1000 ha), the area treated with polyvalent herbicides increased from 52,000 ha in 1981 to 131,000 ha in 1985, while 2,4-D use was irregular.

Herbicides	1981	1982	1983	1984	1985
2,4-D	183	166	122	153	152
Polyvalent	52	62	83	110	131
Total (in 1000 ha)	235	228	205	263	283

d. *Improving disease resistance in high-yielding varieties.* High-yielding varieties (HYV) are mostly grown in the northern region. They represent, on average, 83% and 59% of the total bread wheat and durum wheat seeds used, respectively, in that region during 1982-85.
At present, the most widely cultivated HYV are Karim, followed by INRAT 69 and Ben Bechir (durum wheat), and Ariana 66 followed by Tanit and Salambo (bread wheat). In the case of barley, seeds of the newly-released varieties were grown in commercial fields for the first time in 1985/86.

Some of these varieties lack resistance to the major diseases prevailing in Tunisia. Therefore, attention must be given to improving the level of resistance of the HYV.

B. Barley Program in Tunisia

1. General

Barley has always been an important crop in Tunisia and is more widely grown in the center and south. In the rotation system used in the north, it is always grown after wheat or on poor soils. The lack of interest in this crop in the north compared to the south, is probably due to the fact that it is not widely used for human consumption in the north. However, in the south, barley bread and barley soups are very popular. Furthermore, cereal crops in the center and south are dependent, to a large extent, on climatic conditions, particularly rainfall. These factors help to explain why research on barley improvement was not adequate in Tunisia.

Presently, barley production is very low. Table 2 shows that there has been an increase in the area planted to barley in the north which can be explained by farmers' increased enthusiasm for this crop in the past 5 years. In the center and south, the variation in area under barley is due to rainfall. The maximum area planted to barley was registered in 1985, which was characterized by excellent rainfall distribution. The best yields were also achieved in that year. The poorest yields were obtained during the rain-deficient year of 1983.

In contrast to wheat, the new technology package developed has not so far been applied to barley. It should be mentioned that the production of certified barley seeds only started in 1983, and it remains very low. In 1983 production was 500 mt; in 1984, 600 mt; and in 1985, 1000 mt.

2. History of the Barley Improvement Program in Tunisia

In the early 1970's, the government decided to increase livestock production and reduce imports of meat, milk, and milk derivatives which had became very important due to population growth and improvements in the standard of living. Thus, the increasing demand for animal feed boosted interest in barley. The government then decided to concentrate barley growing in the center, south, and on the poor soils of the north. A research program, started in 1972/73, was mainly concerned with variety improvement using local races and introductions from several countries and from CIMMYT.

However, frequent changes in the researchers involved in the program, meant progress was slow. It was not until 1978, when a young Tunisian scientist joined INRAT, that the program was reactivated, and in 1980, with the start of the INRAT-ICARDA collaborative project, the program started evolving to its present state.

Important results were obtained with the release and registration of three new barley varieties in 1985, and there is a good chance that even better varieties will be released in the near future.

C. History of the Project

As soon as ICARDA could initiate outreach activities, a collaborative agreement between the Tunisian Government and ICARDA was signed on March 11, 1980. The agreement calls for cooperation between the Ministry of Agriculture and ICARDA on cereal (especially barley), food legume, and pasture and forage improvement.

A full-time cereal breeder/pathologist from ICARDA was posted to Tunisia in May 1980 to work with INRAT cereal scientists on the improvement of barley and cereal pathology, with full back-up support from ICARDA's base program.

D. Objectives of the Project

The overall objective of this project was to provide the Tunisian National Program with the necessary support to accelerate the identification of production packages, including new varieties. Training was also a major objective, to fulfill the needs of the cereal program for qualified support staff.

The project had two phases.

<u>First phase (1980-83)</u>

- Strengthen the capacity and research capability of the National Program through manpower training and research support.

- Develop improved barley genotypes with adequate resistance to prevailing diseases and lodging and better adapted to the different agroclimatic conditions in Tunisia, particularly low rainfall areas.

- Improve, by breeding, the desirable characteristics of selected lines.

Second phase (1983 onwards).

- Strengthen cereal pathology at INRAT through training and research support.
- Screen and identify genotypes of barley and wheat resistant/tolerant to prevalent diseases, using artificial epiphytotics and natural inoculation.
- Develop inoculation techniques for efficient screening and selection against barley and wheat diseases.
- Develop a program of research on cultural practices for barley, especially in low rainfall areas.

II. BARLEY BREEDING

1. Materials and Methods

A. Breeding Nurseries: Specification and Layout

A large amount of barley germplasm in the form of segregating populations, observation nurseries, and yield trials originating from various sources, was planted each year at most of the following sites: Hindi-Zitoun, Koudiat (Bou Salem), Boulifa (El-Kef), Tajerouine, and Beja. The H. Zitoun and Tajerouine sites are in low rainfall areas (200-300 mm rain/ season), Boulifa is a semi-dry (300-400 mm), and Beja and Koudiat are sub-humid (400-600 mm) and disease-prone.

At the beginning of the project (1980/81), organization of the program was the most urgent task. The first step was to assemble and evaluate a large barley germplasm pool, indigenous to Tunisia or introduced from ICARDA and CIMMYT. Germplasm movement in the Tunisian national barley program (Figure 2) involves the nurseries discussed below.

a. Pepiniere d'Observation Tunisienne=Tunisian Barley Observation Nursery (POT)

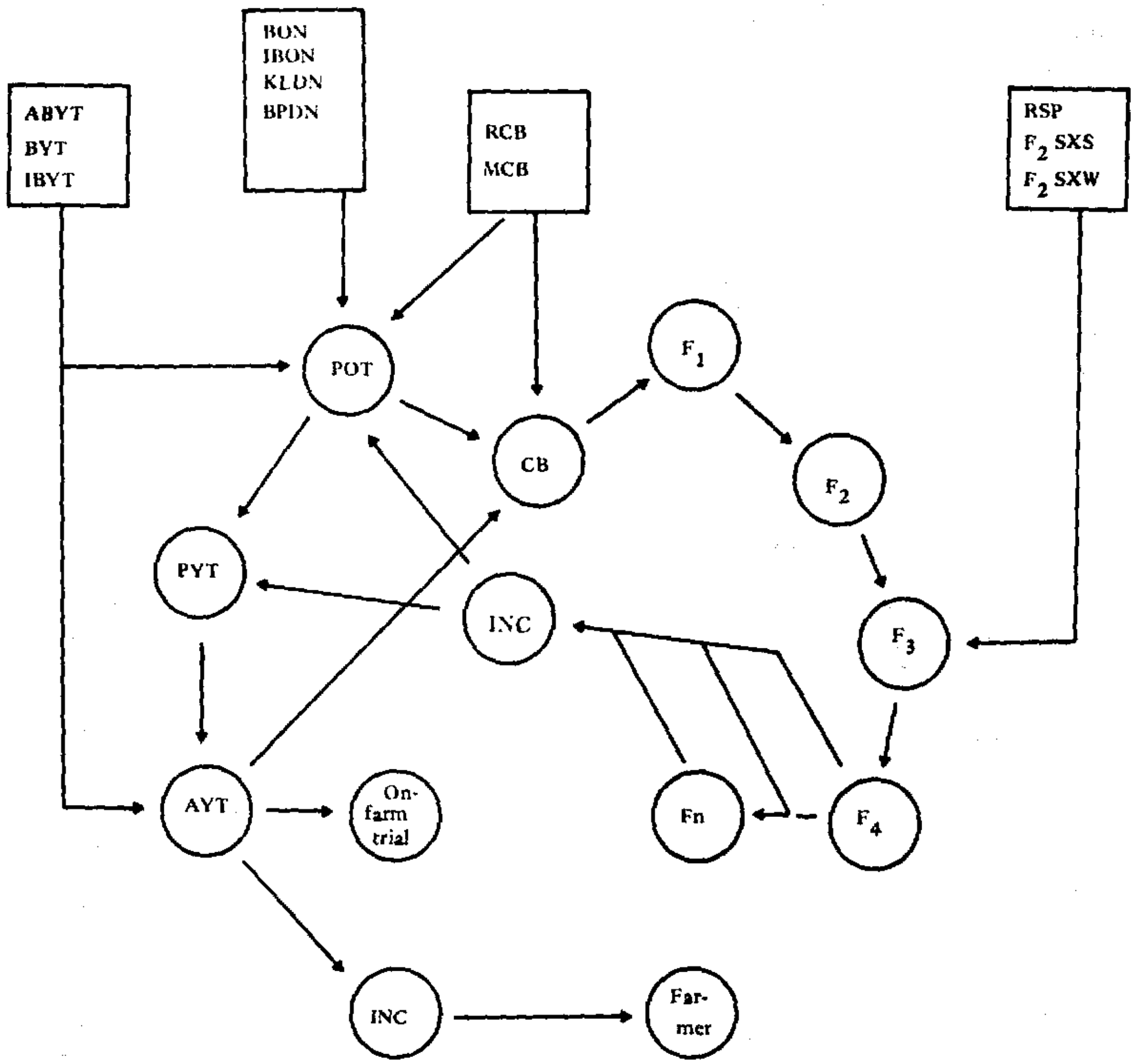
This nursery contains 300-400 lines and consists of all available advanced germplasm in the program , such as finished lines selected from international (BON, IBON, KLDN, PBDN, CB) or national nurseries grown in Tunisia and material harvested in bulk from advanced generations. The nursery is grown (two rows of 2 m with 25 cm row spacing) at different locations representing the different agroclimatic conditions in Tunisia. The nursery is continuously evaluated for disease resistance under artificial epiphytotic conditions, general agronomic value, and drought tolerance. It is the major source for the identification of (1) possible parents with genetic superiority in disease resistance and agronomic traits for crossing, and (2) candidate lines for yield tests in preliminary yield trials (PYT). Therefore, entries are regularly rogued to produce clean seed stocks.

This nursery was also sent to the ICARDA base program in Aleppo, Syria, and other countries in the region for further evaluation.

b. Crossing Block (CB)

The CB is grown at Oued Beja Research Station and contains 120-160 advanced lines and varieties that are used as parents in the crossing program. These parents are evaluated for at least one growing cycle in the POT.

Figure 2. Germplasm movement in the Tunisian barley program.



ABYT	=	Advanced Barley Yield Trial, ICARDA
AYT	=	Advanced Yield Trial, Tunisia
BON	=	Barley Observation Nursery, ICARDA
BPDN	=	Barley Preliminary Disease Nursery, ICARDA
BYT	=	Barley Yield Trial (Regional), ICARDA
CB	=	Crossing Block, Tunisia
IBON	=	International Barley Observation Nursery, CIMMYT
IBYT	=	International Barley Yield Trial, CIMMYT
KLDN	=	Key Location Disease Nursery, ICARDA
MCB	=	Mexican Crossing Block, CIMMYT
POT	=	Pepiniere d'Observation Tunisian, Tunisia
PYT	=	Preliminary Yield Trial, Tunisia
RCB	=	Regional Crossing Block, ICARDA
RSP	=	Regional Segregating Population (F^2), ICARDA
INC	=	Increases

Each season, starting from 1980/81, about 80-120 crosses were made to improve entries with high yield potential but which lack one or more desirable traits, such as disease and lodging resistance, maturity, and grain quality.

Pedigrees in the barley breeding program in Tunisia, effective 1980/81, were designated by the letters COR (Croisement Orge), followed by the year, then the cross number.

c. F1 Population

This is the first generation progeny of single crosses produced in Tunisia. So far, only very limited numbers of top and double crosses have been undertaken. The nursery is regularly inoculated with Helminthosporium gramineum, the agent of barley stripe disease, to select against this disease in successive generations. Entries from this nursery were bulk-harvested and promoted to the F2.

d. F2 Population

In addition to the Tunisian F2, the program regularly receives the Regional Segregating Population (RSP) from the ICARDA base program and the F2 SxS and F2 SxW from CIMMYT. In most years, the segregating populations from Aleppo were also made available to the program.

These nurseries were grown at one location in each of the different agroclimatic areas; sub-humid (Beja), semi-arid (Boulifa), and low rainfall (H. Zitoun). Individual plants selected at these locations were indicated by the letters Bj, Kf and HZ, respectively. Selection criteria were based on plant type, disease and lodging resistance, maturity, and grain type. Seeds of individual plants, kept after seed grading, were advanced to F3 generations.

e. F3 to F7 Populations

The F3 nursery was solid planted in two 2.5-m-long rows at the same sites as the F2. Fifteen heads, from identified superior F3 through F6 populations, were selected from lodging-free, disease resistant/tolerant, and good agronomic type plants. Seeds of individual heads were planted in 1.5-m-long rows to produce successive generations. Selected head-rows were bulked in the F4 through the F7 generations, and increased in the following season for inclusion as advanced lines in the POT and PYT.

f. Preliminary Yield Trials (PYT)

Each trial consists of 25 entries, including 2-3 local and improved checks, which are selected from POT and newly harvested bulks from the advanced generations. The experiments were conducted in a randomized complete block design (RCBD) with three replications and six 2.5-m-long rows spaced 25-cm apart in each plot. The central four rows (2.5 m^2/plot) were harvested for yield evaluation. All lines were again included in the POT for further disease evaluation.

g. Advanced Yield Trials (AYT)

Similar to the PYT, the AYT consist of 25 lines in a RCBD, but include five local and improved checks selected for yield performance from PYT and international trials (i.e. BYT, ABYT, EBYT, and IBYT). Plots had six 5-m-long rows with 25-cm row spacing and four replications. Only 4.5 m of the four central rows per plot were harvested for yield evaluation. Candidate lines from the AYT were also evaluated for disease resistance and agronomic characteristics in POT. Meanwhile, selected lines from these trials were evaluated for grain quality at the grain technology laboratory, INRAT. Entries with high yield potential were tested in the AYT for at least three seasons and used in the crossing program.

In the first three seasons of the project, only two local checks, Ceres and Martin, were used. Starting in the 1983/84 cropping season, three improved checks were used in addition to the two local checks in the AYT. The cultivars Martin, Roho, and Taj were used for the low-rainfall and semi-dry areas, and Faiz and Ceres for sub-humid areas.

B. On-Farm Trials:

After 2 years of yield testing in the AYT, entries exhibiting high yield potential, tolerance to prevalent diseases, lodging resistance , and good grain quality, are promoted to large-scale yield tests for eventual release. The on-farm and demonstration trials, conducted by the Office des Cereales are replicated twice, with a plot size of 20 rows, 40-m-long and with 25-cm row spacing. The central 16 rows (160 m_2/plot) are harvested for yield evaluation.

2. Results

A. Germplasm Selection

The crossing program was started early in the first year of the project. In each year, some 80 - 120 crosses were made to improve selected genotypes lacking desirable traits such as resistance to diseases (scald, leaf rust, powdery mildew, net blotch, and stripe disease), good grain quality, early and medium maturity, and lodging resistance.

Individual plants from the F2 nurseries were selected each year at two or three sites (Beja, Boulifa and H. Zitoun). In the cropping cycles 1980/81 and 1981/82, the selected plants originated from the ICARDA and CIMMYT F2 segregating populations. The 1982/83 season provided the first opportunity to select from F2 populations produced in Tunisia which resulted from crosses made in 1981. The number of selections from the different F2 nurseries during 1980-85 was 520 and, of these, 353 originated from ICARDA F2 populations.

Hundreds of progenies were issued from these crosses, but the number of crosses remaining as F5 and F6 till the 1984/85 season was very low. This was due to the high selection pressure against diseases. Nevertheless, some crosses were bulked in the harvests of 1984 and 1985 from F4, F5, and F6 populations, and some of them were included in the PYT of 1984/85 for yield evaluation, although none were superior to the improved checks.

Similarly, 1430 lines were selected from international nurseries during the last five years; 63% of these lines were selected from ICARDA nurseries (Table 3). Most of these lines were evaluated for yield potential and some have already been released for commercial cultivation (Roho, Taj, and Faiz). Another line, Rihane'S' (Sel. 2L-1AP-3AP-0AP), is undergoing large-scale testing for eventual release.

Table 3. Number of selected barley lines from the international nurseries grown in Tunisia during 1980-85.

Origin	1980/81	1981/82	1982/83	1983/84	1984/85	Total
ICARDA	255	75	143	181	245	899
CIMMYT	72	178	67	150	64	531
Total	327	253	210	331	309	1430

B. Yield Trials

The results reported below represent those of the advanced yield trials (AYT) and the barley yield trials (BYT).

The first year (1980/81)

Yield trials were planted at Beja, Koudiat, Hindi-Zitoun, and Boulifa. Nurseries at the last site were lost because of an infestation of white grubs.

a. Beja and Koudiat

Thirteen lines from the AYT were selected on the basis of high yields, which were significantly ($P< 0.05$) greater than those of the local checks, Ceres and Martin (Table 4). Some of these lines, such as ER/Apm, CM67/sv. Mari, Clipper, WI 2231, and Mari/CM67 were among the best at one or both locations, with yield gains of 21-38% over the standard checks.

Eleven lines were selected from the BYT at Beja on the basis of better yield performance. Yields were 3918-5790 kg/ha and the percentage gain over the check variety was 7-58%.

Table 4. Yield (kg/ha) of barley lines at three locations in Tunisia, 1980/81.

Variety/cross and pedigree	Beja	Koudiat	H.Zitoun
HP 119/7	4413*	3912*	2599
WI 2231	4233*	4395*	2614
Mari/CM67			
CMB72-140-8Y-1B-3Y-1B-1Y-0B	4438*	4358*	2399
SV. Rupal	4116*	3918*	2712
CLF881	4160*	3333	2718
Ceres (national check)	3386	3489	2128
Martin (national check)	2978	2195	2582
Composite 29	4779*	3743*	3826*
Minn 126/CM67	4507*	3588*	2607
ER/Apm	5180*	3910*	2816
CM67/Sv.Mari			
CMB72-14D-8Y-1B-3Y-1B-0Y	5208*	4055*	3031
Arivat	4763*	3940*	3259*
Emir	4463*	3588*	3028
Clipper	5036*	4463*	2495
Kristina	4815*	3958*	2754
WI 2198	3942	3370*	3312*
Ager	3816	2833	3521*
Ceres (national check)	4223	2898	2951
Martin (national check)	3764	2813	2990
Heines standard	6146*	--	5382*
Beecher	5864*	--	4917*
FA010	5641*	--	4758*
Roho	5592*	--	5600*
Sultan x Cr 115-Por	5322*	--	4793*
Ceres (national check)	4847	--	3638
Martin (national check)	4909	--	4382

* Significantly (P< 0.05) greater yield than the best local check, Ceres or Martin.

b. Hindi-Zitoun

The barley research was extended to the major barley-growing areas of the central zone. The objective was to identify genotypes with tolerance to moisture stress and good yield potential.

Nine high-yielding lines from the AYT were selected for further testing. Yields were 3259-5600 kg/ha (Table 4). Of these lines, composite 29, Heines standard, Beecher, WI 2198, Arivat, Roho, FAO 10, and Sultan XCr 115-Por were also selected at Beja and/or Koudiat. Their better performance under high and low rainfall situations suggests wide adaptability.

Nine lines were selected from the BYT at H. Zitoun which performed significantly better than the check variety, Ceres. Of these, eight lines, including ER/Apm, CI 7207/Olli, Arizona/Aths, WI2198, CM67 and Emir/Nordgard 265, were also selected under the favorable, high rainfall environment of Beja. This also suggests wide adaptability.

The selection of a number of lines at Beja and H. Zitoun suggests that the barley disease screening work at Beja is complementary to drought-tolerance screening at H. Zitoun.

Since some of the selected lines lack resistance to some diseases so they will be further crossed to disease-resistant lines.

These data highlight the fact that present national yields are low and could be significantly increased using selected lines with high yields.

The second year (1981/1982)

During the 1981/82 season, screening of the breeding material was extended to other dry sites such as H. Zitoun and Tejerouine, and selection was carried out for drought tolerance from different nurseries and segregating populations. Lodging and disease resistance were important selection criteria at Beja, Koudiat, and Boulifa. Rainfall distribution was irregular between November 1 and January 15; it was becoming dry in the north and completely dry in the central and southern areas.

The barley nurseries at H. Zitoun germinated very late (January 26) and growth, plant height, and yield were considerably reduced. Although the coefficient of variation was high in the experimental trials conducted at this site, some lines in the AYT (Table 5) and BYT, including ER/Apm and Roho, were significantly superior to Martin, the local check. The line WI 2198, outyielded Martin by 38%, but this increase was not significant. Other higher yielding lines are either susceptible or highly-susceptible to powdery mildew at the seedling stage. Most of the selected lines are medium to early-medium types.

In the northern region at Beja and Koudiat stations, many lines such as Nordgard/Kristina, Astina, Gerbel, ER/Apm, and Mazurka significantly outyielded Ceres, the check variety, at both sites. These selected lines are either resistant or moderately resistant to lodging, are medium or medium-late in maturity, but some are susceptible to one or several diseases. Results obtained by the Office des Cereales confirm the performance of ER/Apm at Goubellat (350 mm) where it outyielded Martin by 27%.

Table 5. Yield (kg/ha) of selected barley lines from national AYT at four locations, Tunisia, 1981/82

Variety/cross and pedigree	Boulifa	H. Zitoun	Beja	Koudiat
Api/CM67//ore CMB75-94-27y-1B-2y-1B-3y-0B	4289	882*	3397	3511*
Arimar	3678	875*	3094	3003*
CC89	3942	1086*	3244*	-
H272-500y-500B-500y-0B	4097	1009*	3058	3033*
2762-11016.2	3647	1058*	-	-
Composite 29	3903	873	3425*	3461*
Astina	5558	341	4561*	3786*
Gerbel	5558*	341	4067*	3200*
Api/CM67//Mzq CMB73A-367-18B-1Y-0B	4028	562	3833*	3086*
Jupiter	4889*	853	3886*	-
Mari/CM67 CMB72-140-8Y-1B-3Y-1B-1Y-0B	-	-	3633*	3069*
Masurka	4958	622	4069*	3811*
Aramir	4803	352	3906*	3675*
FL80-1	4928	373	3956*	3542*
CLF796	-	-	3822*	3519*
CLF881	3961	189	4042*	3194*
ER/Apm	4939	1322*	3917*	3389*
WI 2198	3778	1106	3328*	3675*
Roho	-	1306*	2597	-
Clipper	4800	836	3917*	3600*
CI 13871	4692	589	3600*	3628*
Arivat	4078	-	3844*	3594*
Nordgard/Kristina,Ca 49201	-	-	4592*	3675*

* Significantly ($P<0.05$) greater yield than the local check (Ceres for Boulifa, Beja and Koudiat, and Martin for H. Zitoun).

At Boulifa, only two lines, Astina, and Jupiter, significantly outyielded Ceres in the AYT. However, they are susceptible to scald and are medium or medium-late in maturity.

In BYT, only three lines including ER/Apm significantly outyielded the local check at Beja, H. Zitoun, and Boulifa.

The data from Tejeranine were not suitable for statistical analysis due to a high coefficient of variation so selection was undertaken visually.

In 1981/82 increased attention was given to the six-row types. Several lines which significantly outyielded the local check at H. Zitoun, Boulifa, and Beja were selected from the PYT.

The third year (1982/83)

In 1982/83 the yield trials were planted at Beja, Koudiat, Moughran, Boulifa, Tajerouine and H. Zitoun. Due to delayed planting and dry conditions, nurseries at the last two sites were lost.

In the three AYT planted at the first four locations and the 13th BYT grown at Beja and Boulifa, ER/Apm was the highest yielding line (Tables 6 and 7). Some other lines were significantly superior to Ceres, the local check. Of the material tested at Koudiat, Sultan x Cr 115-Por was the only line which had a significantly greater yield than Ceres.

The genotype-environment interaction was highly significant for the three AYT planted at Beja, Koudiat, Moughran, and Boulifa in 1982/83. In some trials, the correlation between grain yield and 1000-kernel weight, as well as protein content, heading date, and plant height was also studied. The correlation and regression analyses showed:

a. Positive correlation between grain yield and 1000-kernel weight at all locations.
b. Negative correlation between grain yield and protein content at all locations.
c. No correlation between grain yield and plant height or with heading date, except at Boulifa where it was negatively correlated.

Table 6. Yield (kg/ha) of selected barley lines from advanced yield trials at four locations, Tunisia, 1982/83.

Variety/cross and pedigree	Boulifa	Beja	Koudiat	Mougran	Average
ER/Apm	4075*	4245*	3041	2057	3355 (124)**
Bco.Mr/Gva	3725*	3916*	3003	1673	3079 (114)
Sultan Cr 115-Por CMB79-297-3Y-1B-1Y-0B	3142	4111*	3126*	1911	3073 (114)
Mari/CM67 CMB72-140-8Y-1B-3Y-1B-1Y-0B	3583*	4015*	2712	1847	3039 (112)
Astina	3411*	4433*	3012	1287	3036 (112)
Aramir	3494*	3843*	2999	1686	3006 (111)
Lignee 131	3531*	3831*	2413	2158	2983 (110)
Ceres (national check)	2956	3332	2683	1834	2701 (100)

* Significantly (P<0.05) outyielded the local check, Ceres.
** Values in parentheses are percent of check.

Table 7. Yield (kg/ha) of selected barley lines from the 13th BYT planted at Beja and Boulifa, Tunisia, 1982/83.

Cross / pedigree	Beja	Boulifa	Average
ER/Apm	6149*	5865*	6007 (131)**
Mari/CM67 CMB72-140-8Y-1B-3Y-3B-0Y	6110*	5725*	5917 (129)
Rihane	6332*	4855*	5593 (122)
Matnan	6322*	4725*	5523 (121)
Rihane"s" ICB76-11-2L-1AP-3AP-0AP	6047*	4880*	5464 (119)
Assala"s"	6108*	4750*	5429 (119)
Beecher (regional check)	6032*	4695*	5363 (117)
Martin (local check)	5299	3865	4582 (100)

* Significantly (P<0.05) outyielded the local check, Martin.
** Values in parentheses are percent of check.

The fourth year (1983/84)

Yield trials were grown at Beja, Koudiat, Boulifa, Tajerouine, and H. Zitoun. Due to the dry conditions during November-March, the nurseries at H. Zitoun were unsuccessful. Meanwhile, a serious attack of BYDV, heavy hail in January, and an unsuitable rotation for the barley field, severely affected the growth of barley nurseries at Beja, resulting in yield reductions (about 50% for ER/Apm and Ceres).

In the AYT, none of the lines significantly outyielded the improved checks at Tajerouine and only Mari/CM67 yielded significantly more than Roho at Boulifa (Table 8). Morever, Harmel'S', two Rihane sister lines, Khouzama'S', Prato 68, Mari/CM67, F8-HB 889-40, CI 13871, WI2269, Astina, and Minak, each yielded more than ER/Apm at Beja or Koudiat.

Over four locations, ER/Apm, WI 2198, and Roho yielded 24%, 34%, and 32%, respectively over Martin, the highest-yielding local check. However, statistical analysis of these three lines across locations showed no significant differences between these genotypes or genotype-environment interactions.

In BYT, some lines yielded significantly higher than Martin, i.e. Rihane, Rihane'S' (at Beja), Mari/CM 67, CI7117-9/Deir Alla 106, and Harmal'S' (at Boulifa). However, none of these lines showed a significant increase over the check at both locations (Table 9).

The high yield potential and yield stability of ER/Apm, Roho, and WI2198 was confirmed again this season by both INRAT and Office des Cereales trials. Therefore, these three lines were recommended for release.

Table 8. Yields (kg/ha) of the best barley lines at different locations in Tunisia, 1983/84.

Variety/cross and pedigree	Tajerouine	Boulifa	Beja	Koudiat
Rihane's' Sel.2L-1AP-1AP-3AP-0AP	2788	3927	2988*	3712
Mari/CM67 CMB72-140-8y-1B-3Y-3B-0Y	1872	5144*	2754	4358*
Harmal's'	1911	4828	2562	4136*
Khousama's'	2361	3821	2931*	3377
Minak	2155	3467	2772	4059*
Astina	1894	3883	2412	4070*
F8-HB-889-40	1417	4133	3359*	3154
WI2269	2400	4217	2752	3912*
Prato 68	2494	4239	3758*	3244
CI 13871	-	-	3116*	3155
Rihane's' sel.2L-1AP-4AP-0AP	-	-	3296*	3392

* Significantly ($P<0.05$) exceeded the improved check (Roho for Tajerouine and Boulifa, and Faiz for Beja and Koudiat).

Table 9. Yields (kg/ha) of the best barley lines selected from BYT, Tunisia 1983/84.

Variety/cross and pedigree	Boulifa	Beja
Mari/CM67 CMB 72-140-8Y-1B-3Y-3B-0Y	4365*	3743
Harmal"s" sel.12L-2AP-0AP	4250*	3550
CI 7117-9/Deir alla 106 ICB77-3423-2AP-2AP-0AP	4240*	3565
Rihane"s" Sel.2L-1AP-3AP-0AP	3520	4321*
Rihane	3760	4269*
Martin (Local Check)	3210	3416

* Significantly ($P<0.05$) exceeded the local check, Martin.

The fifth year (1984/85)

The highlight of the year was the official release of Roho, WI 2198, and ER/Apm in Tunisia under the names Roho, Taj, and Faiz, respectively.

This season, the barley program work was carried out at Beja, Koudiat, Boulifa, and Tajerouine. These newly released varieties were used in all yield trials as improved checks. Only the trials grown at Beja and Boulifa were harvested.

In three AYT, many Rihane sister lines again proved their superior yield performance. Rihane'S' (sel.2L-1AP-3AP-0AP) was significantly superior to the improved checks at both Beja and Boulifa (Table 10) and was superior to Martin at Boulifa in BYT. Because of its high yield and stability during 1982-85, this line was recommended for further testing in on-farm trials conducted by the Office des Cereales. Similarly, other lines such as Mari/CM67 (8Y-1B-3Y-3B-0Y), Api/CM67//Mona, Aramir/cossak, and F8 HB 389-40 were significantly superior to one or more of the improved checks at Boulifa or Beja.

3. The On-Farm Trials

The on-farm barley trials conducted by the Technical Direction of the Office des Cereales were limited in number compared to those for wheat. Each trial consisted of 5x40-m plots, with 2 replications. The seed rate in each trial was 80 kg/ha.

Work on barley started in 1981/82, when INRAT provided the Office des Cereales with a number of barley lines, including ER/Apm, selected from the 1980/81 yield trials. These lines were tested in one on-farm trial at Goubellat. In the 1981/82 season, INRAT selected ER/Apm, Roho, and WI2198 as promising lines, and it was decided to test these three lines on a large scale. Therefore, in 1982/83 only these lines were tested in comparison with the local check, Martin, in the on-farm trials. The results of three seasons, 1982-85 are summarized below.

Table 10. Yields (kg/ha) of barley lines outyielding Roho, Taj, and Faiz in national AYT, Tunisia 1984/85.

Entry/cross and pedigree	Boulifa		Beja	
Rihane's'				
Sel.2L-1AP-1AP-0AP	5917	-	4779	-
Rihane	5711	-	4648	-
Rihane'S'				
Sel.2L-1AP-4AP-0AP	5956	-	4568	-
Rihane's'				
Sel.2L-1AP-3AP-0AP	6406	6022	4726	4981
Mari/CM67				
CM72-140-8Y-1B-3Y-3Y-3B-0Y	6350	-	3613	-
F8 HB 389-40	6211	-	3566	-
H251	6183	-	3738	-
Api/CM67/Mona				
CM73A-368-5B-1Y-1B-500Y-0B	-	5839	-	4994
Aramir/Cossak				
CMSWB77A-458-1H-1Y-1B-1Y-2B-0Y	-	6378	-	-
F632	-	6139	-	-
Nordgarol/Krisitina, cr.49201	-	6106	-	-
Pro/TolI//Cer/TolI/3/Dwg1/4/				
Api/5/Por58-1-440-1Y/10876				
ICB76-73-1L-2AP-0AP	-	-	-	4487
Roho (Improved check)	4917	4617	3794	3888
Taj (Improved check)	5322	5683	3097	3638
Faiz (Improved check)	5350	5933	3188	3811
Ceres (national check)	4417	-	3563	4013
Martin (national check)	5228	4772	3440	3742
LSD0.05	953	667	701	726
CV %	12.1	8.7	13.2	12.9

Data for the 1982/83 crop season showed that Roho yielded more than WI2198 and ER/Apm at Oueslatia, a dry area, but had a similar yield to WI2198 at Fahs, a marginal area. All three lines had similar yields at Siliana, a semi-dry area. However, the three lines outyielded Martin at all three sites (Table 11). The increases over Martin were 25, 20, and 15% for Roho, ER/Apm, and WI 2198, respectively.

In the 1983/84 crop season, the trial at Fahs was discarded because of the very dry conditions that prevailed in the region and consequently data were obtained only from two locations, Oueslatia and Siliana. The three lines out-yielded the check, Martin, at both locations. The yield increase over Martin was 55, 51, and 48% for Roho, WI2198, and ER/Apm, respectively.

In the 1984/85 crop season, trials were planted at Oueslatia, Goubellat, Fahs, Zaghouan, Siliana, Dahmani, and Menzel Temime. Unfortunately, the data from Oueslatia were not available because the entire trial was harvested by the landowner. Five barley cultivars (Roho, Taj, Faiz, Martin, and a 6-rowed local landrace), Tanit, a bread wheat variety, and Karim, a durum wheat variety, were used in each trial. The grain yield and yield components of all varieties were recorded.

The rainfall at these sites was, in general, high and well distributed, ranging from 407 mm at Dehmani to 692 mm at M. Temime, and agroclimatic conditions were favorable for late genotypes. Considerable bird damage occurred, especially at Fahs on the early varieties Roho and Taj. Some barley diseases also developed, especially on the local landrace.

The cultivar Faiz yielded higher than Martin and the local landrace at four out of six locations, while Roho outyielded these two checks at two and four locations, respectively. However, the five barley cultivars did not differ with their overall station yield average (Table 12).

The newly released varieties have good tillering capacity. Based on the average of six locations, Martin and the local land race produced 326 and 313 spikes, respectively, whereas Roho, Taj, and Faiz gave 471, 463, and 442 spikes per m_2, respectively .

Table 11. Yields* (kg/ha) and 1000-kernel weights of Roho, WI2198, and ER/Apm in the semi-arid region, Tunisia, 1982/83 and 1983/84.

Location/ season	Roho		WI2198		ER/Apm		Martin	
	Yield	1000 KW	Yield	1000 KW	Yield	1000 KW	Yield	1000 KW
Siliana								
1982/83	2480	48	2290	45	2660	40	1920	40
1983/84	3190	32	3140	36	3040	32	2030	28
Oueslatia								
1982/83	1340	41	960	43	1190	40	1100	40
1983/84	1230	40	1180	36	1190	41	830	40
Fahs: 82/83	3620	45	3570	46	3240	42	2910	43
Average	2370	41.2	2228	41.2	2264	39.0	1758	38.2
% of Martin	134.8	-	126.7	-	128.8	-	100	-

* Mean of 2 replications.
Data from Office des Cereales

Table 12. Yields (kg/ha)* of commercial barley and wheat varieties in on-farm trials, Tunisia, 1984/85.

Location and rainfall	Roho	Taj	Faiz	Martin	Local	Tanit	Karim
Goubellat (445 mm)	3100	2900	3130	2930	2840	3280	3770
Fahs (523 mm)	2870	3370	3660	3250	2290	6240	7110
Zaghouan (490 mm)	2050	2130	2250	1820	2070	3110	4170
Siliana (432 mm)	2950	2180	2040	3070	2710	-	3280
Dahmani (407 mm)	2660	2660	2620	3300	2680	2940	2700
M. Temime (692 mm)	2030	1540	2410	2110	1870	2490	2330
Average	2610	2463	2685	2747	2410	3610	3730

* Mean of 2 replications.
Data from Office des Cereales

4. Release of Three Barley Varieties

A. History

Taj (WI 2198) is of Australian origin (Waite Institute) and was introduced early in the seasons 1972/73 (3rd RCB), 1975/76 (1st EBYT), and 1976/77 (2nd EBYT). In the later trials grown at Beja, WI2198 yielded 40% more than Martin and was then selected for further yield testing. After four years of testing at the El-Kef (Boulifa) experimental site (1977-80), it ranked first out of 115 yield-tested lines*, and produced on average 40% over Martin and 84% over Ceres. In the harvest of 1979, this line yielded 17% over Martin across two locations, Beja and Koudiat. However, WI2198 was reselected in 1979/80 from RBYT grown at Beja and introduced again in the national yield trials of INRAT in 1980/81.

Roho originated from Denmark, but there is no information available to indicate the date of its introduction into Tunisia. This line was included in the 6th RBYT sent to Tunisia in the 1975/76 season. It was also included in a national yield trial, but did not perform well due to bird damage at the Ariana site. Some information indicated that Roho was yield-tested at Beja in the 1977/78 season and yielded 34% over Martin. Roho was reselected in 1979/80 from PON grown at Beja and advanced to yield trials in the 1980/81 season.

Faiz is an advanced line from the ICARDA cross ER/Apm, introduced to Tunisia through RBYT in the 1979/80 season. At Beja, it yielded 31 and 23% more than Martin and Ceres, respectively. It was then selected and included in the national yield trials of 1980/81 for further testing.

B. Yield Evaluation

In the early stages of this project, ER/Apm, WI2198, and Roho exhibited exceptional yield performance at the drier as well as the wetter sites, in spite of bird damage. In terms of yield gains over the local checks in 1980/81, ER/Apm yielded 23 and 35% over Ceres in the AYT grown at Beja and Koudiat, respectively (Table 1) and 58% in the BYT planted at Beja . In the AYT, Roho and WI2198 yielded 28 and 11%, respectively over Martin at H. Zitoun, and 16% over Ceres at both Beja and Koudiat (Table 1). In the BYT, WI2198 produced 32 and 11% over Ceres at Beja and H. Zitoun, respectively.

*Daaloul, A. and Harrabi, M. 1984. Breeding Barley for Northwest and Central Tunisia. Pages 338-341 <u>in</u> Proceedings of the Barley Diseases and Associated Breeding Methodology Workshop, USAID-MSU/ICARDA/CIMMYT, 20-23 April 1981, Rabat, Morocco. Montana State University, Bozeman, Montana, USA.

In 1981/82, ER/Apm ranked first in BYT averaged across three locations; Beja, Boulifa, and H. Zitoun. The percentage yield increase was 34% over Martin. In the same nursery, WI2198 was amongst the best lines at Boulifa. In the AYT, ER/Apm significantly outyielded the local checks, Ceres and Martin at H. Zitoun, Beja, and Koudiat (Table 5), while Roho and WI 2198 were among the few best-yielding lines at H. Zitoun. Similarly, the results of the on-farm trials showed that ER/Apm yielded 27% over Martin at Goubellat.

In the 1982/83 season, 100 kg of seeds of each of the three lines were obtained from the ICARDA base program for large-scale testing by the Office des Cereales. Half of the seed was planted at Koudiat for prerelease multiplication and enough seed was obtained, cleaned, and treated for further yield testing and multiplication.

In the same season, all trials were lost at H. Zitoun and Tajerouine due to excessively dry conditions at these locations. Therefore, data concerning Roho and WI2198 were obtained only from three on-farm trials grown at the lower-rainfall sites, Oueslatia, Siliana, and Fahs. The percentage yield increase over Martin was 20, 25, and 15% for ER/Apm, Roho, and WI2198, respectively, across all three sites (Table 11). At the experimental level, ER/Apm was again ranked first over the four locations, Beja, Koudiat, Moghrane, and Boulifa. It yielded 24% over Ceres (Table 6) and also ranked first in the BYT, producing 31% over Martin across two locations, Beja and Boulifa (Table 7).

In the 1983/84 season, 100 kg of seeds of each of the three lines were provided to seed multiplication cooperatives for increase. Seed (100 kg) of each line was also distributed to selected farmers for testing at the farm level. Meanwhile, the three lines were grouped in one yield trial and planted under low and high rainfall conditions at four locations, Beja, Koudiat, Boulifa, and Tajerouine, and they were also used as improved checks in all yield trials. Out of four AYTs, none significantly out-yielded Roho or WI 2198 at Tajerouine, the dry site, and only Mari/CM67 yielded better than these two improved checks at the Boulifa site. Eleven lines, including Rihane 's' (sel,2L-1AP-3AP-0AP), had significant yield increases over ER/Apm at Beja and/or Koudiat (Table 8). However, the improved checks yielded 24-34% over Martin, across all sites.

The on-farm trials conducted at Oueslatia and Siliana confirm the yield performance of Roho, WI2198, and ER/Apm. They yielded 50-57% over Martin at Siliana and 42-48% at Ouislatia (Table 11).

The data (Figure 3) showed that Roho and WI2198 adapt well to the lower-rainfall areas, while ER/Apm is better adapted to the more moderate rainfall areas. However, results from the 1983/84 season showed a similarity in adaptation between the three lines at four locations (Beja, Koudiat, Boulifa, and Tajerouine) which represent both rainfall conditions.

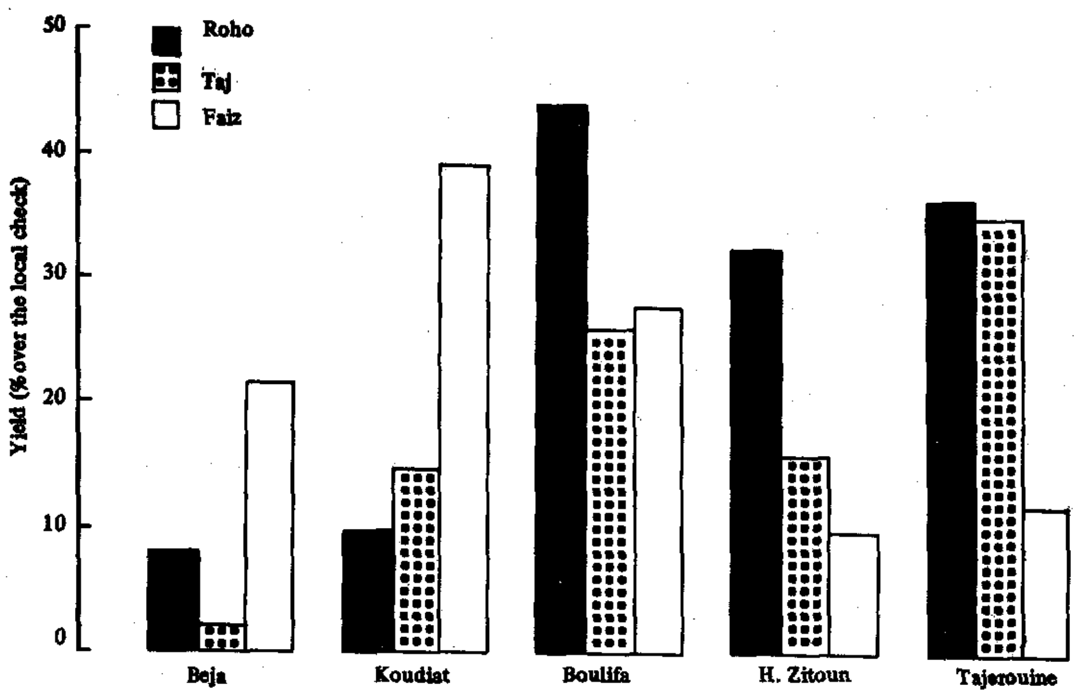


Figure 3. Yield of Roho, Taj, and Faiz as percentage over the best check (Ceres or Martin) at five locations in Tunisia during 1980-84.

Over all four testing seasons, the number of trials in which the three lines significantly outyielded the best local check were 10 out of 10 for Roho, 8 out of 11 for WI2198 (at Boulifa, H. Zitoun, and Tajerouine) and 18 out of 26 for ER/Apm (at Boulifa, Koudiat, and Beja). The percentage yield increase over the best check was 22-37%, 16-35%, and 15-39% for Roho, WI2198, and ER/Apm, respectively.

Based on the consistency of the yield increases and the yield superiority and stability of the three lines, it was recommended in the second Tunisia-ICARDA coordination meeting in September 1984 that these lines be released for commercial cultivation in Tunisia. Afterwards, INRAT prepared the necessary documents which were submitted to the national committee for varietal release. In late February 1985, the three lines were officially registered under the following names:

Faiz = ER/Apm (see Appendix I for certificate of release).
Roho = Roho (see Appendix II for certificate of release)
Taj = WI 2198 (see Appendix III for certificate of release)

Faiz was released for areas receiving more than 350 mm rainfall, and Roho and Taj for areas with less than 400 mm annual rainfall.

C. Disease Resistance

The three varieties are resistant or moderately resistant to net blotch, stripe disease, and powdery mildew, but are moderately susceptible to leaf rust. Taj and Roho are also resistant to BYDV and loose smut. Taj is moderately resistant to scald, while Roho and Faiz are moderately susceptible (Table 13).

D. Plant Type and Grain Quality

The three cultivars are two-rowed types of almost the same height, 60-90 cm according to environmental conditions.

Faiz has a white to yellow aleurone, medium-sized kernels, a 1000- kernel weight (1000 kw) of about 38 g, and moderate protein content. It has good lodging resistance and, in the sub-humid areas, heads two weeks earlier than Ceres.

Roho has a greyish aleurone, large kernels, a 1000-kw of 48 g and protein content of 11.8% (Boulifa, 1984/85). It heads two weeks earlier than Martin.

Taj has similar plant type maturity and kernel color to Roho, but possesses smaller kernels.

All three varieties have higher tillering capacity than the local check, Martin. The average spike number/m_2 for Roho, Taj, and Faiz was 44, 42, and 35% over Martin, respectively, at six locations (Goubellat, Fahs, Zaghouan, Siliana, Dahmani, and Menzel Temime).

Table 13. The best-yielding barley lines* selected at three out of five locations in Tunisia during 1980-85 and their reaction to diseases.

Variety or cross and pedigree	Disease reaction					
	LR	PM	NB	SD	Sc	BYDV
Clipper	30MS	7	5	R	7	MS
Aramir	10MS	6	0	R	8	MS
MARI/CM67						
CMB72-140-8Y-1B-3Y-1B-1Y-0B	50MS	5	0	t	8	MS
Api/CM67//Mzg						
CM73A-367-13B-1Y-0B	10MS	9	9	S	0	MS
Astina	20MS	6	t	R	9	R
Nordgard/Kristina,cr 49901	20MS	8	0	T	9	MR
Minak	20MS	7	4	MS	7	MR
MO.B1337	60MS	7	0	S	9	R
Api/CM67//Mona						
CMB 73A-368-5B-1Y-1B-500Y-0B	30 S	8	t	S	7	MS
F8-HB 889-40	20MS	6	0	R	7	R
Rihane's' (sel.2L-1AP-3AP-0AP)	60MS	6	5	t	4	MS
Rihane's' (sel.2L-1AP-4AP-0AP)	50MS	6	6	R	6	MR
Harmal's'	50MS	8	0	R	8	R
Khouzama's'	40MS	7	0	R	5	MS
Mari/CM67						
CMB72-140-8Y-1B-3Y-3B-0B	50MS	6	0	R	8	R
WI 2269	70MS	8	0	R	9	R
Prato 68	80MS	7	0	R	8	R
Faiz (improved check)	40MS	4	0	R	6	MS
Roho (improved check)	30MS	4	0	R	6	R
Taj (improved check)	10MS	4	0	R	5	R
Ceres (local check)	5MS	5	8	S	8	S
Martin (local check)	10MS	6	9	S	7	S

* None out of these lines significantly outyielded the local or improved checks at Tajerouine and Hindi-Zitoun, the dry sites.

5. Conclusions and Discussion

Results from this work indicate that barley varieties with high average yields are not necessarily widely adapted. A variety may have a yield advantage only under certain environmental conditions. For example, the local cultivars Ceres and Martin express their yield potential only under favorable conditions. Barley is grown mainly under moisture stress and in poor soils. Therefore, breeders should select genotypes that can tolerate these harsh conditions.

Of the hundreds of genotypes yield-tested during the last five years, many were selected under favorable conditions on the basis of yield performance, tolerance to diseases, and resistance to lodging. On the other hand, few lines were identified which had reasonably good yields under low-rainfall conditions.

In the first three seasons, 1980-83, ER/Apm, Roho, WI 2198, Astina, Nordgard/Kristina, Clipper, and Mari/CM67 were the best selected lines for yield. At Hindi-Zitoun, a dry site, the superiority of the first three lines was significant during 1980/81 and 1981/82. The other selected lines showed improved yield performance at Koudiat and Beja (the more favorable sites) and Boulifa, a semi-dry site. In the 1983/84 season, ER/Apm, Roho, and WI2198 were used as improved checks in all trials. During the same season, none of the tested lines were significantly superior to both Roho and WI2198 at Boulifa and Tajerouine, although Rihane's' yielded 10% over Roho at Tajerouine and Mari/CM67 yielded significantly better than Roho at Boulifa. However, Astina and Minak at Koudiat, and F8-Hb889-40 and Rihane's' at Beja, showed significant yield increases over ER/Apm.

The 1982/83 and 1983/84 on-farm trial results confirmed the yield performance of ER/Apm, Roho, and WI2198. In spite of bird damage, they outyielded the local check, Martin, by 29-35% over all three locations and across two seasons.

Because of the superior yield performance and stability of ER/Apm, Roho, and WI2198, they were released for Tunisian farmers under the names Faiz, Roho, and Taj, respectively.

Among the lines selected in 1984/85, there were a series of Rihane sister lines which were well adapted to high rainfall areas. Rihane's' (sel.2L-1AP-3AP-OAP) is the most promising line of this cross, because it showed improved yield performance and stability over local and improved checks during the past three seasons (1982-85). It also seemed to be adapted to the lower rainfall areas. Therefore, seeds of these lines were made available for further testing on a large scale by the Office des Cereales, starting 1985/86.

The trial site mean yield was much higher at Boulifa than Beja in 1984/85, which may be due to lodging and disease pressure at Beja. Boulifa is a more appropriate site for barley yield testing, despite the equal yield advantages at both locations across three seasons, 1981-84 (Table 14). This is because:

a. stress conditions (drought during spring and low temperatures during winter) are frequent at Boulifa,

b. total rainfall during the growing season is low, similar to semi-arid areas, and,

c. the barley genotypes suitable for the less favorable conditions are better differentiated at Boulifa.

In a study on trials conducted in three seasons, 1981-84, the number of lines in the top-yielding category (TYC) at Boulifa was much lower than at Beja. In four AYT and three BYT grown in the same seasons at both locations, 31 and 71 genotypes were in the TYC at Boulifa and Beja, respectively (Table 14). Most of the genotypes selected at Boulifa were also selected at Beja. For example, in the 1981/82 BYT, Rihane was the only line in the TYC at Boulifa, and was in the same category at Beja with only four other lines which included ER/Apm. In the 1982/83 BYT, ER/Apm, WI2231/Magnif 102, and Mari/CM67 formed the TYC at Boulifa, and they were among 13 lines in the same category at Beja. The same observation was made in the AYTs of 1982/83 and 1983/84.

The largest yield advantages for genotypes that can adapt to less favorable conditions occurred at Boulifa. It was impossible to differentiate between them and many other lines specially adapted to more favorable conditions. For these reasons, Boulifa was considered the main station for barley breeding in Tunisia, starting in 1985/86. However, Beja station remains the best location for screening against lodging and diseases, since only scald and powdery mildew prevail at Boulifa.

Table 14. Grand mean (GM) and number of barley lines in the top-yielding category (TYC) in national AYT and regional BYT grown at Boulifa and Beja, Tunisia, 1981-84.

Season	Trials	BEJA		BOULIFA	
		TYC	GM *	TYC	GM*
1981/82	BYT	5	4460	1	5533
1982/83	AYT I	3	3866	3	3189
	AYT II	13	3654	1	3038
	AYT III	17	3438	8	3132
	BYT	13	5575	3	4650
1983/84	AYT I	9	2444	2	3543
	BYT	11	3450	13	3351
	Total	71	-	31	-
	Average	-	3841	-	3777

* kg/ha

III. CEREAL PATHOLOGY

1. Introduction

At the first Tunisia-ICARDA coordination meeting in September 1983, it was acknowledged that the national program now has the capacity to conduct barley breeding with only limited support from ICARDA. Meanwhile, ICARDA was requested by the national program to give more attention to cereal pathology due to the lack of national trained manpower in this field. Therefore, the second step of this collaborative project started in 1983/84.

Diseases are a major constraint to cereal production in North Africa. Evaluation of germplasm and identification of resistant genotypes is a continuous research activity. Barley and wheat germplasm of the national programs, ICARDA, and CIMMYT were screened against prevalent diseases in Tunisia. During the first year (1980/81), natural infection was used for disease screening but in the following seasons more emphasis was placed on artificial inoculation for the major barley and wheat diseases.

In the project, pathology is breeding-oriented, since this work aimed to help breeders screen and select for disease resistance germplasm for:

i. parental genotypes for crossing programs,

ii. disease-free plants starting in early segregating generations, and

iii. high-yielding lines with multiple disease resistance.

A survey on cereal diseases and their importance in the Maghreb countries was carried out in 1983/84 (Table 15). The importance of these diseases varied from year to year.

Table 15. Cereal diseases and insect pests in North Africa 1983/84.

Disease/pest	Incidence		
	BARLEY		
Powdery mildew	+++	+++	+++
Net blotch	+++	+++	+++
Scald	++	+	+
Yellow rust	-	±	-
Leaf rust	++	±	++
Barley stripe	++	++	+
	WHEAT		
Septoria leaf blotch	+	±	+
Tan spot	++	-	+
Yellow rust	±	±	±
Leaf rust	-	-	+
Rapdo virus	-	-	+
	BARLEY AND WHEAT		
Root rot	+	+	+++
BYDV	+++	+	+++
Hessian fly	±	-	+++

+++ very high occurrence

++ high occurrence

\+ moderate occurrence

± poor occurrence

\- absent.

2. Materials and Methods

In 1981/82, pathology nurseries were planted at Mateur. In 1982/83, they were grown at Beja and Mateur and in 1983/84 at Beja only. In 1984/85, the nurseries were extended to Beja, Boulifa, and Ariana.

Besides the natural occurrence of many diseases, Beja and Ariana are appropriate sites for disease screening because facilities for suplementary irrigation are available to encourage infection and disease development. Each year 7000-8000 entries of wheat and barley, representing ICARDA, CIMMYT, and national program germplasm, were artificially inoculated with one or more of the following diseases:

- On wheat: septoria leaf blotch (*Septoria tritici*)
  tan spot (*Helminthosporium tritici-repentis*)
  yellow rust (*Puccinia striiformis*)
  common bunt (*Tilletia caries, T. foetida*)

- On barley: scald (*Rhynchosporium secalis*)
  net blotch (*H. teres*)
  stripe disease (*H. gramineum*).

Natural infections of other diseases, such as BYDV, powdery mildew, and leaf rust on barley developed well during the last seasons, enabling reasonable screening.

Entries were planted in two rows 1-m-long long at Beja, Mateur, and Boulifa, while they were hill-planted at Ariana. Each plot was surrounded by a mixture of susceptible lines chosen as spreaders for different diseases.

The yellow rust inoculum was obtained by multiplying preserved spores on susceptible varieties, Morocco and Tanit, in a greenhouse at INRAT. Spores were then collected from infected leaves and used for inoculation. *Septoria tritici*, *R. secalis*, and *H. teres* were isolated and multiplied at INAT on the artificial media YMA, LBA, and V8 juice, respectively.

Nurseries were inoculated two-to-three times at the tillering-jointing stages during January and February of each season. Wheat seedlings were inoculated with tan spot by covering them with infected straw collected from the Mateur region and seeds were inoculated with spores of common bunt before planting.

The barley F1 nursery grown at Beja was surrounded with two rows of a spreader for H. gramineum collected from infected plants. This provided a continuous source of inoculum for infecting florets at all stages of head development.

Disease scores were recorded during April, using a 0-9 scale and the severity of infection, for scald, tan spot, net blotch, septoria, and powdery mildew. The Leogering method was used for rust readings.

3. Results

A. Wheat Disease

a. Septoria leaf blotch

There was a severe attack of Septoria tritici on wheat during the 1979/80 season, especially in the Mateur region, and the susceptible durum cultivar, Badri, was heavily infected. In the same season, the formerly resistant bread wheat cultivar, Dougga, was found to be susceptible. In 1981, the incidence of septoria was low, but it became serious on susceptible cultivars during 1981/82 and 1984/85. In 1984, septoria was not a serious problem, although some natural infection occurred in different areas.

The first screening for septoria by artificial inoculation was carried out in 1981/82 at Mateur. The inoculum consisted of one isolate from infected durum wheat leaves. Symptoms developed well on durum wheat, but were less on bread wheat. Therefore, in the KLDN and POT, a high percentage of bread wheat lines was resistant compared to the durum wheats. Most of the resistant lines selected from durum germplasm were susceptible to tan spot. Table 16 lists durum lines resistant or moderately resistant to both septoria and tan spot.

In 1982/83, the infection, inoculum build-up, and symptom development were reduced by the dry, windy weather which started mid-January, making results for septoria screening unreliable.

In 1983/84 however, a mixture of three isolates of Septoria tritici was used to inoculate the nurseries grown at Beja . Two of these isolates originated from durum wheat collected at Mateur (the isolate was used in 1981/82) and Beja, and one isolated from bread wheat grown at Bou Rbiaa. The nurseries were inoculated twice, resulting in excellent disease development on both durum and bread wheats.

Table 16. Durum wheat lines in the KLDN, resistant* or moderately resistant to septoria leaf blotch and tan spot, Mateur, Tunisia, 1981/82.

Variety/cross and pedigree	Entry number	Septoria	Tan spot
Ureyik 126/61-130//kohak 2916/Lds/3/ Ruff's',ICD77-183-9AP-0SH-0AP	118	0	3
Cfn/Lan F^4Lan//Jo's'/Grane's' ICD 77.167-2AP-0SH-0AP	164	3	0
Fg'S'/Rabi'S' ICD 74.113-3L-1AP-2AP-0AP	289	3	0
Snipe's'//Amarelejo/Haynaldia ICD 77.216-1AP-4SH-0AP	366	3	0
Plc's'/Cr'S'//Rabi'S'/Blt ICD 77.148-5AP-6SH-0AP	375	3	0
Cr'S'/4/21563/3/61-130//Lds/5/Camel tooth/6/ GS'S'/Cr'S'//2*S0179/Durum 6 CD21860-2AP-4AP-0AP	428	1	2
D.Dwarf S 15/Cr'S/6/Gv'S'/3/BYE*2/Tc// ZBW/4/21563/Gb'S'/5/Cit'S' L44-2AP-2AP-1AP-0AP	515	2	0
Hau27/Chap//21563/3/Mexi'S'/4/D67-3/Gta's' CD14814-2S-2AP-1AP-0AP	785	2	0
Bit'S'/Yel'S' CD23780-2Y-2M-1Y-0Y	793	1	0
Bit'S'/Corm'S'//Shwa'S' CD22356-A-9M-2Y-2M-0Y	948	3	0
Ward 6062/6142 D6674	999	3	0
Lob	1009	1	0

* Selection criteria: 0-3 on a 0-9 scale.

Table 17 shows the nurseries evaluated for septoria resistance and the percentage of resistant lines under Beja conditions, using the 0-9 disease-rating scale and percentage leaf area covered by pycnidia. Readings of 3.1-3.5, 4.1, and 4.2 are considered to be moderately resistant (MR) types. The lines included in the septoria nurseries (DST, VST, and ISEPTON) were the most resistant. Of these lines, 75, 69, and 75% were resistant to septoria. This indicates that a high percentage of the genotypes selected in previous seasons remained resistant to the isolates used in the inoculum. Compared to these results, the KLDN and observation nurseries had low percentages of resistance, ranging from 12% to 35% in durum wheat and 12% to 28% in bread wheat nurseries.

Among the lines selected at one or more of eight locations in North Africa, some proved resistant to both septoria and BYDV (Table 18).

In a preliminary study in the greenhouse, a type of specialization was observed in the isolates used depending on their origin (Table 19). The bread wheat isolates were avirulent on durum wheat varieties, while isolates from the durum varieties were avirulent on bread wheat varieties.

Of the above mentioned isolates, only two (durum and bread wheat isolates) were used for inoculation in 1985. Few durum and bread wheat genotypes have remained resistant to septoria for the two seasons 1983/84 and 1984/85 (Table 20).

Table 17. Percentage of durum and bread wheat lines resistant or moderately resistant* to *Septoria tritici* under artificial epidemics, Beja, *Tunisia*, 1983/84.

Nursery	No. entries tested	Entries R-MR No.	Entries R-MR %
KLDN-D	519	73	14
KLDN-BW	180	34	19
DSN	150	112	75
WSN	50	34	69
DON	100	12	12
DON-RF	81	10	13
WON	136	38	28
RCB-BW	117	57	49
CB-BD	131	35	27
CB-BT	216	76	35
ISEPTON	112	84	75
IBWSN	207	47	23
POT-D	278	33	12
POT-BW	103	36	35

* R= 0-2 on a 0-9 scale

MR= 3.1-3.5, 4.1, and 4.2 on a 0-9 scale and % of leaf area covered by pycnidia.

Table 18. Durum and bread wheat lines selected at different sites in North Africa resistant or moderately resistant to septoria leaf blotch and BYDV at Beja, Tunisia, 1983/84.

Variety/cross and pedigree	Source	Septoria*	BYDV
Bo'S'/Gdo VZ 385 CM 9-11S-1S-0S	DON 61	3.3	MR
Sebou	DON-RF 81	3.3	MR
Shwa'S'/Yav'S' CD 23184-6Y-1M-2Y-1Y-1M-0Y	KLDN-D 427	3.2	MR
Gs'S'/Cr'S'//AA'S'/3/H.0/4/Mexi'S'/5/Memo'S' CD 27215-5B-3Y-3Y-2M-0Y	438	3.2	MR
Mala'S'/4/61-130/Lds//Gs'S'/Cr'S'/3/Gs'S' /5/Rok'S'/Memo CD 32038-B-1Y-4Y-1M-0Y	444	3.4	R
Gs'S'/Cr'S'//AA'S'/3/H.0/4/Mexi'S'/5/Memo'S' /6/Mexi'S'Fa'S'//Me CD 32116-H-1Y-2Y-3M-0Y	445	3.2	R
KVZ-Cgn SE 1066-9S-1S-6S-0S-1K-0K	WON 17	2.1	R
Ymh-TobxRon SE 1756-9S-2-5S-0S-3K-0K	21	3.3	R
(Cndr'S'/II 18889-TprxCo 652643) Nac CM 43378-F-1Y-3M-3Y-1M-1Y-0B	102	3.5	R
S 182-24-C168.3/(Cno-7 C_2)xCc-Tob SWM 6828-6AP-2AP-3AP-1AP-0AP	133	2.5	MR
S 183.24-C168.3/(Cno-7 C_2)xCc-Tob SWM 6828-6AP-2AP-2AP-3AP-0AP	134	3.4	MR

* Scale 0-9 and % of leaf area covered by pycnidia.

Table 19. Seedling reaction of durum and bread wheat varieties to three isolates[1] of Septoria tritici in the greenhouse, Tunisia, 1984.

Variety	Average no. lesions/leaf			Lesion size[2]			Pycnidia formation[3]		
	A	B	C	A	B	C	A	B	C
BREAD WHEAT									
Bulbul	0	0	4	-	-	M	-	-	++
Tanit	0	0	3.6	-	-	M	-	-	++
Dougga	0	0	2.6	-	-	M	-	-	++
DURUM WHEAT									
Jori	3	7	0	M	L	-	+	+++	-
Karim	3	5	0	S	M	-	++	++	-
Maghrebi	1.6	4.5	0	M	L	-	+	+++	-
Haurani	2	5	0	M	L	-	+++	+++	-

1. A = from durum wheat collected in Mateur,
   B = from durum wheat collected in Beja,
   C = from bread wheat collected in Bou Rbiaa

2. L = large, M = medium, S = small

3. + = low, ++ = medium, +++ = high

The variability in reaction might be due to:

1. virulence differences between available isolates,

2. inoculum composition, as the ratio of BW:D isolates in 1983/84 and 1984/85 was 1:2 and 1:1, respectively, and

3. differences in environmental conditions in the different seasons.

b. Yellow rust

Heavy infections of certain diseases may occur in any cropping season in Tunisia. Yellow rust seriously attacked wheat in 1977. Sultan, the bread wheat cultivar most widely grown in Tunisia to date, was discarded because of its susceptibility to this disease. In 1984, a late infection of yellow rust occurred on Tanit (=Nacozari'S'), a bread wheat cultivar, at Beja, Krib, Boulifa, and Mateur. Karim (Bitern'S'), a durum wheat variety, was slightly infected. Tanit was also very susceptible in 1985 and was severely affected in several farmers' fields in the Mateur region, but elsewhere the development of this disease was negligible.

The bread wheat germplasm in the 1984/85 nurseries was more affected by yellow rust than the durum varieties. However, only the lines which may be carrying resistance genes for more than one disease were selected (Tables 20 and 21).

c.Tan spot

In 1981/82, a heavy natural infection of tan spot occurred on wheat in the Mateur region (Table 16). Similarly, early in 1982/83 infection was heavy, but the dry weather during the second half of January and February checked disease development. Symptoms were evident late in the season on durum and bread wheats in the Mateur region. In the same season, about 30 durum wheat lines were selected for plant type as well as resistance to tan spot, but unfortunately most of these were susceptible to septoria the following season.

Table 20. Durum and bread wheat lines resistant or moderately resistant to *Septoria tritici** in Tunisia, 1983/84 and 1984/85 .

Variety/cross and pedigree	Reaction to septoria **	
BREAD WHEAT	1983/84	1984/85
Sap's'/Mon's'	2.2	0.0
Bow's=Bow 1		
CM33203-K-10M-7Y-3M-2Y-1M-0Y	2.1	4.2
Vee's'		
CM33207-F-1M-9Y-0M-7KE-0KE	4.2	3.2
Bb/G11//Sjm/3/Au/Ws 1812		
CM 34580-A-1m-3Y-8M-1Y-1M-0Y	3.2	2.2
Maya 74's'/Nr.Resel		
CM 40891-3KE-1AP-0AP-3AP-1AP-0AP	3.2	2.2
7C/3/Cno/7C/CC/Tob		
CM45414-3AP-1AP-1AP-3AP-0AP	4.2	3.2
Ymh/Ald's'		
SwM3142-8L-4AP-0AP-2AP-0AP	4.2	2.4
DURUM WHEAT		
Gr's'/Boy's'	2.2	0.0
CD20345-2AP-2AP-0AP		
Pin's'/Gre's'//Cit's'/Fg's'		
CD27308-1AP-4AP-0AP	0.0	0.0
Pin's'/Gre's'//Cit's'/Fg's'		
CD27308-1AP-5AP-3AP-0AP	2.2	0.0
Ato's'/D-2		
ICD77-0079-20AP-2AP-0AP	4.2	0.0
Memo's'/Albe's'		
CD35603-3B-1Y-1M-0Y	2.2	0.0
Stk's'//21563/AA's'/3/BD1814/BD1708/ BD1543		
CD21712-2AP-4AP-2AP-0AP	3.2	0.0

* The ratio of durum to bread wheat isolates in the inoculum was 2:1 in 1983/84 and 1:1 in 1984/85.
** Scale 0-9 and % of leaf area covered by pycnidia

Table 21. Durum and bread wheat lines resistant* or moderately resistant to septoria leaf blotch, tan spot, and yellow rust, Tunisia , 1984/85.

Variety/cross and pedigree	Source	Septoria	Tan spot	Yellow rust
DURUM WHEAT				
Mgh72/Plc"s"-IBIS"s"xGta"s"-Rolette	POT-BD			
D78-41-76-12b-2b-0b	261	0	0	10MR
BD2030-Fg"s"				
D78-43-3b-7b-0b	262	0	0	10MR
D68.1.93A-1AXRuff"s"-Fg"s"				
D78-60-2b-12b-0b	264	0	0	0
Fg"s"-Ame172				
D78-116-2b-4b-5b-0b	266	0	0	0
(Mgh's'-Gs's'XAA's'/Gta's'-Cit's)Fg'S'				
D78-145-2b-6b-7b-0b	269	0	0	0
21563-AA'S'xFg's'/Magh72				
D78-148-4b-6b-13b-0b	271	0	0	10MR
BD2080-D7057 X Mgh 72				
D78-206-1b-13b-8b-0b	281	0	0	10MR
BREAD WHEAT				
Snb's'	POT-BT			
CM34630-D-3M-3Y-1M-1Y-0M	81	3	0	0
Pak F4.6313-Nuri x Dga74				
T76-122-4bj-9bj-5bj-4bj-14bj-obj	313	3	0	0
(4777_2/Fn-K58NXGb)vn's'				
CM49912-8bj-1bj-2bj-13bj-obj	323	2	0	0
Blo's'-pima77				
CM52144-2bj-2bj-2bj-0bj	331	2	0	0
SSD/Blo's'	KLDN-W			
CM29963-2L-2AP-1AP-5AP-1AP-1AP-0AP	32	3	4	0
Fury//E4(DW.Mex)Mn6801				
CM42472-1AP-2AP-1AP-1AP-1AP-0AP	46	3	4	0
Peg's'	RCB-BW			
SWM1368-500Y-1B-501Y-503M-0M	68	0	0	0
II58.57/4/Maya74's'/Cgn/3/CC/INIA//Cal				
CM40742-27M-1Y-2M-3Y-4M-1Y-0B	136	0	0	0
Carpentro/carp				
II30724-1C-4C-0C-7M-0Y-0AP	139	2	0	0

* Selection criteria: 0-3 on a 0-9 scale for septoria
0-4 on a 0-9 scale for tan spot
CI < 8 for yellow rust

Screening for resistance to tan spot was carried out at the Ariana site in 1984/85. Although most of the bread wheat entries in the KLDN were affected at the seedling stage, some lines showed adequate levels of resistance at the adult stage. Few lines in this nursery and in POT-BT and POT-BD showed multiple resistance to tan spot, septoria, and yellow rust (Table 21).

d. Common bunt

Although this disease is easily controlled by seed treatment, common bunt is an important wheat disease in Tunisia. In 1985, commercial fields were severely affected in the Goubellat area and production was considerably reduced.

The Tunisian bread wheat observation nursery (POT-BT) was subjected to a preliminary evaluation for common bunt, using one isolate collected from Tanit cultivar grown at Beja. Forty-eight percent of the entries were retained for further testing against other isolates collected later.

B. Barley Diseases

On barley, scald, net blotch, stripe disease, leaf rust, and powdery mildew are very important diseases in Tunisia, and they occur every season. However, the severity of infection varies from year to year in the north and in the zone intermediate between the northern and central areas.

In 1980, yellow rust occurred frequently at Mateur and in other regions in northern Tunisia, but during 1981-85 it was negligible and restricted to a few locations in the Mateur region.

Covered smut and root rots are the dominant diseases in low rainfall areas and covered smut also occurred in the northern regions. Barley yellow dwarf virus (BYDV) is also an important problem on barley and can reach epidemic proportions, such as in the 1983/84 season, in several areas.

Scald developed on a low percentage of lines in the 1981/82 season, even though nurseries were inoculated in the Mateur region. This may be due to the weakness of the isolate collected from the local cultivar grown at Mateur.

The heavy rainfall and mild temperature at the beginning of 1982/83 favored net blotch and scald development early in December and January. Barley seedlings of the early planted commercial fields were considerably affected, especially by net blotch. Afterwards, disease development was reduced by dry, windy weather. However, powdery mildew developed well, and expression of scald and leaf rust was low late in the season at the Beja site.

During 1983/84, nurseries were inoculated twice with net blotch and scald at Beja, and the symptoms of these diseases and of powdery mildew, leaf rust, and BYDV were well developed.

The early rainfall in nothern Tunisia favored inoculum build-up and spore dissemination of H. teres. The local cultivar, Martin was heavily infected at the seedling stage, resulting in total death of the lower leaves. The disease was also very important in Algeria (CV Saida) and Morocco (CV OR 289, OR 905, and Rabat 071).

The nursery most susceptible to H. teres was the Tunisian barley collection of genetic resources (CRG) where 83% of the accessions were susceptible, compared to 9, 16, and 16% for KLDN, barley observation nursery (BON), and POT-OR, respectively (Table 22).

In Tunisia in 1983/84, seedlings of the local cultivars were affected by scald in the Bou Rbiaa and Mateur areas. In the nurseries at Beja (Table 22), this disease was severe on 21% of the entries (POT), 23% (BON), 37% (KLDN), and 36% (CRG). The disease incidence was less in Algeria and Morocco.

An early build-up of aphids resulted in a severe BYDV epidemic on the local varieties, Ceres and Martin in Tunisia and OR 077 in Morocco. Many resistant barley and wheat lines were identified at Beja.

Infection by leaf rust started in early April in Tunisia, but the incidence was less in Morocco and Algeria. Aecia of P. hordei were seen on leaves of the alternate host Ornithogalum umbellatum at the Beja station in early March. The role of the alternate host as a source of primary infection in the region and the development of new races in this area have not yet been studied.

Powdery mildew attacked most of the lines tested. The percentage of resistant and moderately resistant entries was 13% (CRG), 19% (KLDN), 23% (BON), and 25% (POT) (Table 22).

Some entries from the KLDN and BON (1983/84) exhibited field resistance to scald, net blotch, powdery mildew, leaf rust, and BYDV (Table 23).

In 1984/85, scald and net blotch infections were again severe on barley. Three isolates of Rhynchosporium secalis were collected from Beja, Koudiat, and Boulifa. Each isolate was used to inoculate the same set of nurseries at one of three locations.

Many lines were resistant to individual isolates, but few were resistant to all of them (Table 24). Field testing has pointed out the differences in virulence between the three isolates.

Net blotch was aggressive on the local cultivars and land races, using an inoculum of different isolates of H. teres. Very few lines proved to be highly susceptible to this disease, which may be due to the weak virulence of the isolates used, or the low spore concentration in the inoculum, or both.

Each year at Beja, the F1 nursery is surrounded by a mixture of spreader varieties to enhance natural infection by stripe disease (H. gramineum). Most of the spreader plants showed stripe symptoms with profuse sporulation on their leaves. This technique was developed in 1982/83 and 1983/84 and proved satisfactory for selection against this disease starting at the F2 generation. The presence of striped plants in the population and the use of spreaders around and inside the populations ensure reasonably high infection to allow further selection in following generations. Consequently, before reaching the stage of advanced generations, a high percentage of susceptible plants will have been eliminated.

Table 22. Percentage of barley lines resistant and moderately resistant* to diseases on the different nurseries, Tunisia 1983/84.

Disease	Nursery KLDN	BON	CRG	POT
Net blotch (NB)	91	84	17	84
Scald (Sc)	63	77	64	79
Powdery mildew (PM)	19	23	13	25
BYDV	44	46	69	39
NB+Sc	58	64	11	66
NB+Sc+BYDV	22	28	6	24
NB+Sc+BYDV+PM+LR	2.5	5.2	2.6	2.8

* Selection criteria:
- 0-4 on a 0-9 scale for NB,Sc, and PM.
- 0-2 on a 0-5 scale for BYDV
- CI < 8 for leaf rust (LR)

Table 23. Barley lines from the KLDN and BON resistant or moderately resistant* to disease, Beja and Boulifa, Tunisia 1983/84.

Variety/cross and pedigree	Source	Disease SC	NB	PM	LR	BYDV
BKF/Maguelone 1604/4/CM67/3/Apro//SV. 02109/Mari CMB 77A-1614-2AP-0AP	KLDN 107	0	0	5	10MS	MR
M69.69/Hja C4715//WA2196-68 CMSW 77A-0045-1AP-0AP	185	0	0	5	5MR	
Vanguard/Julia//Zephyr Kronsted 72-73-89-18-1y-1B-1Y-0B	218	4	0	5	5MR	MR
Kervana/Alouette ICB 77-0361-2AP-0AP	262	0	0	4	0	MR
Julia//Tetra/Kreuzung CMB 77A-0917-4AP-0AP	264	0	0	5	0	MR
5819/1420//Aramir CMB 77A-1726-3AP-1AP-0AP	235	0	0	5	5MS	MR
Hebe CMSWB 77A-0563-1AP-0AP	326	0	0	5	5MR	MR
WI 2198/Emir CMB 77A-352-3AP-0AP	BON 2	0	0	5	5MS	R
WI 2198/Emir CMB 77A-352-1AP-0AP	7	0	0	4	5MS	R
Deir Alla 106/Strain 205 ICB 77-99-1AP-0AP	28	0	0	5	5MS	R
WI 2197/Arabishe ICB 77-42-4AP-0SH-0AP	38	0	0	5	5MS	MR
1331.68//Api/CM67 CMSWB 77A-563-1AP-0AP	81	0	0	5	5MR	MR
G.P.B. 176/Piroline	138	0	0	5	10MR	MR

* Selection criteria:
<4 for scald (SC) and net blotch (NB) and <5 for powdery mildew (PM) on a 0-9 scale.
<2 on a 0-5 scale for BYDV
CI < 8 for leaf rust (LR).

4. Discussion

The results obtained in the seasons 1981/82, 1983/84, and 1984/85 indicate that the level of germplasm resistance to Septoria tritici under Tunisian conditions is improving. The percentage of resistant and moderately resistant lines has grown from 8% (1981/82) and 29% (1983/84) to 42% (1984/85) in the KLDN-D, from 24% (1983/84) to 49% (1984/85) in the DON, and from 41% (1983/84) to 58% (1984/85) in the WON, in spite of more severe disease development in 1983/84 and 1984/85 on the check varieties used in the KLDN.

Tanit, the high-yielding bread wheat variety released in 1980, is susceptible to the major wheat diseases in Tunisia, such as septoria leaf blotch, yellow rust, tan spot, and common bunt. Besides reducing yield, diseases also increase storage damage and affect grain quality. The INRAT breeders now have alternative lines in their programs. Among the promising bread wheat lines, Bow 1 and SNB'S' (Table 25) are better yielders than Tanit and have a good level of disease resistance. Therefore, these two lines were under large-scale testing in 1985/86 for further yield evaluation and possible release.

In durum wheats, the commercial varieties Karim and Ben Bechir are also susceptible to septoria, but no new varieties have so far outyielded Karim. Some lines were equivalent to Karim in terms of yield but did not show any other advantageous character for their registration and release.

Amongst the highest-yielding barley lines during 1982-85, Rihane'S' (sel.2L-1AP-3AP-0AP) is one of those less affected by diseases (Table 24), and proved resistant to three scald isolates in field tests. This line is also being tested on a large scale for possible release. Others, such as Astina, Mari/CM67, and Minak, are also high-yielding lines, but they lack resistance to scald.

It is evident that identification of multiple disease-resistant, high-yielding lines may provide a rapid solution to serious disease problems in Tunisia and other countries in the region.

Atlas 46 was resistant to the scald isolates used in field inoculation. This line is a common parent to three entries, and may be responsible for the resistance of these entries (Table 24). It also had good resistance to scald on a regional basis.

Similarly, the common parents in the bread wheat lines resistant to Septoria tritici in Tunisia (Tables 18, 20, and 21) are Klein Rendidor, Kavkaz, Chris, and Tezano Pintos Precoz, which might be responsible for resistance to the isolates of septoria used in the inoculum and other foliar diseases such as tan spot.

Table 24. Barley lines resistant or moderately resistant **to three** Tunisian scald isolates* also with acceptable **resistance** to powdery mildew and **net blotch, Tunisia 1984/85.**

	Variety/cross and pedigree
	Rihane's' Sel.2L-1AP-3AP-0AP
	Rihane's' Sel. 2L-1AP-1AP-0AP
**	Lignee 527 Com. Cr. 229//As46/Pro
**	Clipper/Volla CMB 77A-0896-1AP-0AP
	WI 2197/A.Hor 346.70 ICB 78-0009-4AP=0SH-5AP-1AP-0AP
	Atlas 46
**	Roho//Alger/Ceres, 362-1-1 ICB 77-0186-1AP-2AP-2AP-0AP
**	WI 2291/EH 20-F_3-B1 ICB 78-0671-14AP-2AP-0AP
	H 272/Nopal's' CMB 76A-531-500B-500Y-0B-501Y-0B

* Field testing at three sites:
Beja : for Beja isolate
Ariana : for Koudiat isolate
Boulifa : for Boulifa isolate

** Resistant to leaf rust (CI < 8).

Table 25. Yield of bread wheat lines has a percentage of the check Tanit, and reaction to septoria leaf blotch and yellow rust, Tunisia, 1984/85.

Variety/cross and pedigree	Yield* (kg/ha)	YR	Septoria	Years of testing
1. Snb's' CM 34630-D-3M-3y-1m-1y-0m	120	0	3	2
2. Seri 82	119	0	9.9	2
3. BOW 1	112	0	3	3
4. Ures T.81	104	5MR	7.6	5
5. Genaro F.81	109	0	8.6	5
6. Mrs-MoxP10 CM 43533-m-1y-2m-1y-0m	103	0	3.2	1
7. Pak F4.6313-NurixDga74 T.76-122-4bj-9bj-5bj-4bj-14bj-0bj	111	0	3.2	1
8. (4777/Fn-K58NxGb)Pvn's' CM 49912-8bj-1bj-2bj-13bj-0bj	107	0	2.3	1
9. Gof's'-maya74 CM50095-1bj-7bj-2bj-9bj-0bj	104	0	3.2	1
10. ys's'-S1s's' CM53059-2bj-8bj-13bj-3bj-0bj	107	0	3.3	1

* Mean at Beja, Koudiat, Boulifa, Krib, and Mateur for lines 1-8, and Beja and Kef for lines 9 and 10.

IV- GRAIN QUALITY

Since 1978, the promising lines of durum wheat, bread wheat, and barley included in the AYT have been evaluated for grain quality characteristics at the Technology Laboratory of INRAT. The common traits evaluated for the three crops are protein content, 1000-kernel weight (1000-kw), and specific weight (SW). Other tests were conducted for wheat, such as the micro baking and alveograph tests for bread wheat, and the yellow berry, yellow pigments, vitreousness, and micro pasta tests for durum wheat. The results provided information to breeders which helped in the selection of high-yielding, good quality cultivars. Some of the findings are summarized below.

1. Influence of environment on quality traits

a. 1000-kw and SW. Both indicate the degree of kernel filling of the grain. The 1000-kw proved to be most sensitive to environment, locations, and years. For a given genotype, deviation of this trait from the mean over several years may be explained by improper filling of the grain. This may result from drought, hot wind (sirroco), or any other factor that hampers plant metabolism or translocation of the carbohydrate and protein reserves from the vegetative plant parts to the grain. The range of this variation in 1000-kw can be used as an indication of genotypic stability.

b. Yellow berry. This results from the imbalanced carbohydrate/protein ratio in the grain and varies with environment. It is common during the rainy season (e.g. 1984/85) and is more important in higher rainfall areas such as Beja than Koudiat or Boulifa. At levels above 15% it reduces grain quality of durum wheat by affecting the total protein content, semolina yield, and pasta quality. Experiments conducted under an appropriate irrigation system may be useful in selecting against yellow berry.

2. Chemical characteristics of grain

The composition and total protein content of a given variety to a large extent determines its use. Total protein content is highly correlated to baking quality of bread wheat or pasta making quality of durum wheat. It also affects the malting quality of barley. Total protein content is the trait that is most sensitive to environment, and in general, it increases with aridity and is negatively correlated to grain yield.

In the light of the data obtained, different INRAT stations were used for screening for various grain quality characteristics. Beja is favorable for screening against yellow berry, but unfavorable for maximizing total protein content. Koudiat and Boulifa are favorable for screening to maximize total protein content, 1000-kw, and specific weight, while Krib and Mateur are intermediary locations.

During 1981-85, some promising lines of durum wheat, bread wheat, and barley were identified in terms of grain yield. The characteristics of the most promising lines are shown in Tables 26, 27, and 28.

Table 26. Grain quality characteristics of the most promising durum wheat lines in the breeding program, Tunisia, 1984/85.

Variety/cross and pedigree	BEJA					BOULIFA				
	1000 KW	SW	Protein* content (%)	Yellow berry (%)	Pigments (ppm)	1000 KW	SW	Protein conetnt (%)	Yellow berry (%)	Pigments (ppm)
Fg's'-Palestinian20.c.606xMexi's'/Rabi's' CD10438-4M-1Y-0M	50.2	85.0	9.8	51.75	7.85	43.7	82.0	14.1	0.25	7.50
(CFn5-Mca's'xGr's'/Mario's')JO's'-Gr's' CD10612-B-4M-1Y-1M-0Y	47.4	87.0	11.2	10.5	6.75	43.5	84.0	13.4	1.50	6.75
Ruff's'-Fg's'xMexi75/SHWA's' CD22344-A-8M-1Y-1M-1Y-2Y-1M-0Y	45.9	84.0	9.5	25.0	8.9	49.5	86.0	13.0	0.50	8.55
SO 179//SO 179/Durum 6/3/PtL's' CD20632-2AP-3AP-0AP	49.1	87.0	10.4	8.00	8.5	-	-	-	-	-
MELLEGUE CD7455-4Y-1Y-0Y	53.2	84.5	10.2	44.0	7.30	-	-	-	-	-
YAV's'-Snipe's'- CD39272-10M-1Y-1M-1Y-0M	53.0	88.0	10.4	6.75	6.00	-	-	-	-	
KARIM	54.5	88.0	13.0	42.50	7.85	54.9	85.0	13.6	0	5.30
Ben Bachir	46.1	48.5	11.9	38.50	7.85	49.4	83.5	12.7	0.25	7.85
Maghrebi	55.6	85.5	10.8	7.00	5.90	41.0	84.0	14.1	0	6.45

* N x 5.7 P. 100 DM

Table 27. Grain quality characteristics of the most promising bread wheat lines, Tunisia, 1984/85.

Variety/cross and pedigree	BEJA 1000-kw	BEJA SW	BEJA Protein content(%)	BOULIFA 1000-kw	BOULIFA SW	BOULIFA Protein content(%)
Snb's' cm 34630 D-3m-1m-1y-0m	50.7	84.5	12.2	37.6	81.0	14.3
Seri 82	46.4	84.0	10.9	39.6	81.0	12.9
BOW 1	42.0	86.0	11.5	36.5	80.0	13.5
Ures T 81	41.3	86.0	11.2	-	-	-
Genaro F-81	40.9	85.0	11.4	36.4	83.5	13.0
Mrs-mo x PLO cm 43533-m-1y-2m-1y-0M	45.5	84.0	10.9	40.4	80.0	14.4
Pak F46313-Nuri x Dga 74 T76-122-4bj-9bj-5bj-4bj-14bj-0bj	45.3	86.0	12.3	38.4	82.5	15.1
GOF's'-maya 74 cm 50095-1bj-7bj-2bj-9bj-0bj	45.6	85.0	10.9	43.2	80.0	14.7
Yd's'-SLS's' cm 53059-2bj-8bj-13bj-3bj-0bj	49.8	85.0	10.8	43.5	80.0	15.7
(4777_{2}/Fn-K58Nxgb) PVn's' cm-49912-8bj-1bj-2bj-1bj-0bj	43.6	83.0	13.2	38.7	80.0	-
Dougga 74	38.7	86.0	12.0	34.5	83.0	13.8
Tanit	38.7	84.0	11.8	39.3	83.0	13.7

Table 28. Grain quality of the most promising barley lines, Tunisia 1984/85.

Variety/cross and pedigree	BEJA			BOULIFA		
	1000-kw	SW	Protein content(%)	1000-kw	SW	Protein content(%)
Rihane's' Sel-2L-1AP-1AP-0AP	34.3	57.5	6.6	40.2	65.0	8.60
Rihane	43.4	65.0	5.6	43.4	70.0	11.1
Rihane's' Sel 2L-1AP-4AP-0AP	-	-	-	41.3	66.5	8.70
Rihane's' Sel 2L-1AP-3AP-3AP,0AP	43.6*	62*	64*	39.0	67.0	9.11
Mari CM67 CM72-140-8Y-1B-3Y-3B-0Y	37.4	62.5	6.0	40.9	71.0	10.2
F8 HB 389-40	-	-	-	38.0	73.0	10.8
H251	38.2	62.5	6.3	37.2	63.0	8.3
API/CM67/Mona CMB73A-386-1Y-1B-500Y-0B	42.6	66	7.2	34.2	68.5	11.2
Aramir/Cossack CMS WB 77A-458-1H-1Y-1B-1Y-2B-0Y	-	-	-	45.6	74.0	10.1
F632	-	-	-	45.4	75.0	9.0
Nordgrol/Kristina, Cr 49201	-	-	-	39.8	73.0	9.5
Roho	49*	63*	7.8*	47.8*	65.0*	11.8*
Taj	45*	66.8*	8.3*	46.7*	66.8*	10.2*
Faiz	38*	67.8*	7.7*	47.7	70.0	8.8
Ceres	40.3*	72.8*	8.6*	41.7	75.0	12.3
Martin	44.7*	61.5*	9.1*	46.9*	68.9*	12.7*

* Average of two trials.

V. TRAINING, VISITS AND WORKSHOPS

The scarcity of trained support staff is one of the constraints on national scientists working on cereal production. ICARDA seeks, through cooperative projects, to strengthen the capacity of national programs to undertake their own agricultural research. Therefore, the principal objectives of training are the development of scientific skills at national level, and the strengthening of links between ICARDA and the national programs.

To fulfill the different training needs of national programs, the ICARDA training program is divided into four categories.

1. *Long-term* residential courses of three (after 1984) or six months (before 1984) for junior and senior technicians.
2. Specialized short courses or workshops (2 weeks-1 month) on specific topics. This type of course may be carried out at the ICARDA base program or at the national level in cooperation with one or more national programs.
3. Support for higher degree training (M.Sc. or Ph.D.) where students are registered at local or overseas universities.
4. Visits to ICARDA by research workers at various levels, from the region, to improve their research skills through direct involvement in ICARDA's research activities and programs.

Tunisian scientists and support staff have been involved in most of these training categories. During 1979-85, ten engineers or technicians attended residential courses. Ten were trained for a short period on a specific topic of the ICARDA cereal research activities, such as breeding, agronomy, pathology, grain quality, genetic resources, farm management, farm machinery, etc. (Appendix IV).

The joint ICARDA-CIMMYT regional traveling workshops on cereals, carried out in Morocco, Spain, and Portugal in 1984 and 1985, have strengthened contacts between cereal scientists of different national programs in the region and adjacent European countries (Morocco, Tunisia, Spain, Portugal) and scientists from CIMMYT and ICARDA. The group, which included four Tunisian scientists, visited different cereal experimental stations and research institutes in each country. The objective of traveling workshops is to provide opportunities

1. to discuss and exchange ideas, information, and genetic material,
2. to identify common problems,
3. to evaluate national scientists' own breeding material when grown in different environments, and
4. to assist the national program in selection and note-taking.

The ICARDA collaborative project with Tunisia is also supporting some thesis research on cereals. Three scientists working in the project from INRAT are completing their Ph.D. theses. One of them is working on selection methodology; the second is studying different characteristics of wheat adapted to dry and semi-dry conditions; and the third has already completed his Diplome d'Etudes Approfondies (DEA) on barley, and is now completing his Ph.D. on the same subject.

From INAT, ICARDA is supporting five students for M.Sc. degrees in cereal pathology and breeding. Another student was identified in 1985 to work on BYDV.

Similarly, ICARDA is helping national scientists to participate in seminars and workshops held in the region or elsewhere. During the last five years, senior scientists from Tunisia have participated in several workshops such as:

1. Barley diseases and associated breeding methodology, Rabat, Morocco, 1981 (two participants).

2. Seed production, Aleppo, Syria, 1982 (two participants).

3. Arab conference on cereal industry, Amman-Jordan, 1984 (one participant).

4. Seed production. Rabat, Morocco, 1985 (one participant).

5. The Arab conference for agricultural research on basic food crops, Aleppo, Syria, 1985 (two participants).

In each crop season, one or two scientists visit ICARDA's base program to study new research developments in different aspects of the cereal improvement program, or to participate in program planning meetings (see Appendix V). Similarly, ICARDA scientists frequently visit the project and help in selection, note-taking, etc.

ICARDA's review team visited the collaborative projects in Tunisia during 1983. Their visit allowed closer interaction with national scientists. In addition, scientists from various national programs have visited Tunisia to see the development of the project. ICARDA also provided consultancies in different disciplines, such as:

- Cereal technology: Dr. P. Williams (1982), ICARDA consultant.

- Barley improvement: Dr. Andereas Hadjichristodoulou (1985), Agricultural Research Institute, Nicosia, Cyprus.

- Wheat improvement: Prof. P. Auriau (1985), INRA, France, for Mr. M. Deghais Ph.D. thesis work.

- Statistical analyses: Dr. R. Peterson (1985), ICARDA consultant, for statistical analyses for the demonstration plots conducted by the Office des Cereales, Tunis.

An annual coordination meeting is held in September of each year in Tunisia. Tunisian and ICARDA scientists attend the meeting to evaluate the results of the previous season and plan and discuss needs for the coming season (see Appendix VI for the equipment supplied to the Tunisian cereal program). The first coordination meeting was in 1983.

ICARDA keeps in touch with former trainees through continuous visits and dissemination of information, such as proceedings of workshops and conferences, and through ICARDA newsletters.

VI. GENERAL CONCLUSION AND RECOMMENDATIONS

In Tunisia, barley is an important crop, especially in the central and southern regions. Little attention was given to this crop in the past in terms of breeding and good cultural practices. During the last 20 years some trials were conducted by INRAT and the Office des Cereales but due to the scarcity of facilities and discontinuity within the program, the results did not reach farmer level.

In 1980, the barley program at INRAT was strengthened with the establishment of a collaborative project between the Ministry of Agriculture of Tunisia and ICARDA. Since the inception of this project, a breeder/pathologist from ICARDA has been posted in Tunisia to work closely with the cereal team of INRAT on barley improvement and cereal pathology. A Tunisian scientist was selected to work in the same program.

The five years of cooperation between INRAT and ICARDA on cereal improvement have paid off. Among the most pronounced results are:

a. Introduction of new germplasm to Tunisia.

b. Identification and release of three barley varieties adapted to Tunisian conditions (Roho, Taj, and Faiz) in 1985. These varieties, on average, out-produced the local cultivars Ceres and Martin by 30% and are now in commercial cultivation. Other promising lines are already in large-scale yield testing for eventual release.

c. Initiation of a national barley breeding program.

d. Training of a Tunisian researcher who is now in charge of the barley program, with limited technical back-up from ICARDA. Similarly, many engineers and technicians working in cereal programs took advantage of regular or specialized short training courses on the different activities of ICARDA's cereal improvement program. Morever, national scientists participated in workshops and seminars, and support was given for M.Sc. and Ph.D. degrees.

e. The start of a cereal pathology program to identify resistant genotypes for use as parents in crossing programs, to select disease resistant plants in the segregating populations, and to identify multiple disease resistant, high-yielding lines. Bobwhite 1, Sunbird'S' (bread wheat), and Rihane'S' (barley) are a few examples. More pathology results will be available in future.

The cooperation between ICARDA and INRAT emphasized barley improvement and there are now very solid bases to continue strengthening the following areas:

- Continue looking for drought tolerant, high-yielding genetic stocks.
- Improve resistance to major diseases in the region.
- Identify barley genotypes with good straw quality.
- Look for barley genotypes with double exploitation (grains and grazing).
- Adjust and develop suitable cultural techniques and agronomic practices for low rainfall areas, to give yield increases and stability.
- Train Tunisian technicians and set up an extension program to transfer new technology to farmers.

PUBLICATIONS FROM THE TUNISIA/ICARDA COLLABORATIVE PROJECT IN CEREAL IMPROVEMENT

El Ahmed, A.A. Ghodbane, F. Laribi and M. El Felah (1984). Barley diseases in Tunisia and sources of resistance. Pages 262-272 in Proceedings of the Barley Diseases and Associated Breeding Methodology Workshop, USAID/ICARDA/CIMMYT, 20-23 April 1981, Rabat, Morocco.

El Ahmed, A.,A.R. Maamouri and M. Deghais (1984). Wheat breeding for septoria resistance: identification of resistant genotypes. Rachis 3 (2): 20-23.

El-Ahmed, A., M. El Felah (1986). A method to screen for barley stripe disease starting in the F_2 populations. Rachis 5(1), (in press).

El Felah, M. (1985). Analyse comparee du comportement varietal chez l'orge (Hordeum vulgare L.) cas de 69 varietes. These de Diplome d'Etudes Approfondies de Genetique, Faculte des Sciences de Tunis, Tunisie.

Ghodbane, A., A. El Ahmed, F. Laribi and H. Ketata (1984). Barley program in Tunisia for improving resistance to powdery mildew. Pages 126-129 in Proceedings of the Barley Diseases and Associated Breeding Methodology Workshop, USAID-MSU/ICARDA/CIMMYT, 20-23 April 1981, Rabat, Morocco. Montana State University., Bozeman, Montana, USA.

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INRAT-ICARDA (1985). Amelioration Varietale de l'Orge, Programme de Cooperation entre l'INRAT et ICARDA (Brochure en Francais et Arabe).

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Lasram, M.,A. El Ahmed and M.S. Mekni (1985). Barley, its importance in the Maghreb Countries and perspectives for its improvement. The Arab Conference for Agricultural Research on Basic Food Crops. AFESD/ICARDA, March 31st-April 5th, 1985, Aleppo, Syria (in Arabic).

APPENDIX I: Release Certificate of Faiz Variety

REPUBLIQUE TUNISIENNE

MINISTERE DE L'AGRICULTURE

DIRECTION DE LA PRODUCTION VEGETALE

Le Ministre de l'Agriculture

Vu la loi n° 76-113 du 25 Novembre, relative à l'organisation et au contrôle de la production et de la commercialisation des semences et plants et notamment son article 4,

Vu le decrêt n° 78-479 du 2 mai 1978 fixant les attributions, la composition et les modalités de fonctionnement du Comité National Consultatif des Semences et Plants,

Vu le decrêt n° 80-261 du 26 Février 1980, relatif à un Catalogue Officiel et listes des espèces et variétés des plantes agricoles,

Sur proposition du Comité National Consultatif des Semences et Plants réuni le 27 Février 1985 à la Direction de la Production Végétale,

-=: D E C I D E :=-

Article Premier : La variété d'Orge FAIZ (1239) obtenue par l'I.N.R.A.T. est inscrite au Catalogue Officiel des espèces et variétés des plantes agricoles.

Article Deux : L'inscription au Catalogue de la variété d'orge FAIZ porte sur une période de dix ans et expire le 31 Décembre 1995.

Tunis, le 11 AVR. 1985

Proposé par :

Le Président du Comité

[redacted]

Le Ministre de l'Agriculture

Signé : L. BEN OSMAN

APPENDIX II : Release Certificate of Roho Variety

RÉPUBLIQUE TUNISIENNE

MINISTÈRE DE L'AGRICULTURE

DIRECTION DE LA PRODUCTION VEGETALE

Le Ministre de l'Agriculture

Vu la loi n° 76-113 du 25 Novembre, relative à l'organisation et au contrôle de la production et de la commercialisation des semences et plants et notamment son article 4,

Vu le decrêt n° 78-479 du 2 mai 1978 fixant les attributions, la composition et les modalités de fonctionnement du Comité National Consultatif des Semences et Plants,

Vu le decrêt n° 80-261 du 26 Février 1980, relatif à un Catalogue Officiel et listes des espèces et variétés des plantes agricoles,

Sur proposition du Comité National Consultatif des Semences et Plants réuni le 27 Février 1985 à la Direction de la Production Végétale,

-= : D E C I D E : =-

Article Premier : La variété d'Orge ROHO (849) obtenue par l'I.N.R.A.T. est inscrite au Catalogue Officiel des espèces et variétés des plantes agricoles.

Article Deux : L'inscription au Catalogue de la variété d'Orge ROHO porte sur une période de dix ans et expire le 31 Décembre 1995.

Tunis, le 11 AVR. 1985

Proposée par :

Le Président du Comité

Malek BEJBALAZ

Le Ministre de l'Agriculture

Signé : L. BEN OSMAN

APPENDIX III: Release Certificate of Taj Variety

REPUBLIQUE TUNISIENNE

MINISTERE DE L'AGRICULTURE

DIRECTION DE LA PRODUCTION VEGETALE

Le Ministre de l'Agriculture

Vu la loi n° 76-113 du 25 Novembre, relative à l'organisation et au contrôle de la production et de la commercialisation des semences et plants et notamment son article 4,

Vu le decrêt n° 78-479 du 2 mai 1978 fixant les attributions, la composition et les modalités de fonctionnement du Comité National consultatif des Semences et Plants,

Vu le decrêt n° 80-261 du 26 Février 1980, relatif à un Catalogue Officiel et listes des espèces et variétés des plantes agricoles,

Sur proposition du Comité National Consultatif des Semences et Plants réuni le 27 Février 1985 à la Direction de la Production Végétale,

-= : D E C I D E :=-

Article Premier : La variété d'orge TAJ (926) obtenue par l'I.N.R.A.T. est inscrite au Catalogue Officiel des espèces et variétés des plantes agricoles.

Article Deux : L'inscription au Catalogue de la variété d'orge TAJ porte sur une période de dix ans et expire le 31 Décembre 1995.

Tunis, le [illegible]

Proposée par :

Le Président du Comité

Malek BEN SALAH

Le Ministre de l'Agriculture

Signé : L. BEN OSMAN

APPENDIX IV

CEREAL IMPROVEMENT PROGRAM
LIST OF ICARDA TRAINEES FROM TUNISIA

NO.	YEAR	NAME/ADDRESS	DURATION	DISCIPLINE
1	1979	Mhiri Fraj, Office des Cereales, Tunis	6 months	Breeding
2		El-Felah Mouldi, INRAT, Ariana	6 months	Breeding
3	1980	Ayed Mohamed Salah, CRDA, Kef	6 months	Breeding
4		Salhi Ahmed, ESA, Kef	6 months	Breeding
5	1981	Abdennabi Ridha, Office des Cereales, Tunis	6 months	Breeding
6		Ben Nejma Ali, INRAT, Ariana	27 days	Technology
7	1982	Yousfi Mohamed Salah, Office des Cereales, Jandouba	6 months	Breeding
8		Ben Djemia Chadli, INRAT, Ariana	13 days	Oyjord
9		Rhouma Sayar, INRAT, Kef	6 months	Breeding
10	1983	Khalfat Brahim, INRAT, Ariana	30 days	Oyjord
11		Farhani Moncef, INRAT, Kef	6 months	Breeding
12		Mosbahi Mohamed, INRAT, Ariana	30 days	Pathology
13		Yousfi Mohamed Salah, Office des Cereales, Jandouba	12 days	Seed Production
14	1984	Sakouhi Lazhar, INRAT, Beja	6 months	Breeding
15		Zarkouna M.Tawfik, INRAT-Beja	30 days	Farm Operation
16		Guermazi Faker, DPV, Tunis	14 days	Seed Production
17	1985	Ben A. Nourredine, INRAT-Kef	3 months	Breeding
18		Debbech Khaled, INRAT, Ariana	14 days	Technology
19		El Abed Mohamed, INAT, Tunis	30 days	Genetic Resources
20		Amara Hajer, INAT, Tunis	7 days	Dual purpose barley

APPENDIX V

CEREAL IMPROVEMENT PROGRAM

VISITS OF TUNISIAN SCIENTISTS TO ICARDA

1. Dr. Abdulrazak Daaloul (1980 & 1984), Professor, INAT, Tunis.

2. Mr. Laroussi Tounsi (1980 & 1985), Office des Cereales, Tunis.

3. Mr. Ali Maamouri (1981), Head of Genetic Laboratory, INRAT, Ariana.

4. Dr. Habib Ketata (1981), Associate Prof. INAT, Tunis.

5. Mr. Mahmoud Deghais (1981 and 1984), Bread Wheat Breeder, INRAT, Ariana.

6. Mr. Mouldi El Felah (1984), Balrey Breeder, INRAT, Ariana.

7. Mr. Moncef Ben Salem (1984), Head of Technology Laboratory, INRAT, Ariana.

8. Dr. Moncef Harrabi (1985), Pathologist, INAT, Tunis.

APPENDIX VI

CEREAL IMPROVEMENT PROGRAM

EQUIPMENT SUPPLIED TO TUNISIA FROM ICARDA

1\. Vogel thresher (1981)

2\. Head thresher (1981)

2\. Oyjord seeder (1982 and 1983)

2\. Hege combiner (1981 and 1983)

2\. Cars (1980 and 1981)

2\. Deawner (1984)

1\. Pickup (1985)

Pathology Equipment (1982, 1983, and 1984)