FARM RESOURCE MANAGEMENT PROGRAM

Annual Report for 1992

ICARDA

Established in 1977, the International Center for Agricultural Research in the Dry Areas (ICARDA) is governed by an independent Board of Trustees. Based at Aleppo, Syria, it is one of 18 centers supported by the Consultative Group on International Agricultural Research (CGIAR), which is an international group of representatives of donor agencies, eminent agricultural scientists, and institutional administrators from developed and developing countries who guide and support its work.

The CGIAR seeks to enhance and sustain food production and, at the same time, improve socioeconomic conditions of people, through strengthening national research systems in developing countries.

ICARDA focuses its research efforts on areas with a dry summer and where precipitation in winter ranges from 200 to 600 mm. The Center has a world responsibility for the improvement of barley, lentil, and faba bean, and a regional responsibility—in West Asia and North Africa—for the improvement of wheat, chickpea, and pasture and forage crops and the associated farming systems.

Much of ICARDA's research is carried out on a 948-hectare farm at its headquarters at Tel Hadya, about 35 km southwest of Aleppo. ICARDA also manages other sites where it tests material under a variety of agroecological conditions in Syria and Lebanon. However, the full scope of ICARDA's activities can be appreciated only when account is taken of the cooperative research carried out with many countries in West Asia and North Africa.

The results of research are transferred through ICARDA's cooperation with national and regional research institutions, with universities and ministries of agriculture, and through the technical assistance and training that the Center provides. A range of training programs are offered extending from residential courses for groups to advanced research opportunities for individuals. These efforts are supported by seminars, publications, and by specialized information services.

FARM RESOURCE MANAGEMENT PROGRAM

Annual Report for 1992

International Center for Agricultural Research in the Dry Areas
P.O. Box 5466, Aleppo, Syria

This report was written and compiled by program scientists and represents a working document of ICARDA. Its primary objective is to communicate the season's research results quickly to fellow scientists, particularly those within West Asia and North Africa, with whom ICARDA has close collaboration. Due to the tight production deadlines, editing of the report was kept to a minimum.

Table of Contents

1. INTRODUCTION

1.1 Content of this Report

The research agenda of the Farm Resource Management Program encompasses the whole rainfed agricultural environment of WANA: the climate, the natural resources, soil, water and natural vegetation; the farming systems that utilize those resources; the social, economic and policy contexts in which those systems function; and the interactions between these, particularly as they affect productivity and the conservation of the resource base. Research is interdisciplinary, both within the Program and through linkages with other Programs and national scientists. It seeks to promote the effective and sustainable utilization of soil, water and vegetation; to identify constraints to productivity and ways to relieve them, technical, socio-economic or through policy measures; and to gauge the effectiveness of new inputs and technologies through studies of adoption and impact. The information generated is fed back into research planning centerwide.

To date, these various research activities have been grouped and administered rather loosely within three notional projects:

- Agroecological characterization for resource management;
- Management of soil, water and nutrients;
- Adoption and impact of technology;

and these groupings are reflected in the structure of this report. Each project is covered by one fairly long chapter.

However, because of the interdisciplinary nature of much of the research, there are few sharp demarcations between activities or between the projects into which they are grouped. For instance, each year we report the 'Dryland Resource Management Project' under Agroecological Characterization (Chapter 2). The six case studies within the project individually comprise different mixes of technical and socio-economic activities, mainly of a diagnostic nature, which might equally well be classified under the broad socio-economic umbrella of the Adoption and Impact Project.

Similarly, a wheat monitoring study in farmers' fields is reported this year under Soil, Water and Nutrients (Chapter 3) because it was initiated from an agronomic viewpoint and includes details of farmers' soil and crop management; but one of its major concerns is the adoption of improved varieties, and it is planned in the second year to examine the influence of the socio-economic backgrounds of individual farmers on their field practices and adoption behavior. In our next report, this work might be most appropriately reported as an Adoption and Impact study.

The main point here is that in interdisciplinary research, the activity and its usefulness is more important than the labels attached and the project titles under which it is administered. A second point perhaps is that, with such a diverse research agenda, the underlying coherence and direction of the work is not always fully transparent. Annual Reports are rapidly written and do not aim to cover each year all the ongoing research activities. An editorial attempt is made in the following chapters to cross-reference discreetly where this appears useful.

In all recent FRMP Annual Reports, Chapter 2 has comprised an Executive Summary of the rest of the report. To save time and space, this has been omitted this year. Instead, there is a short survey of the contents at the beginning of each of the three main technical chapters. It is hoped these will be sufficient to highlight in summary form the principal findings of the work reported.

1.2 Staff News

The year was very sadly overshadowed by the death early in December of Graham Walker following a road accident. This was a great shock to the Program. Graham had been with us for little more than a year, but in that time his quiet, relaxed but committed approach to the practical application of his considerable agrometeorological skills to the problems of WANA agriculture had won him much respect and many friends throughout ICARDA. He is greatly missed. This Report carries one of his last pieces of work, on the climatic adaptation of chickpea in WANA, a version of the paper he presented at the ICARDA/ICRISAT chickpea workshop at ICARDA in October.

More happily, FRMP has welcomed the arrival of three new senior staff members: Peter Smith, Visiting Senior Economist; most recently with the University of Manchester, his interests include management studies and resource-utilization issues at both user and policy levels; Abelardo Rodriguez, Agricultural Economist, has transferred from the AZRI/MART project in Quetta, where he worked on livestock marketing and water harvesting; he will strengthen the links FRMP is building to the activities in Balochistan; and John Ryan, Soil Fertility Specialist, recently with the MIAC project at Settat (Morocco) and previously a long-time staff member at the American University of Beirut, takes over responsibilities for the Soil Laboratory and the regional soil-fertility network. In addition, Akhtar Beg, an oilseed crop specialist from Pakistan, has joined FRMP as a visiting scientist, to improve ICARDA's knowledge of these neglected crops.

Not least, Program outreach activities have been substantially augmented by the presence in North Africa, since late 1991, of Drs M. Saade and L. El-Fattal. Supported by a Rockefeller fellowship, Maurice Saade has completed a specific study of triticale production in Tunisia and is now, more generally, examining the impact of improved cereal production technology in North Africa. Lamia El-Fattal has completed a study of women and change in legume-production technology (funded by a McNamara fellowship), and she is now retained as a consultant to assist in ICARDA's review of gender issues in WANA agriculture.

On the debit side, Abdullah Matar has now left us, after a long consultancy period following his official retirement, which facilitated the handover to John Ryan. The Program thanks him for many years devoted and enthusiastic service. Elizabeth Bailey has also moved on but, fortunately, only upstairs into the International Cooperation office. Her pioneering work managing the Dryland Resource Management Project, which has established a model for future resource-management activities, is greatly appreciated; and we look forward to her continuing administrative encouragement of anticipated successor projects.

Also counted on the debit side are abortive attempts during 1992 to fill an additional agricultural economist post (now frozen) and to fill the position of soil conservation/land management specialist. An appointment to this latter position is particularly important to justify the high profile FRMP (and ICARDA) has claimed for its resource management work. The training scientist position remains frozen, and the Program is grateful to Afif Dakermanji meantime for keeping FRMP training activities moving smoothly.

The regional staffing of the Program has, fortunately, remained very stable through the year, with only one resignation, that of Mohamed Tahhan; but the large number of vacant but frozen positions at this level is a cause of concern.

Finally, on a happy note, congratulations to Abdul Bari Salkini on the successful completion of his PhD studies at Reading University, England, with his thesis entitled "Impact Assessment of supplemental irrigation on rainfed wheat-based farming systems in Syria".

1.3 The Weather in Syria during the 1991/92 Season

The 1991/92 season was noteworthy for the exceptionally hard winter it brought to many parts of the Near East, from Turkey in the North to Egypt in the South. Northern Syria was no exception. The average temperature from December to March was the lowest recorded since ICARDA started observations in 1978 and the temperature remained moderate until mid-June. The total number of 57 frost days at Tel Hadya was 20 more than the average. Absolute minimum temperatures did not quite reach their lowest recorded values, although at around -8°C at all ICARDA sites in January they were lower than usual. Snow fell repeatedly, and for four days the ground at Tel Hadya was snow covered.

Precipitation over the season was close to the long-term average. A singular event was a storm which brought 40 mm rain to Tel Hadya on 25 October but only a few millimeters at the other sites. While precipitation up to February was generally on the high side, March rainfall was scant and April was virtually rainless. However, more than 20 mm were recorded at all sites in May.

While lentils were very adversely affected by the cold winter, chickpea, wheat and barley did well. The early onset of the rains meant that early planting was possible. While the low winter temperature slowed development, it also decreased evapotranspiration, so that a good supply of soil moisture was available to the crops in spring, more than offsetting the low rainfall in March and April. The rather cool spring also slowed crop development; the wheat harvest in Tel Hadya was delayed about three weeks compared with previous years. Crops could therefore make productive use of the late rainfall in May. In years in which the temperature rises earlier, such late rains are lost for crops approaching maturity.

Table 1.1 Monthly precipitation (mm) for the 1991/92 season

	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	TOTAL
<u>Jindiress</u>													
1991/92 season	3.2	19.8	45.9	139.4	29.0	93.6	28.0	0.8	27.3	37.8	0.0	0.0	424.8
Long term average (32s.)	1.5	31.0	54.8	93.5	82.4	74.5	64.7	42.4	19.6	3.4	0.3	0.8	468.9
% of long term average	213	64	84	149	35	126	43	2	139	1112	0	0	91
<u>Tel Hadya</u>													
1991/92 season	0.0	73.0	25.2	74.0	62.3	75.4	15.8	0.4	23.0	3.5	0.0	0.0	352.6
Long term average (14s.)	0.5	28.0	46.8	55.2	61.1	52.0	41.8	26.4	14.8	3.0	0.0	0.1	329.7
% of long term average	0	261	54	134	102	145	38	2	155	117	n/a	0	1.7
<u>Breda</u>													
1991/92 season	0.0	18.8	28.6	36.4	51.4	75.8	20.4	0.0	28.8	3.0	0.0	0.0	263.2
Long term average (34s.)	1.2	16.9	30.7	52.8	48.8	39.4	33.9	16.5	1.5	1.5	0.1	0.0	272.3
% of long term average	0	111	93	69	105	192	60	175	200	0	0	n/a	97
<u>Boueidar</u>													
1991/92 season	0.0	24.2	18.4	48.4	47.0	74.6	10.8	0.0	20.0	6.0	0.0	0.0	249.6
Long term average (19s.)	0.1	15.2	22.8	35.7	38.1	36.0	28.6	16.6	9.9	0.9	0.1	0.0	204.0
% of long term average	0	159	81	136	123	207	38	0	204	667	0	n/a	122
<u>Ghrerife</u>													
1991/92 season	0.0	18.4	21.0	54.3	50.0	70.4	14.4	0.0	27.8	15.6	0.0	0.0	271.8
Long term average (7s.)	0.0	35.7	23.4	40.8	44.9	40.4	34.6	11.4	14.3	2.7	0.0	0.0	248.2
% of long term average	n/a	52	90	133	111	174	42	0	194	578	n/a	n/a	110
<u>Terbol</u>													
1991/92 season	0.0	26.8	85.0	260.6	127.4	233.1	172.9	11.4	43.7	23.8	0.0	0.0	984.7
Long term average (11s.)	0.0	34.2	64.5	44.5	94.5	109.7	102.6	24.9	16.2	2.7	0.3	0.0	533.9
% of long term average	n/a	111	132	276	135	212	169	46	270	881	0	n/a	184

Table 1.2 Monthly air temperature (°C) for the 1991/92 season

	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG
Jindiress												
Mean max.	31.4	27.5	18.8	10.6	8.4	8.6	15.8	24.1	26.6	30.3	32.5	34.9
Mean min.	16.6	14.1	6.8	3.2	-1.7	0.1	2.4	8.7	12.1	15.8	18.6	20.4
Average	24.0	20.8	12.8	6.9	3.4	4.4	9.1	16.4	19.4	23.1	25.6	27.7
Abs. max.	36.6	36.5	23.3	14.2	13.2	14.8	23.7	31.0	37.0	36.6	39.2	41.3
Abs. min.	11.1	8.0	3.0	-3.5	-8.0	-7.0	-6.2	3.3	6.2	11.3	14.3	18.3
Tel Hadya												
Mean max.	34.3	28.0	20.1	11.2	7.8	8.5	15.9	23.9	28.0	32.7	34.9	37.6
Mean min.	17.1	13.2	6.8	2.5	-1.5	-0.3	1.2	5.6	10.5	15.5	18.8	21.1
Average	25.7	20.6	13.5	6.9	3.2	4.0	8.6	14.8	19.3	24.1	26.9	29.4
Abs. max.	40.3	35.6	24.6	14.3	13.5	14.3	23.6	30.8	38.4	38.6	40.6	42.5
Abs. min.	11.1	8.2	0.0	-4.5	-8.8	-6.2	-7.2	-0.2	5.5	11.8	11.2	18.2
Breda												
Mean max.	34.5	28.0	18.4	11.5	7.0	8.0	14.8	23.9	27.6	33.8	35.6	36.8
Mean min.	17.3	14.0	5.1	2.5	-2.5	-0.9	1.0	5.7	11.3	16.6	19.0	19.1
Average	25.9	21.0	11.8	7.0	2.3	3.6	7.9	14.8	19.5	25.2	27.3	28.0
Abs. max.	41.2	36.0	23.0	17.0	11.9	15.6	23.0	32.2	39.9	39.5	42.0	41.5
Abs. min.	13.0	7.1	-2.0	-4.0	-8.2	-6.5	-4.7	0.2	4.4	14.1	14.8	16.6
Boueidar												
Mean max.	33.3	27.1	19.7	10.2	6.9	8.1	15.8	23.8	27.6	33.3	35.3	37.5
Mean min.	12.6	10.5	3.9	0.6	-2.2	-0.6	0.7	3.7	9.5	13.2	14.7	16.6
Average	23.0	18.8	11.8	5.4	2.4	3.8	8.3	13.8	18.6	23.3	25.0	27.1
Abs. max.	39.3	33.0	23.9	13.6	11.0	14.9	24.9	30.8	39.0	38.5	41.0	41.8
Abs. min.	8.8	4.8	-2.0	-5.1	-8.1	-6.9	-6.8	-1.7	3.0	8.0	10.1	12.1
Ghrerife												
Mean max.	33.1	27.9	20.5	11.2	7.0	9.6	13.0	24.2	27.0	32.9	34.9	37.1
Mean min.	16.6	14.2	7.8	2.5	-1.9	1.5	0.3	8.7	13.5	17.1	18.9	20.7
Average	24.9	21.1	14.2	6.9	2.5	5.6	6.7	16.5	20.3	25.0	26.9	28.9
Abs. max.	39.4	35.2	23.2	14.2	11.0	17.8	22.0	31.1	38.6	38.3	41.0	41.5
Abs. min.	14.2	7.8	3.2	-3.5	-7.3	-4.0	-7.2	5.1	8.7	13.0	14.9	17.8
Terbol												
Mean max.	31.2	26.1	19.0	9.5	7.4	6.1	12.5	21.0	24.5	28.9	31.0	34.1
Mean min.	9.9	8.1	3.5	0.3	-2.9	-3.4	-0.2	4.3	7.0	10.2	10.3	12.0
Average	20.6	17.1	11.3	4.9	2.3	1.4	6.2	12.6	15.8	19.6	20.7	23.1
Abs. max.	37.0	32.0	24.0	15.5	11.0	15.0	24.0	29.5	34.5	34.0	36.0	38.2
Abs. min.	6.5	2.5	-1.5	-4.5	-8.5	-12.0	-6.0	-1.5	1.5	5.0	7.0	7.5

Table 1.3 Frost events during the 1991/92 season

	NOV	DEC	JAN	FEB	MAR	APR	MAY	Season
Jindiress								
No. of frost days	-	8	22	13	8	-	-	51
Abs. min. (°C)	-	-3.5	-8.0	-7.0	-6.2	-	-	-8.0
Tel Hadya								
No. of frost days	1	7	19	16	13	1	-	57
Abs. min. (°C)	-0.0	-4.5	-8.8	-6.2	-7.2	-0.2	-	-8.8
Breda								
No. of frost days	4	10	24	20	15	-	-	73
Abs. min. (°C)	-2.0	-4.0	-8.2	-6.5	-4.7	-	-	-8.2
Boueidar								
No. of frost days	3	18	22	16	12	1	-	72
Abs. min. (°C)	-2.0	-5.1	-8.1	-6.9	-6.8	-1.7	-	-8.1
Ghrerife								
No. of frost days	-	9	22	6	15	-	-	52
Abs. min. (°C)	-	-3.5	-7.3	-4.0	-7.2	-	-	-7.3
Terbol								
No. of frost days	2	12	24	25	20	5	-	88
Abs. min. (°C)	-1.5	-4.5	-8.5	-12.0	-6.0	-1.5	-	-12.0

Table 1.4 Frost events at 5 cm above the ground during the 1991/92 season

	NOV	DEC	JAN	FEB	MAR	APR	MAY	Season
Tel Hadya								
Frost days	3	11	19	21	16	1	-	71
Abs. min. (°C)	-0.5	-5.4	-9.6	-7.9	-8.3	-0.2	-	-9.6

2. AGROECOLOGICAL CHARACTERIZATION FOR RESOURCE MANAGEMENT

Introduction

This project has the long-term goal of helping ICARDA and national programs to solve weather-related agricultural problems and to improve the efficiency, relevance and targeting of research through the application of techniques which both characterize agro-ecological variability and predict how such variability will interact with and modify the impact of new technology.

The main focus of the project is on climate and on its local, daily manifestation everywhere as weather. Rarely mentioned, but taking an appreciable proportion of project resources, is the collection and computerization of daily weather data from six ICARDA stations in northern Syria. While summarized only very briefly in reports such as this, these data underpin many ICARDA research activities and are published in full annually in a separate document (ICARDA Meteorological Report).

Such daily weather data are feedstock for the development of climatic descriptors. This is one field to which, with hindsight, arguably ICARDA paid too little attention in the past. In house, it had little more than a subjective apprehension of the agro-ecological environments of its target region and the climatic needs and locations of its target crops. Graham walker's thrust towards the establishment of both meteorological and crop data bases was a start to remedy the deficiency, and -- through collaboration with FAO and national meteorological services -- we hope to continue it. His section in last year's report (FRMP 1992), "Preliminary Climatic Analysis for Syria" and again in this chapter "Climatic Adaptation of Chickpea in WANA" (2.1) provide simple examples of how such data bases may be utilized to relate crops and crop research to their agroclimatic context.

Another approach is through modelling. A major activity in this project over many years has been the development and application of the Spatial Weather Generator (SWG), a software package that can interpolate weather parameters (daily rainfall, temperature and solar radiation values) derived from scattered reporting stations to any intermediate point and generate simulated weather sequences, as required, for running crop-growth models (Goebel 1990, 1991). The second section of this chapter, "Validation and Use of Farmer Interview Methods" (2.2), utilizes the SWG and a crop-growth simulation model, SIMTAG, in conjunction with the interview and data analysis methods of März (1987, 1990) to identify, in a sample region of Morocco, areas in which farmers' crop yields are seriously below their environmental potential.

However, there is more to agro-ecological characterization than climate studies and crop modelling. Assertions are frequently made about the degradation of soil and vegetation resources and declining water tables, but hard facts are often scarce. In Resource Studies (2.3), two new research initiatives, on groundwater and on the application of remote sensing to the study of steppe degradation are outlined. In both cases, the eventual aim is to seek, in cooperation with the actual users, ways in which to utilize these resources more sustainably, but the first step is to establish what is really happening on the ground.

There are parallels here with some of the activities in the six case studies of the project "Dryland Resource Management" (2.4), each of which sets out to describe the current management practices and indigenous perceptions with regard to a specific fragile resource. This work will be reported more fully in the proceedings of a workshop to be held in May 1993.

The final section of this chapter is a very brief update on the Taurus Mountains Project (2.5), a collaborative enterprise with Çukurova University. A much longer account of the project's activities was given in this report last year. This work provides the widest interpretation of agroecological characterization, encompassing the socio-economics of the farming systems as well as the biophysical characteristics of the environments in which they are practised. (References at the end of each section.)

2.1 Climatic Adaptation of Chickpea in WANA

2.1.1 Where is chickpea grown in WANA?

Table 2.1.1 presents sown area, yield, and production data for countries in the West Asia/North Africa (WANA) region. This identifies Turkey as the dominant producer in the region. Only 7 countries produce more than 10,000 tonnes annually, and a broad analysis of chickpea in relation to climate must inevitably focus on the principal areas of production. Of these seven, Ethiopia is not included in the climatic analysis because chickpea environments there are more akin to the semi-arid tropics than to chickpea environments in the rest of WANA.

Table 2.1.1. Area, yield and production of chickpea for WANA countries

Country	Period	Area (th ha)	Yield (kg/ha)	Prod (th t)	Period	Area (th ha)	Yield (kg/ha)	Prod (th t)
Turkey	89-91	860	950	816	80-91	526	1010	533
Iran	87-89	563	530	301	84-89	513	630	321
Ethiopia					80-86	152	740	112
Morocco	89-91	74	760	56	61-91	97	650	62
Syria	89-91	49	520	26	80-91	69	660	46
Algeria	89-91	37	490	18	80-91	46	350	16
Tunisia					80-91	33	680	23
Lebanon	88-90	4	1200	5				
Iraq	88-90	3	800	2				
Sudan	89-91	1.3	1570	2.1	80-91	1.0	1170	1.1
Jordan	88-90	0.8	960	0.8	81-90	1.5	680	1.0
Egypt	88-90	6	1670	10				

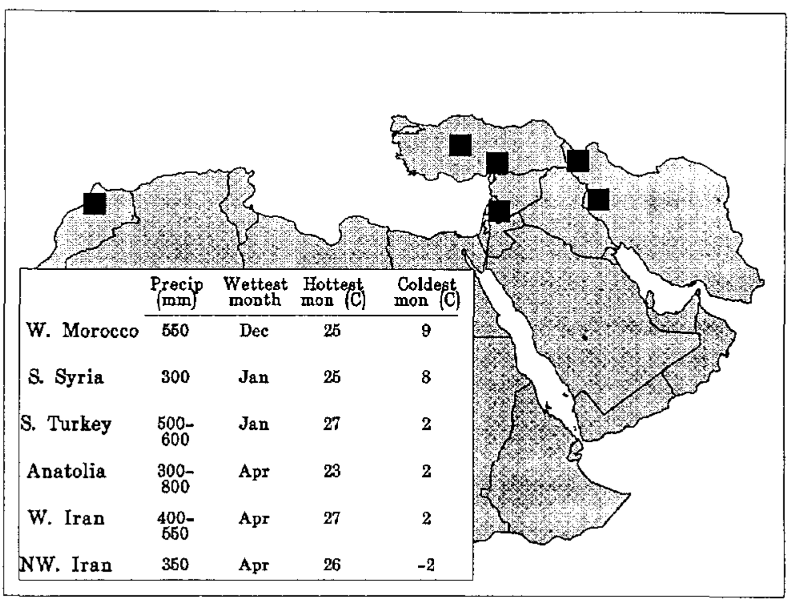
Notes: Iran data are for total food legumes, which chickpea dominates.
FAO figures for Iraq, Egypt and Lebanon

2.1.2 What is the general climatic environment for chickpea?

The WANA region is most usually considered to have a classic 'Mediterranean' climate, with a cool, wet winter and hot, dry summer. However, the looseness of this description masks important geographical variation in the means and extremes of temperature, and in the means and seasonal distributions of precipitation, in chickpea-growing regions.

Furthermore, in West Asia, much of the chickpea-growing region is at altitudes above 900 m, and elevation plays an important moderating effect on the thermal environment. Moreover, in these highland areas, the peak precipitation period tends to be in the spring (April-May) rather than winter (December-February).

The range of climates in which chickpea is grown in WANA therefore appears to be fairly broad (Fig. 2.1.1). For example, in coastal plains regions of North Africa January mean temperatures are typically 10°C or higher, while in north-western Iran the January



	Precip (mm)	Wettest month	Hottest mon (C)	Coldest mon (C)
W. Morocco	550	Dec	25	9
S. Syria	300	Jan	25	8
S. Turkey	500-600	Jan	27	2
Anatolia	300-800	Apr	23	2
W. Iran	400-550	Apr	27	2
NW. Iran	350	Apr	26	-2

Figure 2.1.1 Chickpea climates in WANA

mean is below zero. However, because the crop is almost exclusively spring-sown, chickpea-growing regions do have certain climatic aspects in common. These include: a cropping season that begins after the (normal) peak rainfall period, so the that crop is typically grown on residual moisture; high temperatures (daily maxima near or exceeding 30°C) and low daily mean relative humidity (near or below 50%) during the pod-filling stage; and negligible risk of damage from frost.

Despite these similarities, important environmental differences remain. We know that seeding date of spring chickpea is related to temperature, and that the chickpea-growing regions of WANA with the mildest winters have earlier (February) seeding, a longer growing season, and shorter mean daylength, than the regions that have the coldest winters and May seeding. Thus, in phenological terms, there is a broad spectrum of environments for spring chickpea in WANA.

For winter chickpea, which is sown before the normal peak precipitation period, the important environmental aspects are obviously somewhat different. Tolerance to frost is much more important than it is for spring chickpea, and tolerance to high temperatures during pod-filling is less important. However, because winter chickpea is new and has not been widely adopted, it is not yet possible to describe its preferred climatic setting. This actually creates an opportunity for a multi-disciplinary, systematic approach for new crop introduction, rather than an more empirical model. From a climatological perspective, identifying regions that meet crop-sensitive climatic criteria is in principle a relatively straightforward task, that should contribute to the more streamlined introduction of new germplasm/management packages.

2.1.3 Chickpea distribution in relation to climate

Where chickpea is grown depends on several factors, climate being one. Others factors include demand for chickpea, prices, competition from other crops, and availability of labor or land.

The geographical distribution of chickpea therefore represents an amalgam of a variety of influences, from which isolating the influence of one factor is hazardous. So it needs to be stated that any climate-based analysis of the distribution of the crop is subject to uncertainties due to non-climate factors.

A full climatic analysis of the distribution is also complicated by the nature of the published agricultural statistics usually used to describe the distribution. These statistics are based on primary or at best secondary-level national administrative units, which do not usually respect ecological boundaries. (Syria is an exception, since it collects statistics jointly at administrative and ecological levels.) Unless very detailed, eg. sub-district or village-level, statistics are available (these are never published) from statistics-gathering agencies, it is clearly better to have not only the agricultural statistics but also land capability maps/legends describing the land use. Alternatively, anecdotal or other information on crop distribution can be utilized. This all helps to avoid fuzziness in describing where a crop is grown, which would in turn lead to difficulties in defining the applicable climate.

The following sections list some country-based findings that contribute to a better understanding of the ecological limits of dryland spring chickpea cultivation.

a) *Turkey*. Chickpea can be grown on the Anatolian plateau where average annual precipitation is as low as 300 mm (Fig. 2.1.2), but here the average temperature of the hottest month (when the crop is pod-filling) is only about 22°C (Fig 2.1.3). In contrast, in south-east Anatolia (north of the Syrian border) chickpea cultivation is less frequent, even though precipitation is 400-600 mm. Lentil, which is winter-sown, is the predominant food legume in this area. Chickpea is not cultivated in north-eastern Turkey as the climate is not warm enough. Analysis

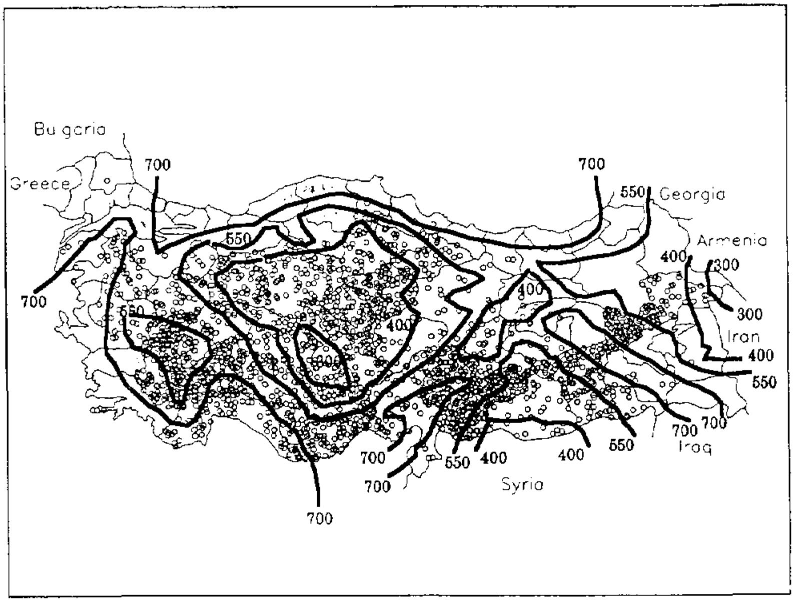


Figure 2.1.2 Chickpea in Turkey (one dot = 300 ha)
Isohyets of annual average precipitation

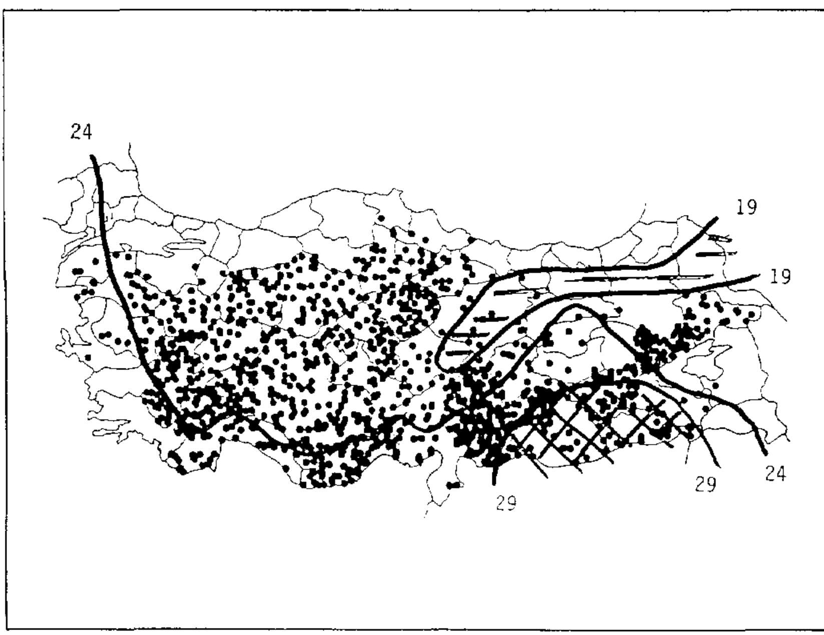


Figure 2.1.3 Chickpea in Turkey (one dot = 500 ha)
Average temperature (°C) of hottest month

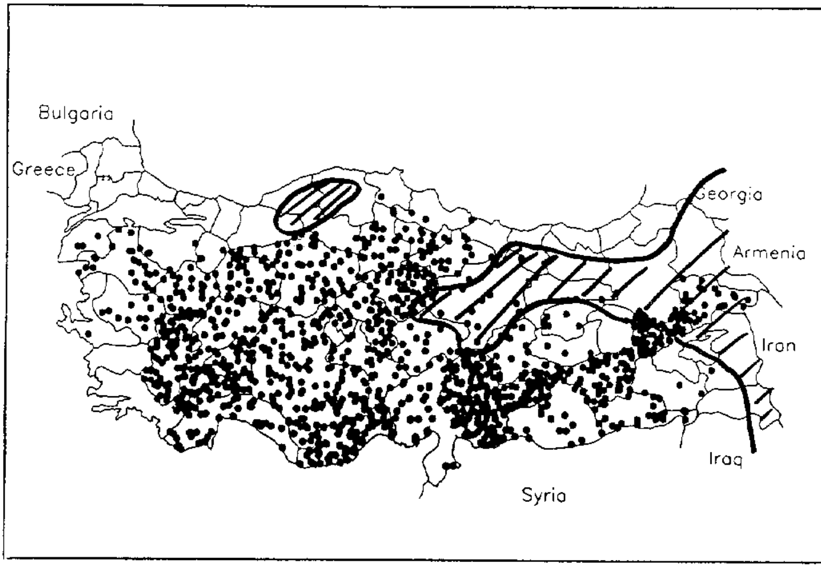


Figure 2.1.4 Chickpea in Turkey (one dot = 500 ha)
/// = less than 6 months with mean temperature >10°C

suggests that more than 6 months with mean temperature greater than 10°C is needed (Fig. 2.1.4). Chickpea is also little grown where humidity is high, which rules out areas near the northern (Black Sea) coast and the Mediterranean coast.

b) *Syria*. Chickpea is grown in the north-west in an extension of the belt in south-eastern Turkey, where precipitation averages more than 400 mm (Fig. 2.1.5) and the mean temperature of hottest month is less than 28°C. There is some cultivation now in the north-east (maybe 7,000 ha) where summers are hotter, but this is winter chickpea. In the Hauran area of southern Syria the density of cultivation is high (about 7% of the total land area in Daraa province) yet the precipitation is on average less than 400 mm, and in some parts less than 300 mm. Despite the low average precipitation, two additional factors contribute to the success of chickpea in this region. First, the average temperatures are lower than in north-west Syria, and second, in

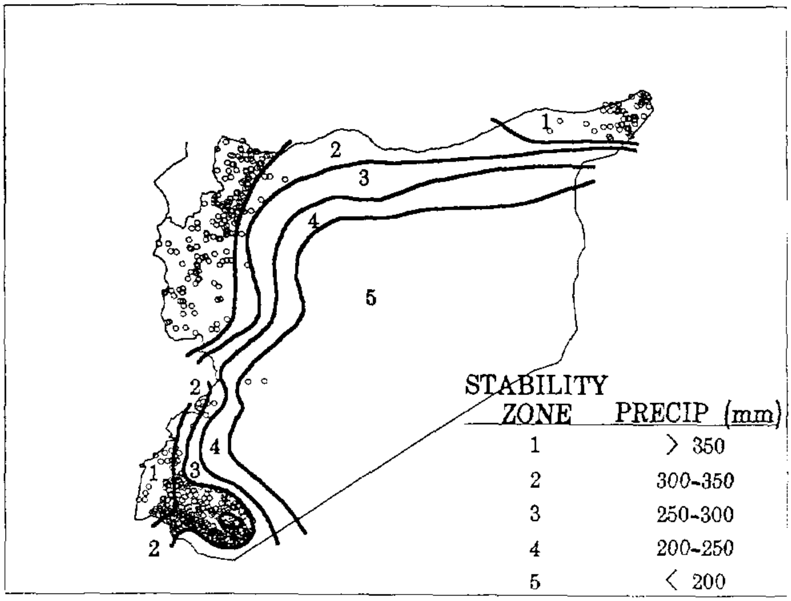


Figure 2.1.5 Chickpea in Syria (one dot = 100 ha)

very dry years, farmers may drastically cut back on sown area. By planting in March, farmers already know if there is enough water to sustain a crop, as less than 20% of the average September to August precipitation falls after mid-March in this area. Fig. 2.1.6 shows the variability of sown area in Daraa and Sweida provinces of southern Syria.

c) *Iran*. Published Iranian agricultural statistics aggregate food legumes, so it is not possible to separate chickpea from lentil and faba bean. However, chickpea is the dominant food legume, so the food legume distribution map does give a reasonable picture (supported by additional information) of where chickpea is concentrated.

This identifies provinces in NW and W Iran as having the highest density of chickpea cultivation (Fig. 2.1.7). In this region precipitation is mostly between 300 and 500 mm, of which

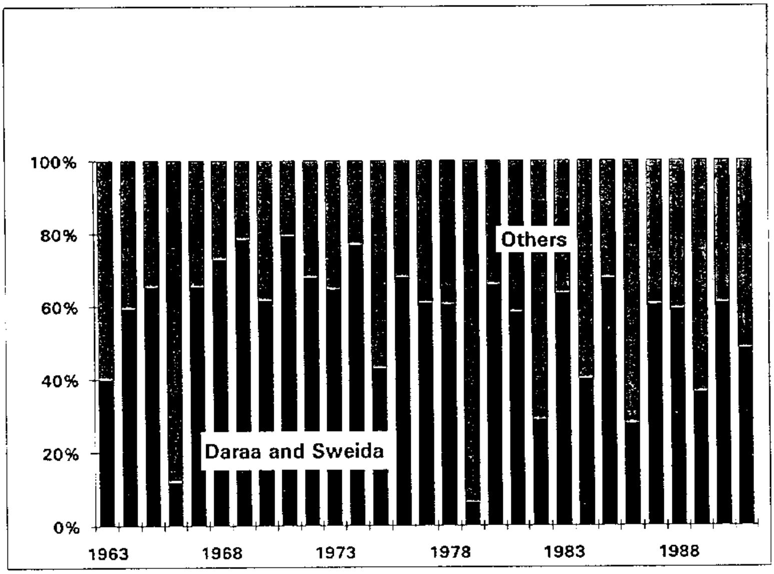


Figure 2.1.6 Syria chickpea area: % in Daraa and Sweida provinces

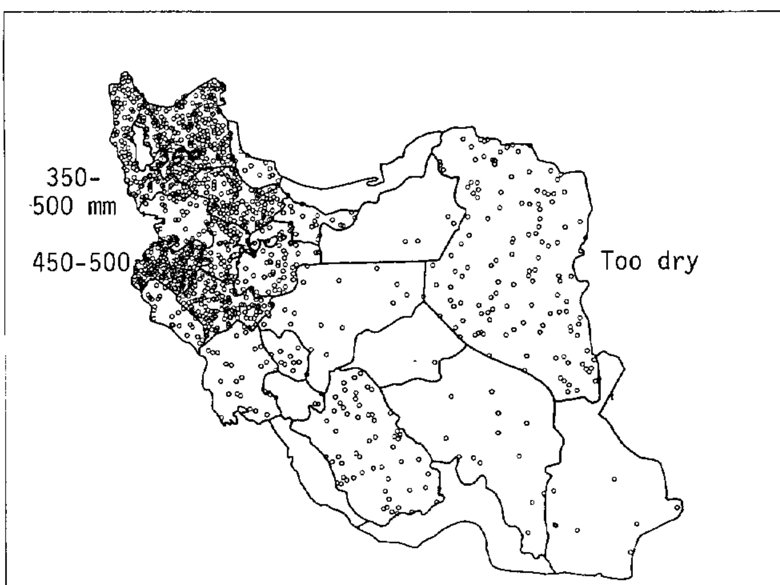


Figure 2.1.7 Food legumes in Iran (one dot = 400 ha)

up to 50% may fall as snow and is probably less effective than an equivalent amount of rainfall. The average temperature of the hottest month in the dominant provinces for chickpea ranges from 24 to 27°C, and the region has 7 months with an average temperature exceeding 10°C, so summers are about as long, but hotter, than on the Anatolian plateau (compare with Fig. 2.1.3).

d) *Morocco*. Most spring chickpea production in Morocco occurs where annual average precipitation is near or above 500 mm, although some chickpea cultivation is found as low as the 300 mm isohyet. (Fig. 2.1.8). In chickpea production areas in Morocco, 10 to 12 months have a mean temperature above 10°C, and the temperature of the hottest month ranges from 22 to 26°C. However, in contrast to most of West Asia (because of earlier seeding) the crop is mature well before the hottest time of the year.

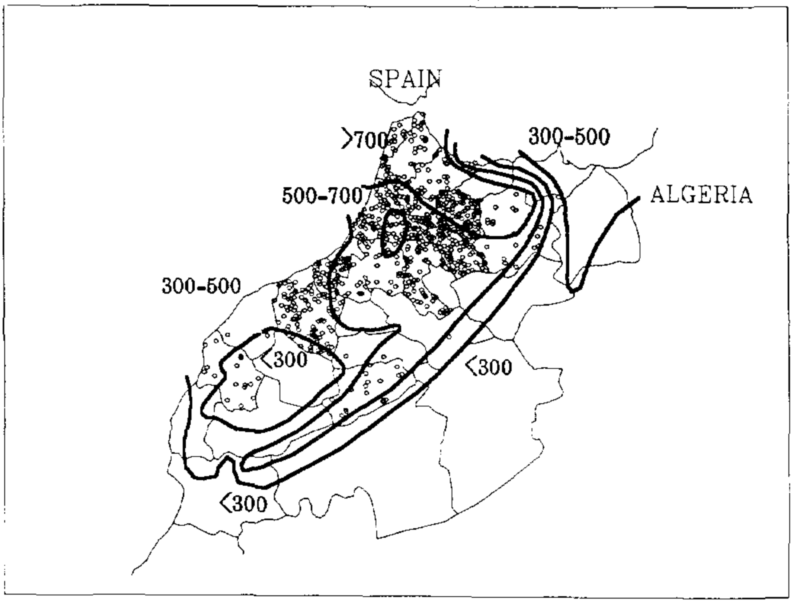


Figure 2.1.8 Chickpea in Morocco (one dot = 100 ha)

e) *Algeria*. Chickpea cultivation is most concentrated in the western coastal and adjoining interior plains in a triangle roughly defined by Oran, Sidi Bel Abbes and Tlemcen, and in the eastern coastal/interior plains between Skikda and Annaba on the coast, to Guelma, Constantine, and Mila inland. The eastern region has higher and more reliable rainfall - around 450 to 550 mm on average, while the western region is drier, and spring chickpea cropping mostly occurs between the 300 and 400 mm isohyets. Late (April) frost is a concern at higher elevations, and risk of frost combined with drought presumably limits chickpea cultivation in these areas. In the main regions of chickpea cultivation, the temperature of the hottest month is about 25°C.

From the above, we can determine that the principal climatic constraints defining the current boundaries of spring chickpea cultivation are:

- inadequate rainfall to meet evaporative demand, as in south-east Anatolia, north-central/north-east Syria and north-western Iraq (high temperature stress may also be a limitation) and in areas to the south of main rainfall belts in the Mahgreb;
- low summer temperature and a growing season that is too short to achieve crop maturity (north-eastern Turkey); and
- high rainfall and humidity, leading to disease constraints and seeding problems in wet soil (coastal areas of Turkey and Syria) though this seems to be less of a restriction in Mahgreb countries.

Any expansion of the chickpea zone of adaptation would have to be based on the removal of these constraints. The constraint that has received the most attention from breeders is the first, using winter rather than spring chickpea to break this climatic barrier. Winter chickpea's growing season would avoid the period of extremely high evaporative demand and high temperatures, and the largest potential area of expansion is in south-east Anatolia and extreme NE

Syria, where precipitation mostly exceeds 400 mm. However, this region averages a few days of frost in March, and frost can occur in April, so cold tolerance (or avoidance) is an important requirement.

Winter chickpea could also replace spring chickpea within the existing zone of adaptation, and regions with minimal frost risk are the most obvious candidates from a stress avoidance standpoint. However, these regions also tend to be relatively wet, and seeding would have to occur at the wettest (on average) time of year, eg. parts of northern Morocco, and complications might arise from seeding difficulties, disease, or waterlogging.

Replacing spring with winter chickpea in the relatively dry regions with low frost risk (eg. southern Syria) is a questionable option for farmers, because spring planting gives them an option not to plant if it is too dry (see next section). However, if there exist areas where rainfall, though low, is more reliable than in southern Syria, then these would be better candidates for replacement with winter chickpea.

Winter chickpea may also be a viable alternative to the spring type in the coldest regions in which spring chickpea is currently cultivated in WANA, ie. W/NW Iran. In Iran the growing season is short due to the late spring and high summer temperatures, and planting can also be delayed because the planting season coincides with/follows the wettest month (April). Yields are consequently low. With autumn seeding these problems are avoided. The crop will be insulated by snow for much of the winter, and as air temperature rises very rapidly in spring late frost may not be much of a threat. Some experimentation with autumn seeding has now begun in western Iran. This approach may also be possible in parts of the Anatolian plateau.

2.1.4 Chickpea yield and production in relation to climate

Time-averaged national mean chickpea yields in WANA range from less than 500 kg/ha (Algeria) to about 1000 kg/ha (Turkey) (Table 2.1.1).

That Turkey has the highest yields is not surprising because of the relatively high (for WANA) mean rainfall, and the relatively low summer temperatures on the Anatolian plateau where most of the crop is grown. Yields in Algeria seem low, given the importance of the crop in the eastern Guelma-Skikda region, which has average precipitation around 500 mm.

However, yield does not give a complete picture of the impact of weather variability on chickpea production. At least this is the case in Syria, where farmers may reduce the area sown if they judge conditions to be too dry to obtain an economic yield. This is practised most severely in the important southern provinces Daraa and Sweida (Fig. 2.1.6). The average annual precipitation there is the lowest among all of the main regions of chickpea production in WANA, and when precipitation looks like going well under the average, as in 1979 when Izra weather station recorded only 140 mm - about 50% of normal - from October 1978 to March 1979, farmers may refrain from seeding altogether.

Chickpea yield series are plotted in Fig. 2.1.9. The most striking aspect of this graph is the lack of any positive yield trends. In Turkey the slightly negative trend is likely related to

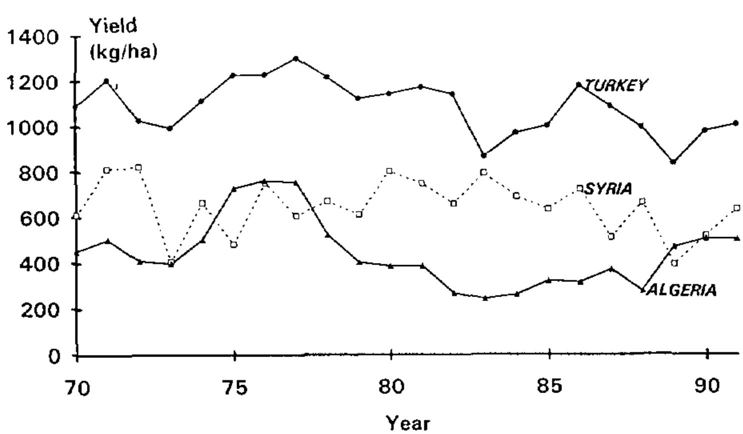


Figure 2.1.9 Chickpea yields, 1970-91

the replacement of fallow with chickpea and so a shifting of chickpea cultivation to drier conditions since 1980, when the fallow replacement program began in earnest. The series in Iran is too short to analyse. With the Algerian data, the trend in the magnitude of the area sown appears to have been responsible for the yield trends over the last 20 years - yield is negatively correlated with area. Syrian chickpea yield shows if anything a negative trend over the 1980s.

The absence of positive yield trends implies either a deteriorating climate offsetting technological gains, a systematic shift to drier areas, or, alternatively, limited technological advances and/or slow adoption by farmers. Given that the phenomenon of no yield increase is widespread, the last explanation seems most likely.

2.1.5 Fallow replacement by chickpea?

Turkey has achieved a very high (> 50%) replacement of fallow over the last decade or so, especially by lentil and chickpea. Together, these two crops have replaced about 1.5 million ha of fallow since 1980. The basis for fallow replacement was a production potential from continuous cropping greater than that from fallow cropping over the 2-year cycle. This was found (Guler and Karaca 1988) to depend on precipitation, soil depth, temperature and relative humidity, and a climatological index was derived to predict where fallow could be replaced. Comparison of the resulting map (Fig. 9 in Guler and Karaca) with the average annual precipitation in Turkey (see Fig. 2.1.2 above) shows that the area recommended to be retained under fallow closely approximates that with less than 400 mm annual average precipitation. This at least gives a guideline which other countries might use as a starting point for fallow replacement.

Iran has about 6 million ha of fallow (Pala, unpublished) the bulk of which is probably in areas too dry to contemplate continuous cropping. However, some fallow replacement is now occurring, notably in Bakhataran province, most of which receives 400-550 mm annual average precipitation. Bakhtaran has about 340,000 ha of cereals, 120,000 ha of fallow, and about 70,000 ha of chickpea. Chickpea area is increasing at the expense of fallow there, and presumably elsewhere, as the food legume area in Iran increased steadily from 430,000 to 617,000 ha between 1984 and 1989. Although it does not have the fallow replacement potential of Turkey, Iran appears to have good potential for fallow replacement by food legumes in the relatively wet west-central provinces of Bakhtaran, Lorestan, Ilam, and Kordestan. Prospects are more marginal in the drier areas of the north-west (west and east Azerbaijan, Hamadan and Zanjan).

In Algeria there is about 1.5 million ha of fallow, of which about 25% occurs where annual precipitation exceeds 400 mm. This would appear to offer some scope for increased cropping intensity. Syria has minimal prospect of replacing fallow with food legumes, as above a certain rainfall isohyet farmers are already required to crop continuously.

Fallow area in Morocco is estimated at more than 2 million ha and in Tunisia at 0.4 million ha (Pala, unpublished). The disposition of this land with respect to climatic zones was not available at the time of writing, although almost certainly the potential for significant replacement exists.

2.1.6 <u>Summary and conclusions</u>

Total sown chickpea area in WANA is constrained by a range of influences, of which climate is but one. From the climatic standpoint, expanding the zone of adaptation would have to involve new germplasm or management practices that act to move back the current climatic barriers. The primary barriers in different parts of the region are (Fig 2.1.10):

- high summer temperatures and/or low precipitation, sometimes in combination with winter/spring frost risk (south-east Anatolia, north-central and north-east Syria, and parts of Mahgreb);

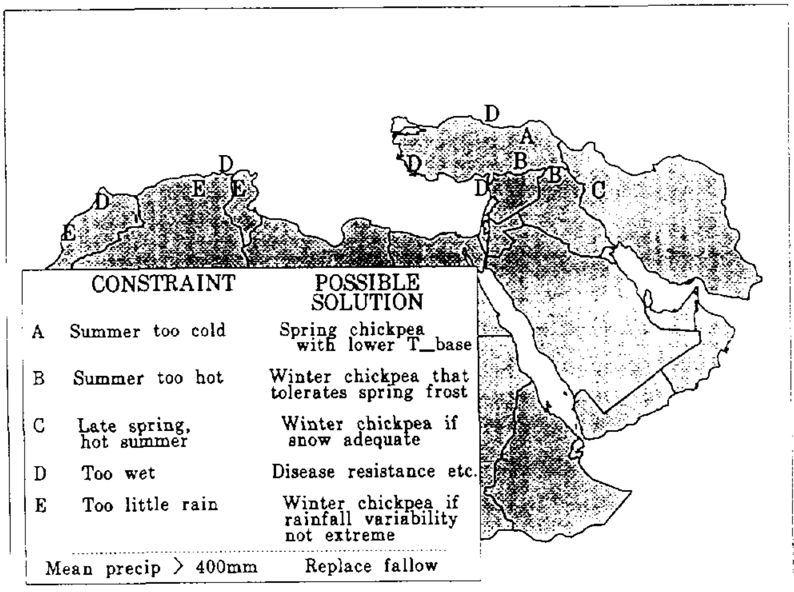


Figure 2.1.10 Chickpea climatic constraints

- low summer temperatures (north-east Turkey); and
- conditions that are too wet/humid (coastal regions throughout WANA).

Within existing areas of adaptation, the best chances for replacing spring with winter chickpea are where:

- frost risk is low and precipitation is not high but is relatively reliable (possibly some near-coastal areas of Mahgreb); and
- winter snowfall is sufficient to insulate the crop (wetter parts of western Iran, and possibly parts of the Anatolian plateau).

Superimposed on these possibilities, winter or spring chickpea may be a suitable crop for fallow replacement in Morocco, Algeria, Tunisia, and Iran.

National average chickpea yields appear unaffected by technology over the last 20 years. Either by management or breeding, the surest way to improve on this situation is to shift the phenology of the crop (make it earlier) to increase transpiration at the expense of evaporation from the soil surface, and to maximize the transpiration that is achieved at low air saturation deficit. Together, these changes would bring about dramatic improvements in water-use efficiency. Based on experience with other crops (cereals) that have both winter and spring habits, and on paired yield trials of winter and spring chickpea, this the surest way of bringing about yield gains. ***The late Graham Walker, with technical assistance from S. Moralli***

Reference

Guler, M. and Karaca, M. 1988. Agroclimatological criteria for determining the boundaries of fallow practice. pp 41-40 In Winter Cereals and Food Legumes in Mountainous Areas. (Eds J.P. Srivastava, M.C. Saxena, S. Varma and M. Tahir). ICARDA, Aleppo, Syria.

2.2 Validation and Use of Farmer Interview Methods to Define Crop Yield Distributions for Yield-Gap Estimation with Crop-Growth Simulation

2.2.1 Introduction

A method of characterizing crop yield distributions over time for a given soil type and crop rotation in a small farming district through single-visit farmer interviews (Nordblom et al. 1992) was developed from the interview and data analysis methods of März (1987, 1990). The method calls for selection of sample farmers having the same soils and crop rotations to minimize sources of variation in yields other than weather. Only older farmers (appearing over 55 years of age) should be interviewed, to benefit from their long experience in the local environment. Farmers are each asked to provide estimates of the frequencies of 'good', 'normal' and 'poor' seasons (per 10 years) **based on their lifetime experience with their particular soil and crop rotation.** Then they are asked the magnitudes of wheat grain yields they associate with each category of season and the yields of the other crops associated with these wheat yields.

The frequency and yield data are then summarized statistically to find the crop means, variances and covariances. These statistics become the inputs to the MULTISIM program for generating normally distributed, multivariate stochastic yield values (Nordblom et al. 1992) which can be plotted as cumulative frequency distributions.

The use of farmers' yield estimates has received considerable attention in 'farming systems' literature. Murphy et al (1991) provide a review of the subject, with an annotated bibliography, comparing methods for estimating farm and district cereal yields. In general, estimates from crop sampling, even where properly done, tend to overstate crop yields, approximating biological yield rather than economic yields in which there are normal harvesting losses. There are numerous sources of bias to guard against in recording farmers' yield estimates as well as in sample cutting estimates. Murphy et al (1991) showed that with proper care in technique, farmers' estimates can give more accurate measures of district yields than sample cutting. The purpose of our survey, however, was to define the distributions of crop yields over past years, based on farmers' recall.

Validation of the method requires the availability of appropriate historical data on crop yields to compare with yield distributions generated with data from farmer interviews. Ideally, the interviews should relate to the same soil type and the same crop varieties, managed in the same way, as those on which the historic yield records are based. Official district yield records, however, variously aggregate a range of growing conditions, including a diversity of soils and crop rotations, depending on the sampling and estimation procedures used. In districts with diverse growing conditions, a sample of farmers selected for uniformity of soils and crop management practices is unlikely to represent the district very well unless farms with different growing condition are in the minority.

In the present study, the Centres de Travaux (CT) in each of nine districts (five in Settat Province, Chaouia Region, and four in Safi Province, Abda Region, Fig. 2.2.1) were approached for advice on the single most typical soil and crop management condition in the district. This provided the information for targeting ten farmers for interview in each district. Interview locations are detailed in Table 2.2.1. The idea was to compare (a) distributions of crop yields based on farmer reports with those from (b) district records and also with (c) potential yield distributions generated by the crop growth simulation model, SIMTAG, for the same growing conditions.

Table 2.2.1. Identification of 1992 farmer interview locations and sample districts in Morocco

District Name	Interview Location	Soil Type	Soil Depth	% Stones	Typical Crop Rotation*
Chaouia Region					
Ras l'Ain	32°58'N 07°20'W	Dandoun	25-50cm	10	W-B-Lentil
Ouled Fares	32°47'N 07°09'W	Rmel	25-50cm	10	W-B-Lentil
Ain Derban	33°03'N 07°15'W	Fourar	< 25cm	10	W-B-F
Ouled Mhamed	33°07'N 07°03'W	Hamri	25-50cm	10	B-W-B-F
Ouled Omar	33°08'N 07°14'W	Tirs	> 100cm	0	W-B-faba bean
Abda Region					
Had l'Bkhati	32°27'N 08°38'W	Tirs	> 100cm	0	W-faba bean
Sida Aissa	32°23'N 08°53'W	Hrach	~ 50cm	10	W-M & B-M
Moul Bergui	32°32'N 09°00'W	Hrach	~ 25cm	30	W-M & B-M
Tlat Bouguedra	32°12'N 08°53'W	Hamri	25-50cm	10	W-M & B-M

W = wheat, M = maize, B = barley, F = fallow

Decisions on which districts to sample were made to include a wide range of growing conditions: different rainfall zones, soil

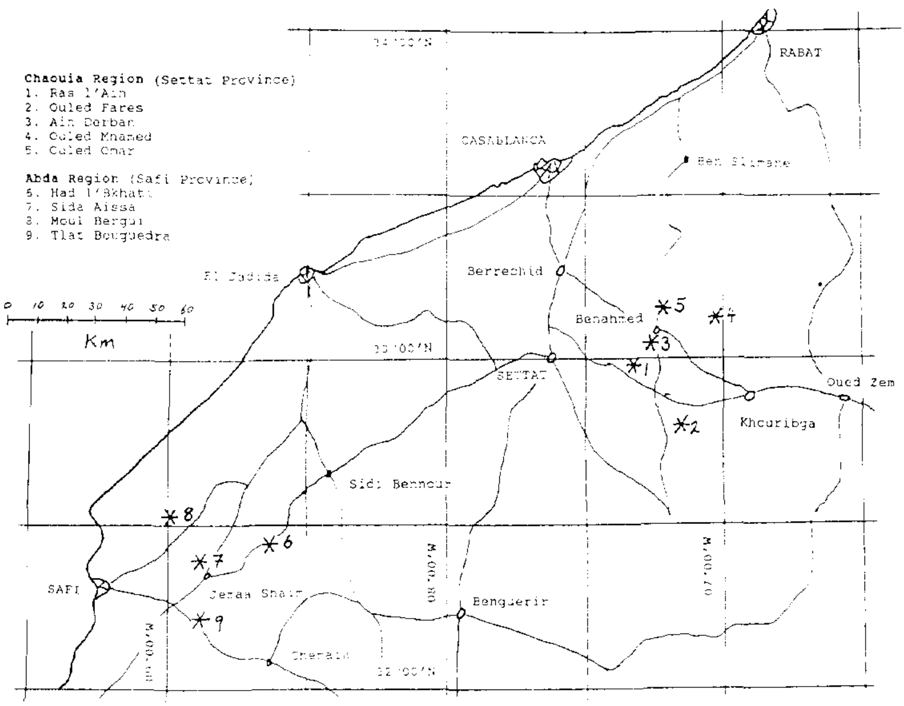


Figure 2.2.1 1992 Interview locations

types, elevations and crop rotations. Within the selected districts, however, only farmers having the "typical crop rotation and soil" of the district and located in a small geographic area within one or two km of the point designated by the coordinates (Table 2.2.1) were sought for interview. Only after completion of the interviews was it discovered that soil and weather data needed to run the SIMTAG wheat growth model were available for the four sample districts in Safi Province (Abda Region) but not for the five sample districts in Settat Province (Chaouia Region). An exception was provided by nine years of weather data for the Sidi El Aidi Research Station which has conditions most like one of the sample districts (Ouled Omar) in the Chaouia Region.

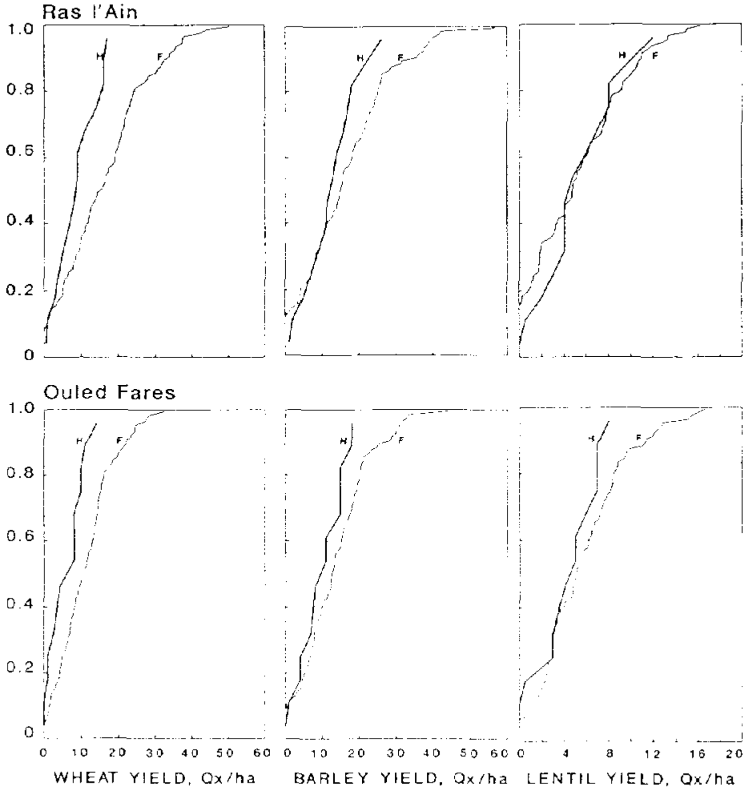
It was also discovered too late that historical yield statistics were available for the five sample districts in Chaouia (for 14 years in each), but not for the four districts in Abda. This leaves us able to validate the farmer interview method against historic records only in Chaouia, and then to show examples for Abda of estimating yield gaps between farmers' yields and potential yields (SIMTAG). The exception is the district of Ouled Omar, where interview data, historic yield records and nine years of comparable SIMTAG results are available.

2.2.2 Validation comparisons

For two interview locations in Chaouia Region, Ras l'Ain and Ouled Fares, we are able to compare yield distributions from farmers' recollection for three crops (wheat, barley and lentil) with district yield records of 14 years, plotted as cumulative distributions in each case (Fig. 2.2.2). In general, one may characterize the results as showing the farmers' distributions to have higher median yields and greater variance than the historical records for these districts.

This is not surprising, as the survey focussed only upon a single soil type and crop rotation in each district. While wheat and barley may be grown on other soils in these districts, lentil production may have been limited more narrowly to the soils and crop rotations targeted in the survey. This would explain the closer match between farmers' and district histories in the case of lentil crops. Greater variance is always expected at the level of a single farm than at the district level where there are diverse growing conditions due to soil, aspect or elevation, and different weather conditions from site to site in any given year.

By inspection, the match between farmers' and district level distributions in Fig. 2.2.2 is poorest for wheat, poor also for barley and poor for lentil at one of the survey locations (Ouled Fares). At the other location (Ras l'Ain) the match was best for



H = 14-year district yield, historical records.

F = 100-year distribution generated from farmer interview data with MULTISIM.

Qx = quintal = 100 kg

Figure 2.2.2 Wheat, barley and lentil yield distributions at Ras l'Ain and Ouled Fares, Chaouia region, Morocco

lentil, with nearly identical median values but greater variance in the farmers' distribution. Data for all three crops were gathered from the same ten farmers at each location, so differences in farmers could not explain the inconsistencies seen in these results.

That the farmers systematically overstated their yield experiences in the cases of wheat and barley, but not for lentil crops on the same land is not plausible, particularly as no taxes are levied against agricultural production. It is likely that the "short" 14-year historical records understate the long-run potentials; the average rainfall at El Jadida for the months of March through May (the time of wheat heading and grain filling) for the 1951-1990 period were 30% higher than the average for those months in the 14 years for which we have historical yield records in the Chaouia region. Most likely also is the possibility that our survey samples were not representative of these districts, focusing as they did on single crop rotations on common soil types.

At two other survey locations in the Chaouia Region, Ain Derban and Ouled Mhamed, the matches between district records and farmers' distributions are better but still imperfect (Fig. 2.2.3). The tendency for farmers' distributions to exceed those of the district remains: median yields of farmers' wheat and barley are 15 to 50% higher. But variances are closer to agreement and the high ends of the distributions are well matched, except in the case of wheat at Ain Derban where farmers reported chances of higher yields. Nevertheless, these two survey locations appear to represent their districts much better than those in Fig. 2.2.2.

The final survey location for which we have district records is Ouled Omar (Fig. 2.2.4). The farmer-district comparison has the same imperfections as noted in Fig. 2.2.2, suggesting a poor representativeness of our sample. Indeed, our survey concentrated on farmers with deep (>100 cm) "Tirs" soils, although shallower soils are also widely cultivated in the district. Median yields of wheat and barley of sample farmers were about 30% and 10% greater, respectively, than those of the district. The greatest differences were at the top ends of the distributions: farmers' distributions indicated yields perhaps 180% and 130% of the highest district yields of wheat and barley, respectively.

While this is a concern, it is important to remember the historical district series only goes back 14 years. As already mentioned in the case of El Jadida rainfall data, the 14 years of record may be unrepresentative of the climate, from the farmers' perspectives, as their experience may be two or three times longer. A 14-year record is rather short in these environments.

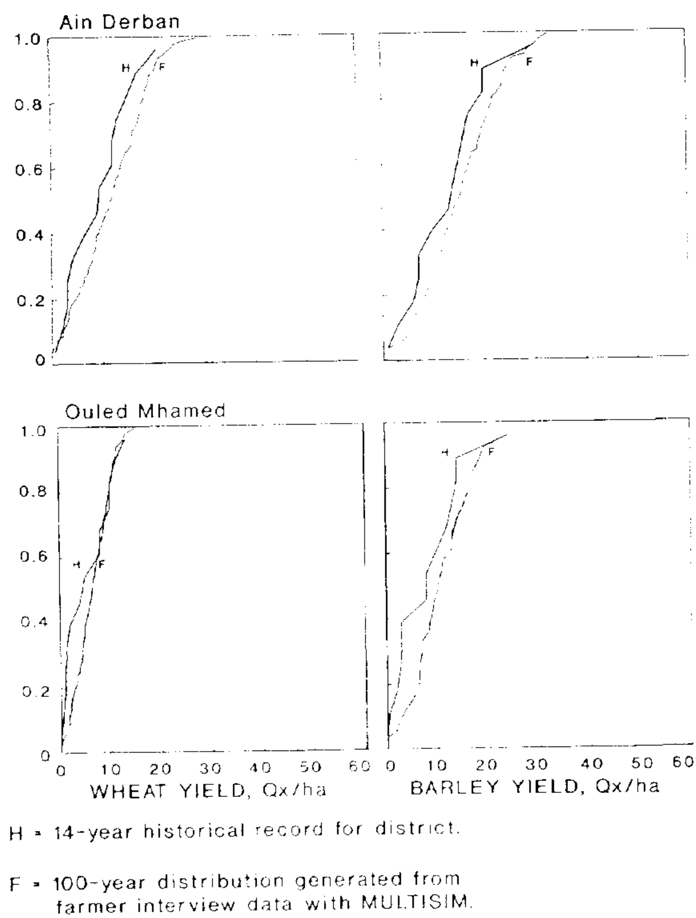
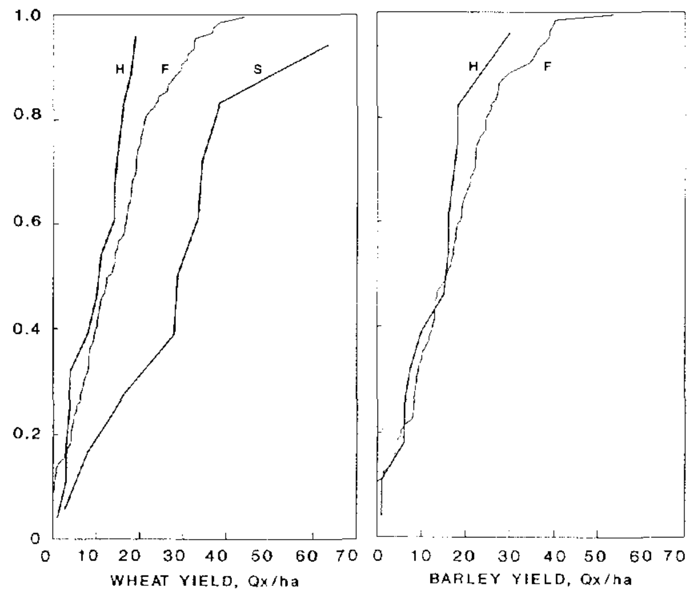


Figure 2.2.3 Wheat and barley yield distributions at Ain Derban and Ouled Mhamed, Chacuia region, Morocco



H = 14-year historical record for district.

F = 100 year distribution generated from farmer interview data with MULTISIM.

S = SIMTAG simulation of wheat yield based on 9 seasons of actual wheather records.

Figure 2.2.4 Wheat and barley yield distributions at Ouled Omar, Chaouia region, Morocco

2.2.3 <u>Comparison of historical, farmers' and simulated yields</u>

Climate and soils at the Ouled Omar survey location are similar to those of the Sidi El Aidi Research Station, for which nine years' daily weather records and detailed soil data are available. These data were sufficient to run the SIMTAG wheat growth model and, fortunately, include both poor and good crop years. The results are compared with the wheat yield distributions at Ouled Omar in Fig. 2.2.4. That SIMTAG results are similar to those measured in researcher-managed on-station experiments and, therefore, an indication of the potential wheat yield level has been shown by El Mourid (1988). If we can take the nine years' data from Sidi El Aidi as representative of the Ouled Omar survey location, then a large yield gap appears (Fig. 2.2.4). This may be the gap between farmers' crop performance and the potential performance under their conditions. Of course, it is not in any farmer's economic interest to attain the physical maximum potential yield.

However, such a large yield gap raises many additional questions. The farmers' distribution may understate the facts, although this possibility may be discounted in the present case for which corroborating historical records are available. The SIMTAG results may err where the soil or weather data are unrepresentative or where one of the simulation parameters is set inappropriately (eg. for wheat variety or sowing date). But if all these worries can be set aside, then there is a real yield gap, and we must ask what problems are preventing farmers from achieving their economic potential yields. There could be insect, weed, disease, plant nutrient, tillage or other constraints. Many of these may have economic solutions which could be found with a relevantly focussed research program. National programs of on-farm agronomic research could be planned and justified on such indications of yield gaps between farmers' and simulated yield.

2.2.4 A window on the future: rapid yield-gap analysis over large areas

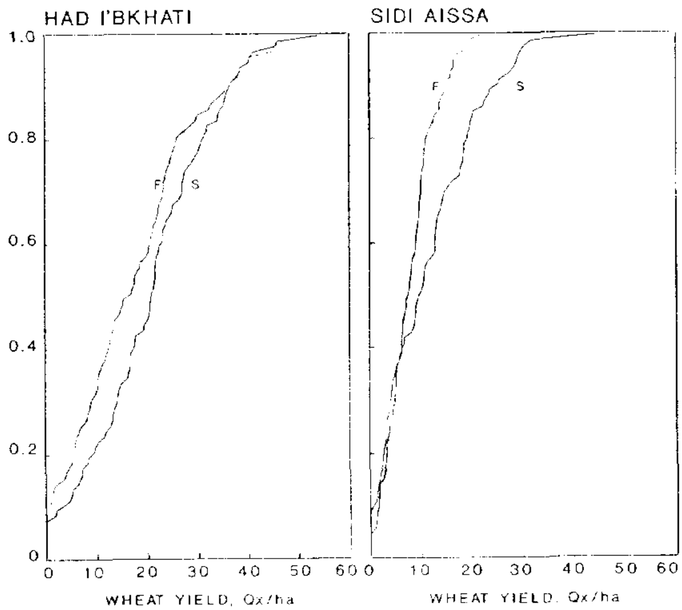
Most farms are not located next to a research station with a long series of weather records. However, this problem is largely solved by the Spatial Weather Generator (SWG) developed at ICARDA (Goebel 1990, 1991). Enabling an interpolation of weather parameters, derived from scattered reporting points with sufficiently long weather records, to any intermediate point, the SWG can generate a long series of daily rainfall, temperature and solar radiation values suitable for running a crop-growth simulation model; and where soil data are also available, growth simulations can be run to estimate potential yield distributions.

As part of the IDRC-funded project on agro-ecological characterization in which ICARDA, INRA-Morocco and DMN-Morocco are collaborating, weather data have been made available that permit the SWG to simulate weather at any site in Morocco north of 32°N and west of 7°30'W. This covers all four of our survey locations in Abda Region (Fig. 2.2.1), and 100 years of daily weather data were simulated for each of them. A 97-year SIMTAG run was completed using the SWG and soil data for each site. The results for two of them, Had l'Bkhati and Sidi Aissa were plotted as cumulative frequency distributions side by side with the farmers' distributions (Fig. 2.2.5).

Results for Had l'Bkhati indicate that farmers there are doing about as well as they could, with yields only about 20% below the median potential yield. Furthermore, the top end of the potential distribution is no more attractive than their own. **If this is the true yield gap**, there would be few economic payoffs from agronomic trials in this district.

Sidi Aissa presents a different story (Fig. 2.2.5), with median simulated potentials about one third greater than farmers' reported yields. Above the median, potential yields appear to exceed farmers' reports by 50 to 80% or more. The lower tails of the distributions are similar except that SIMTAG predicts zero yields about one year in ten at this location; the farmers' distribution suggests zero yields about one year in twenty. As crop yields below about 200 kg/ha will likely not be harvested (Nordblom 1983) but used for grazing, this difference may not be significant.

If this is the true yield gap at Sidi Aissa, it could be worthwhile for farmers, researchers, extensionists and planners to seek solutions to local constraints on yields. However, it is not certain that the correct soil data were used in these two examples;



F = 100-year distribution generated from farmer interview data with MULTISIM.

S = SIMTAG Simulation based on local soil descriptions and 97 seasons of daily weather from the Spatial Weather Generator (SWG)

Figure 2.2.5 Cumulative frequency distributions of wheat yields at contrasting sites in Abda region, Morocco: farmer reports vs. simulated potential yields

the large mapping units on the available map make it difficult to identify profiles representative of conditions at the interview locations. Until this can be done, the yield distributions simulated must be regarded as provisional. Further, SIMTAG often performs poorly for shallow soils, such as those at the final two survey locations (Moul Bergui and Tlat Bouguedra), simulating yield distributions well below those reported by farmers. These are not plotted, as further crop modelling work is needed to solve this problem.

2.2.5 Conclusions

These examples serve to illustrate the potential of the yield-gap approach. With an adequate soil map to guide sampling locations for farmer interviews and simulated weather data from the SWG to run SIMTAG, estimates of yield gaps can be made rapidly over large areas. Confidence in those estimates will be greatest where farmer reports can be corroborated with historical records, where the SWG output is not vitiated by topographic features or sparseness of weather records and where SIMTAG has been calibrated for the local soils. ***T. Nordblom, F. Shomo (PFLP), and W. Goebel and H. Harris (FRMP), with M. el Mourid, M. Boughlala, A. Ambri, M. el Oumri and the late H. Farihane (INRA, Morocco), and A. el Ouali and A. Jmiy (DMN, Morocco).***

References

El Mourid, M. 1988. Testing and validation of a wheat crop growth model in a semi-arid region. In Performance of wheat and barley cultivars under different soil moisture regimes in a semi-arid region. PhD Dissertation, Department of Agronomy, Iowa State University, Ames, Iowa, USA.

Goebel, W. 1990. Spatial rainfall generation: examples from a case study in the Aleppo area, NW Syria. In Farm Resource Management Program Annual Report for 1989. ICARDA-162 En. ICARDA, Aleppo, Syria. pp. 179-214.

Goebel, W. 1991. Spatial weather generation: more examples from a case study in the Aleppo area, NW Syria. In Farm Resource Management Program Annual Report for 1990. ICARDA-221 En. ICARDA, Aleppo, Syria. pp. 152-185.

März, U. 1987. Methods to simulate distributions of crop yields based on farmer interviews. ICARDA-117 En, ICARDA, Aleppo, Syria.

März, U. 1990. Farm classification and impact analysis of mixed farming systems in northern Syria. In Doppler, W. (ed). Farming Systems and Resource Economics in the Tropics, Vol. 7. Wissenschaftsverlag Vauk, Kiel, Germany.

Murphy, J., D.J. Casley and J.J. Curry. 1991. Farmers' estimations as a source of production data: methodological guidelines for cereals in Africa. World Bank Technical Paper Number 132. Africa Technical Department Series. The World Bank, Washington, D.C.

Nordblom, T.L. 1983. Livestock-crop interactions: the decision to harvest or to graze mature grain crops. Discussion Paper No. 10, Farming Systems Program, ICARDA, Aleppo, Syria.

Nordblom, T., F. Shomo, H. Farihane, M. el Mourid, M. Boughlala and H. Harris. 1992. Estimating the frequency distribution of farmers' crop yields. In Farm Resource Management Program Annual Report for 1991. ICARDA-038, ICARDA, Aleppo, Syria. pp. 145-158.

2.3 Resource Studies

2.3.1 Groundwater management study

A joint study of the problems of managing groundwater (particularly in areas in which supplemental irrigation is important) has been started with the Department of Irrigation and Water Use, SMAAR. The motivation of the study has come from two directions: the first is the widespread decline in groundwater levels in many parts of the region, including much of Syria. The second is the emergence in the social sciences of a new paradigm (in the strict sense) of human behavior which challenges the accepted wisdom that tells us that common property resources must always be the subject of destructive competition (the "tragedy of the commons" thesis). Between the two, we seem to have both a serious problem, and a newly-opened route to a solution.

The study consists of three parts: modelling farmers' irrigation decisions (in a realistic way); modelling the impact of these decisions on the level of groundwater resources; and investigating both the relevant literature, and farmers perceptions of the groundwater problem and of the regulation of pumping.

An essential first step in the study is the establishment of a network of collaborating farmers who are prepared to let us take regular measurements of water depths in their wells. This has now been completed, with the generous help of DIWU, Agricultural Extension, and Ministry of Irrigation staff in Hassake, Aleppo and Idleb Mohafazas.

2.3.2 Evaluation of effectiveness of remote sensing technology for land degradation in the steppe

In view of both the interest within ICARDA in expanding our activities into the steppe, and the growing concern with the way that the evidence for the phenomena of degradation and desertification has been overstated and distorted, it was decided to investigate the effectiveness of remote sensing technology for locating and measuring the extent of different ground conditions of interest.

Because of the large areas of steppe in the region, and the cost factors involved, it was further decided to concentrate on satellite-mounted systems. Of the available systems, Landsat TM seemed to offer the best combination of spatial resolution (the pixels represent an area of 30 x 30 meters on the ground) and spectral resolution (TM gathers radiation from the ground in 7 bands, distributed between the visible blue and thermal infra-red).

For convenience of access, and because of potentially productive overlaps with other ICARDA activities, a full scene of L/TM data (i.e. a 180 km square) with its northwest corner near Aleppo was acquired, in the form of computer-compatible tapes (CCTs). This scene reaches as far south as Palmyra, and as far east as the Rasafa neighborhood.

Sensing had been done in early July, this time being chosen to accommodate the interest in the extent (and mechanism) of irreversible changes in the physical basis of the system; and soil differences are least masked at that time of year by short-term changes in moisture content or by vegetation (at least, in the areas concerned). Five days fieldwork, preceded by two days general reconnaissance were done; records of traverses were maintained using the Global Positioning System for accurate location.

Attempts to process the tapes at Çukurova University failed, despite the generous efforts of Professors Yegingil and Dinc and their departments. The problems were mainly those of processing time and data transfer rates between essential components of the interpretation system (eg. geographic correction and image analysis), which were resident in different pieces of hardware. Attempts to process them at ICARDA fared even worse: we could not even read the tapes.

The tapes were then taken to the National Remote Sensing Centre, Farnborough, UK and processed on a GEMS system there. The arrangement is a useful but unusual one: users are given a free half-day tuition on the installation, and then charged for machine time and (separately) for advice, with the user doing the actual work. A number of general points emerged:

i) Working on <u>large</u> areas, with multi-way classifications, is very time consuming on small computers and really needs access to a large, fast (eg. mainframe) machine.

ii) Geographic correction (i.e making the image the same shape as a specified map projection) is essential but also time consuming.

iii) NRSC can re-format tapes fairly cheaply to get over problems of "readability"

iv) Attempts to automate the interpretation of the imagery have not yet succeeded (and are being generally abandoned); the best strategy appears to be to do fairly extensive pre-interpretation fieldwork, and to use this as a basis for a supervised classification, followed up by map-making using a combination of the unclassified (but contrast-enhanced, i.e "false colour") image, the classified image, and knowledge of ground conditions.

Supervised classification was used: areas of various known types are marked on the screen, and the software is used to classify the whole image, each pixel being assigned to the type which it most resembles, on a maximum likelihood criterion. It was found to be quite important to test the effect of varying the probability limits for inclusion in a particular class: the boundaries of "natural" classes expand and shrink by rather small amounts, and, with shrinkage, small "perforations" also appear in their on-screen images. However, "artificial" units shrink and expand wildly with small changes in the probability criterion. In the latter case, they often develop into "gobblers", i.e. classes that swallow other known natural units in a way that cuts across obvious technical relationships.

A number of factors of interest emerged:

i) For soils, and provided that one is looking at the nature of something corresponding to a land capability mapping unit, the technology is highly effective and discriminative in the circumstances described: dry soils, vegetation cover at its nadir. (The technology is known to be poor at discriminating small linear features, eg. gullies - which are of limited importance in the study area.)

ii) In the area studied, very large amounts of dust are undoubtedly being moved by wind, but, from the images and the fieldwork, they originate mostly (for exceptions, see below) from small and circumscribed areas, chiefly in sabkhas*, but also in wind-sorted re-deposits downwind of these, and much of the area is

* Unvegetated or sparsely vegetated areas, subject to periodic inundation and having considerable surface deposits of salts in the dry season.

neither eroded, nor at serious risk of wind erosion. (The widespread appearance of vegetation being on wind-eroded pedestals is misleading: in many cases, these are deposits of material excavated by ants, etc, associated with clumps of particular species of vegetation.)

iii) There is evidence of sheet, rill and gully erosion in the Isiriyah Hills; apart from the conditions described in (ii), general wind movement of soil is common only in the zone around the flat-topped hills in the North of the area, and the sandy area described in (iv).

iv) Extreme de-vegetation is restricted to areas of light, coarse grained soils to the east of the study area, and only there does (barley) cultivation have anything approaching a permanent effect on eliminating revegetation after cultivation. This is significant: except on the most unfavorable parent materials, the steppe (at least, in the study area) is almost certainly a resilient rather than a fragile habitat (even if we do not like the look of some of its repressed phases, or find them unproductive or otherwise inconvenient).

v) In the drier areas (i.e south and east of the current estimate of the position of the 200 mm isohyet) general cultivation of barley is not observed. It is restricted to wadis, where (natural) water concentration permits at least some growth.

Work still outstanding comprises a quantitative evaluation of the consistency of the output of the mapping process described above, and an attempt to investigate the significance of the different mapping units (i.e how they differ in capacity for rehabilitation, how they come to be as they are, etc). This will provide a firmer foundation for intended socio-economic studies, eg on policy impacts on land degradation, the effects of users' goals and constraints on steppe productivity, and the design of practical regimes of rehabilitation. *Peter Smith*

2.4 Dryland Resource Management and the Improvement of Rainfed Agriculture in the Drier Areas of West Asia and North Africa

2.4.1 Introduction

As has been outlined previously (FRMP 1991; 1992), this project comprises separate case studies in six countries with the general objectives: (1) at specific locations, to describe and analyze current resource management practices and indigenous perceptions of options for sustainable improvements; and (2) to initiate within national programs interdisciplinary activities that address the problems of farmers and herders in drier areas. This report summarizes the activities and achievements of each of the six national case-study teams during 1992, as they have worked towards the deadline of the final project workshop in May 1993.

2.4.2 Lebanon case study

The objectives of the case study were initially to document and assess the effect of developments and changes in the village of Buarij (on the eastern slopes of the Lebanon Mountains above Zahle) on the resource base and resource management, and to identify the determinants of these changes with a view to identifying where possible improvements in resource management could be made. It was proposed also to examine the interface between the village and other land users. When it was found that Buarij maintains traditional grazing arrangements with sheepowners from the village of Arsal (a large village on the western slopes of the Anti-Lebanon mountains), the study was extended to include Arsal.

Progress was initially delayed due to the harsh weather conditions (snow) over the 1991/92 winter. Initial village-level information (population, land holdings, etc.) was collected from official sources. A questionnaire was prepared for the inventory of resources and management strategies. In Buarij, this initial survey included all village households and will provide a data base from which a smaller sample will be selected for further in-depth surveys. Formal survey documents for more detailed investigations (on historical development; utilization of village production: crops, animal products, fuel, etc.; and land use and management) have also been prepared, but a lot of this information is expected to be obtained through informal discussions during visits to the village. In Arsal, the village is too large to conduct a complete inventory of resources and management strategies, by interviewing every household. So, a sample of households was selected, based on the data obtained from secondary sources.

An initial finding has been that Buarij is no longer a truly agricultural village, as described in Fuller (1961). Few villagers are full-time farmers, and few keep livestock, though most households still farm their orchards and vegetable plots close to the village. There are signs of extensive abandoned terracing around the village. It is now agreed, that, although Buarij may prove an interesting micro study in terms of historical development, the study, and any future proposals, should focus on Arsal.

Arsal is in a much drier zone. Average rainfall is said to be around 200 mm. Originally a Bedouin camp, it now has a population of approximately 40,000. The village 'owns' a vast area of the surrounding land, mainly "jurd" (hill land). No official figures are known yet, but the Mukhtar estimates 35,000 ha. Despite being in the 200 mm zone, this village does not fit ICARDA's classification of a "barley-livestock" system. It can best be described as a fruit tree-livestock system. The village owns large numbers of animals which exist mainly on grazing around the village in winter, and move down the Bekaa Valley to places like Buarij in the spring.

The village used to be known as a major wheat producer. The most striking feature of the village today is the area planted to fruit trees, primarily cherries, and vines. Many of the trees are new or only a few years old. It is not clear how many of the trees are planted on what was once wheat land, but many of the new plantations appear to be on virgin land on hillsides. In many cases these are planted in natural water catchment basins, and there is a variety of soil/water conservation practices: bunding, terraced banks, stone-walled terracing, etc. However, there are also examples of new plots on steep, exposed slopes, with cultivation up and down the slope. The team was told this was because the land was too steep to allow easy cultivation across the slope. However, the farmers also report that as most precipitation falls as snow, that slowly melts into the soil, there is little soil erosion. From first observations the uncultivated hill land provides very poor grazing.

Arsal provides an interesting study for the purposes of the project. A number of issues can be addressed: notably, soil/water management techniques in fruit tree plantations, and the question of how the village supports its livestock numbers (and, associated with this, possible improvements of village rangeland).

[*Case-study team*: Drs Shady Hamadeh (Livestock Scientist), Helga Seeden (Ethno-archaeologist), Rami Zureik (Soil Scientist) and Riad Baalbaki (Agronomist), all from the American University of Beirut.]

2.4.3 Libya case study

The original proposal was to compare different systems of land use in the Jeffara plain. These included the "open" range land, a government cereal project, and a government range reserve. These were to be compared in terms of their management (how used, by whom), their productivity (cereal yields and vegetative production), and their impact on the resource base. Local difficulties, including the lack of a socio-economist in the team, delayed the start of substantive work in this study; and suggestions were made either to reduce the scope of the study in the original area or choose a new area. Recent news from Libya indicates that an alternative study site has been identified and a socio-economist has joined the team.

[*Case-study team*: Dr M. Idrissi and Mr A. Semakhi, of the Agricultural Research Center, Tripoli.]

2.4.4 Jordan case study

This study has the objective of establishing the differences between alternative forms of rangeland management in terms of their effect on rangeland resources, and in relation to the local land users' production aims and perspectives. The study location comprises a land transect in southern Jordan which runs east and west of the Lajoun range reserve. Five distinct areas of land management are included:

1. The governmental range reserve (protected since 1981).
2. The cooperative range reserve (protected since 1983).
3. A new area of governmental range reserve (protected since 1990; a small area has been planted to atriplex).
4. Open rangeland.
5. Barley production.

The team has made good progress in the technical assessments of rangeland vegetation including measurements of vegetative production (including barley), vegetation composition, and soil samples. A questionnaire survey of about 90 farmers in the study area has been completed and analysis is underway.

The next step is to combine the technical information with information on different management practices (obtained from interviews with those responsible for management of the various reserves) and with information from the detailed farm level survey, in order to identify the critical factors and produce recommendations for further research or development activities.

[*Case-study technical committee*: Dr K. Tadros and Mr N. Katkhuda (NCARTT), Dr M. Salem and Dr A.F. Al Gadi (University of Jordan).]

2.4.5 Pakistan case study

The study involves (i) an economic analysis of the water harvesting trials conducted by the Arid Zone Research Institute (AZRI), Quetta, Balochistan, over the last 4 years, incorporating results from trials and historical data on rainfall in order to simulate yields and net returns from the different treatments under variable rainfall conditions; (ii) a survey of local farmers' perceptions of water-harvesting with a view to assessing the adoption potential of the system under test.

The survey, which will provide information on farmers' land-use patterns, traditional practices, and their perceptions of water harvesting, is being conducted in 5 agro-ecological zones, with 25-30 farmers in each zone. A draft questionnaire has been prepared. The first part will be completed through interviews with the farmer; the second part consists of observations taken on the farm.

Technical problems associated with the model being used to estimate run-off from the water catchment plots in the trials have been resolved; and the modelling work for economic and risk analysis (which will use the run-off model, combined with a model for estimating soil water availability, to simulate yields using historical rainfall data) can proceed.

[*Case-study team*: Dr U. Mustapha, Mr K.N. Babar, Mr Z.A. Qureshi (AZRI).]

2.4.6 Tunisia case study

This study is being conducted by a team of scientists from the Institut des Regions Arides (IRA) which already has considerable experience in conducting research into resource degradation and land use management in southern Tunisia. This is perhaps the only case study where the team is in a position to conduct some trial developmental work, as well as identify problems and constraints.

The team has selected a study area of approx. 15,000 ha (7,000 ha in the Jeffara plain and 8000 ha in the jebel) near to Medinine. A soil map has been produced based on a field survey of soils. An inventory of rangeland vegetation throughout the study area has been completed and the area subsequently divided into different study areas (production zones) based on this inventory. A map has been produced. The jebel areas have been divided into ten major "jessour" (water harvesting) systems of roughly 800 ha each and these have been mapped. Surveys of crop production and livestock production have been completed. The socio-economic survey is focussed on three villages at varying altitudes in the jebel: Argoub, Graguer and Ndeina. The people from Argoub were originally from the plain and still own land there so the survey will cover activities in the plain. The team is still in the process of analyzing the data.

[*Case-study team*: Dr H. Khattali, Dr B. Chahbani, Dr N. Naceur, Dr M. Neffati, and Dr T. Khorchani (IRA).]

2.4.7 Yemen case study

This study focuses on the deterioration of the traditional system of water harvesting (collapse of terracing on the upper slopes, leading to increased runoff and to floods and erosion of valuable agricultural land in the wadis).

The study area chosen is located in the south-eastern part of Hajjah Province, running from the mountain top down to the village of Kohlan and down the slopes to Wadi Sharis. The area can be divided agro-ecologically into three zones: the upper slopes, the middle and lower slopes, and the wadi banks and valley floor. Each of these zones is characterized by its own rainfall and temperature regime, terrace and land use pattern, and cropping system, and, we would expect, by different resource management practices.

This area was chosen for the following reasons: 1) it is broadly representative of both the agro-ecology and the resource problems of Yemen's western escarpment, the major rainfed agricultural region in the country; 2) it contains within a fairly small area the major elements of the mountain slope-wadi bed system of water and soil management; and 3) it is readily accessible from the operational bases of the study team, the Agricultural Research and Extension

Authority (AREA) and the University of Sana'a (UOS).

A course to train six field recorders in survey techniques and analysis of questionnaire data was conducted in September 1992 (by R. Tutwiler and M. Saade). In the pre-test of the questionnaire thirty farmers located in six distinct agro-ecological zones were interviewed. As a result of the observations gained during the pre-test field trips, the team were better able to define the agro-ecological and socio-economic variability within the study area which has now been divided into six zones which were sampled for the survey. Delineation of these zones and sampling for the formal survey were greatly assisted by the development of maps. The team has made considerable progress in mapping and classifying land based on agro-climatic, soil, land use and resource condition factors. They have developed and applied a scheme for classifying terraced land by degree of degradation using aerial photographs and field surveys. Maps of the location of these terrace classifications can be overlaid with maps of soil, rainfall, cropping pattern, demographic and other data. From the pre-test interviews it was clearly established that the case study focus on the degradation of terraced land is of direct relevance to farmers' concerns in the region.

[*Case-study team*: M. Al-Aqil (Coordinator, Agronomy and Crops), M. Sallam (Extension), O. Al-Saghier (Livestock), M. Al-Farah (Rangeland), all from AREA; M. Al-Hebshi (Coordinator, Agricultural Economics), I. Al-Fatiah (Soil and Water), A. Ghanem (Rural Sociology), from UOS.]

Elizabeth Bailey.

References

FRMP, 1991, 1992. Annual Reports for 1990 and 1991. Farm Resource Management Program, ICARDA, Aleppo, Syria.

Fuller, A., 1961. Buarij, Portrait of a Lebanese Muslim village.

2.5 Çukurova University/ICARDA Collaborative Project: Development of Small-Scale Farmers of the Taurus Mountains of Turkey

The joint ICARDA/University of Çukurova Taurus Mountain project (see FRMP 1992, for details) has completed the first two years of a projected five-year life span. Initial results from the 1991/92 growing season have indicated that livestock production, particularly that of goats, is considerably more profitable than crop production at current yield levels. Farm size did not appear to be a major variable at issue when compared with that of enterprise mixture (pure crop, mixed, pure livestock). Minor scale activities such as pome and stone fruit production and apiculture were generally more profitable than annual crop production, but the extent of these sorts of enterprises in the target villages is currently small. The potential for increased profitability from apiculture appears to be large, given the introduction of some simple techniques for improved management such as use of Fluvalinate strips for control of Varroa jacobsoni and the elimination of chalkbrood disease.

Preliminary germplasm evaluation trials of cereals, food legumes and forage mixtures indicated that there was considerable scope for improvement in crop productivity. In the case of wheat for example, farmers have been growing until now a range of varieties adapted to the Adana plain conditions which are largely unsuited to their mountain environment. In Kiralan village small-plot yields exceeding 4 t/ha were recorded for the facultative and winter varieties Gun-91 and Bezostaya, suggesting considerable promise for improved cereal production if these yield levels are repeated in subsequent seasons.

Pasture management studies continued in 1992. Natural pasture yields were dependent to some extent on elevation and ranged from approximately 2.7 t/ha in the lower Kiralan village to 1.4 t/ha in the higher pastures at Yukari Beklemedik. Grazing pressure in the higher pastures was lower than expected (approximately 35% utilization) which possibly implies potential for increased animal production. Initial pilot studies on the introduction of crossbread goats (German Fawn x local Hair) indicated potentially greater milk yields. These studies are to be expanded in 1992/93 for verification purposes. *D. Keatinge (IC), based on material supplied by Çukurova University team, led by Prof. Onur Erkan.*

Reference

FRMP, 1992. Annual report for 1991. Farm Resource Management Program, ICARDA, Aleppo, Syria.

3. MANAGEMENT OF SOIL, WATER AND NUTRIENTS

Introduction

The long-term goal of this project is the development of productive and sustainable agricultural systems which optimize the efficiency of use and which conserve the basic and vital resources of soil, water and crop nutrients. Under this fairly broad umbrella, research is conducted on soil conservation and management; water conservation and management; soil fertility, nutrient management and fertilizer use; specific crops and their management in a systems context; and crop rotations. There are many linkages from those activities to the work of other Programs and to other Projects within FRMP.

The present chapter reports on:

- Soil conservation. In a second year of testing and utilizing techniques for wind erosion measurement, environmental conditions were less extreme, but conservation tillage was shown to reduce soil movement almost to zero in a vulnerable grazed stubble field (3.1); and, so far, in an agronomic investigation of barley rotations intercropped with atriplex hedges (a potential erosion control technique), there is no evidence of the bushes affecting arable crop growth (3.2).
- Water management. Supplemental irrigation is a crucial concept for the efficient utilization of limited supplies of water, but it is difficult to conduct accurate experiments with overhead sprinkler systems; hence, the evaluation of a drip system reported here (3.3).
- Soil fertility and nutrient cycling. Nitrogen dynamics in long-term wheat rotations is the subject of two short reports. The effects of the inclusion of legumes are evident in topsoil values of mineral-N, total N and organic matter (3.4), and a collaborative project with Reading University is monitoring

nitrogen balances and flows using ^{15}N (3.5). In a related activity, ^{15}N is being used also to determine the efficiency of use by wheat of nitrogen fertilizer under different regimes of supplemental irrigation (3.6). And the future activities of the ongoing regional soil fertility network are appraised in section 3.7.

- Oilseed crops. Although most WANA countries import much of the edible oil they consume, oilseed crops still get little research attention. Here we report production comparisons of rape and mustard varieties under dryland conditions and supplemental irrigation; of safflower varieties under dryland conditions; and of sunflower varieties under different supplemental irrigation regimes (3.8).
- On-farm crop studies. The ultimate test of any new cultivar or research technology is its performance on farmers' fields and its adoption by farmers. A summary of three years on-farm barley trials, collaborative with Cereals Program, confirms the importance of selection venue on cultivar performance in a harsh growth environment (3.9); and there is a report also of preliminary findings in a study of farmers' wheat yields and adoption of new varieties in relation to the local cropping environment and management practices (3.10).
- Crop rotations. Over a period of years, the biological and economic productivity of an arable field depends not only on the individual crops grown but also on their sequence, on the carry-over effects from one crop and its management to the next crop, and on slowly building cumulative effects. One conclusion from the ongoing long-term wheat rotations at Tel Hadya (3.11; also referred to in 3.4 and 3.5) and long-term barley rotations at Tel Hadya and Breda (3.12) is that continuous cropping with cereals is not the most productive rotation in either situation.

3.1 Wind Erosion Studies

3.1.1 Introduction

The erosion of soil by wind depends on the interaction between wind speed and soil resistance to movement. Erosion occurs when the wind speed exceeds a threshold above which the power of the wind to move soil particles is greater than the resistance of the particles to movement. This threshold speed is a function of the conditions on and near the soil surface, in particular, the following factors: wind speed, surface cover, surface roughness, surface crusting, and the size and stability of soil aggregates.

The aim of the present study is to determine the magnitude of erosion losses and to quantify their relationships to those factors, under Syrian conditions. As noted previously (FRMP 1992), erosive winds occur here mainly during June, July and August. At this time of year the soil is dry and the surface cover very sparse. After harvest in May and June, sheep graze cereal stubble, leaving large areas almost entirely bare. Erodibility is increased as soil aggregates are pulverized by the hooves of sheep during grazing. Summer is therefore the vulnerable period for wind erosion.

During summer 1992, erosion was studied at 5 locations (11 fields) along a rainfall and soils gradient (Table 3.1.1). Wind data and soil surface conditions for those locations are described in sections 3.1.2 and 3.1.3. Wind erosion measurements and physical and chemical analyses of the collected soil are presented in sections 3.1.4 and 3.1.5, interpretation of all information in section 3.1.6 and conclusions in section 3.1.7.

3.1.2 Wind Speeds and Direction During the Erosive Season of 1992

Average monthly wind speeds at five ICARDA stations (Table 3.1.2) were substantially lower than the long-term means. At Breda, Tel Hadya and Ghrerife, reductions in wind speeds over the whole erosive season were 27, 18 and 18 %. Wind speeds were highest in July, but at Breda, Tel Hadya and Ghrerife these were 23, 7 and 9% below the long-term means.

Table 3.1.1. Wind erosion study sites, 1992

No.	Location	Field	Previous crop	Harvest/tillage details
1	Tel Hadya	THM	Medicago	
2	Breda	a) BRF	Bare fallow	
		b) BRFSH	Bare fallow	Spike-toothed harrow
3	Breda	a) BBG	Barley	Combine-harvested, then grazed
		b) BBGDF	Barley	As 3a, then ducksfoot tillage (100%)
4	Urdjl	UBH	Barley	Hand-harvested, all biomass removed
5	Urjdl	UHT	Barley	Hand-harvested. ducksfoot tillage (20%)
6	El Azami	ENG	Barley	Crop lines E-W, combine-harvested, then grazed
7	El Azami	ENT	Barley	As 6, then ducksfoot tillage 20%)
8	El Azami	ESG	Barley	Crop lines N-S, combine-harvested, then grazed
9	El Azami	EST	Barley	As 8, then ducksfoot tillage (20%)
10	Mragha	MNP	Degraded steppe	
11	Mragha	MIP	Steppe improved with *Atriplex spp*	

Urdjl is 7 km south of Breda; El Azami is 9 km south of Khanasser. Ducksfoot tillage (20%) is one pass of a ducksfoot cultivar every 10 m, disturbing about 20% of the total surface.

Table 3.1.2. Average wind speed (m/s) at 2 m height during the erosive season of 1992 at Jindiress, Tel Hadya, Breda, Ghrerife and Bouider

	Ji	TH	Br	GH	Bu
June	3.32	3.22	3.57	3.33	2.91
July	4.59	5.20	4.32	3.80	3.61
August	3.94	4.29	3.56	2.84	2.65
September	2.70	3.01	2.54	2.04	1.77
Average	**3.64**	**3.93**	**3.50**	**3.00**	**2.74**

The wind direction distributions (Table 3.1.3) conformed well with long-term values. Westerly winds were slightly less predominant. In June and September, the beginning and end of the season, winds were mainly from the north-west. In July and August, the period with the highest wind speeds, winds were predominantly westerly, as in the long-term distribution. At Tel Hadya, Breda and Mragha, detailed wind data were collected (Table 3.1.4); at Urdjl and El Azami, average daily wind speeds were measured for part of the erosive season (Table 3.1.5).

Table 3.1.3. Wind direction distribution (percent) during the erosive season of 1992 at Tel Hadya (10 m height)

	N	NE	E	SE	S	SW	W	NW
June	3	0	0	0	0	3	37	57
July	0	0	0	0	0	10	77	13
August	10	3	0	0	0	3	65	19
September	20	3	0	0	0	7	27	43
Average	**8**	**2**	**0**	**0**	**0**	**6**	**51**	**33**

Table 3.1.4. Average wind speed, average maximum wind speed, highest daily average wind speed, highest hourly average wind speed and maximum wind speed (m/s) at 2 m height at Tel Hadya, Breda and Mragha

1992	Av.	Av. max	H.Day Av	H.Hour Av	Max
TH					
July	-	-	8.7	10.5	13.3
Aug	4.4	8.7	7.7	10.1	12.9
Sept	3.4	8.1	6.4	6.7	13.9
Breda					
June	3.6		6.7	10.2	
July	4.3		6.9	10.7	
Aug	3.5		5.8	9.9	
Sept	2.5		4.7	9.2	
Mragha					
June	4.3	9.5	5.9	10.4	13.0
July	4.8	9.8	6.6	10.5	12.6
Aug	4.2	8.6	7.2	9.9	11.7
Sept	3.1	7.0	4.0	8.7	10.8

Table 3.1.5. Average wind speed and highest daily average wind speed (m/s) at 2 m height for Urdjl and El Azami (* = incomplete record)

1992	Urdjl		El Azami	
	Average	H.Day Av	Average	H.Day Av
June	3.9*	4.4*	-	-
July	3.9	5.6	4.8*	6.5*
August	3.2	5.9	3.6	6.6
September	2.5*	4.3*	2.3*	3.3*

Although wind speeds were substantially below average, erosive conditions occurred at some time at all stations. The detailed data (Table 3.1.4) show maximum average hourly wind speeds over 10 m/s and maximum wind speeds over 13 m/s at Tel Hadya, Breda and Mragha. Such speeds could lead to substantial erosion from an erodible soil.

3.1.3 Soil Surface Conditions

Surface cover, roughness and crusting were measured on a 20 x 10 grid (1 m^2), with three replications. Surface cover and crusting are calculated as percentages. Surface roughness is calculated as the standard deviation of the heights (cm), times 4. Table 3.1.6 shows average values of total vegetation cover and of surface roughness in a west-east direction.

Aggregate size was determined by sieving soil surface samples by hand gently, to obtain the non-erodible, creep, saltation and suspension fractions. Afterwards, the samples were sieved mechanically for 10 minutes, to study the breakdown of aggregates. Average values for surface crusting, aggregate size and aggregate stability are shown in Table 3.1.7. Due to the massive structure of the soils there are no loose aggregates at the soil surface at Mragha.

Table 3.1.6. Total vegetation cover (%) and surface roughness for the 11 experimental fields

Field	Vegetation %	Roughness
1 (THM)	15	5.0
2a (BRF)	1	9.1
2b (BRFSH)	1	5.1
3a (BBG)	30	3.6
3b (BBGDF)	10	11.6
4 (UBH)	1	3.8
5 (UHT)	1	3.5
6 (ENG)	1	1.7
7 (ENT)	1	1.7
8 (ESG)	17	5.5
9 (EST)	10	5.7
10 (MNP)	8	4.2
11 (MIP)	20	7.0

Table 3.1.7. Surface crusting (%), aggregate size (%) and stability (%) for 9 experimental fields

Field	Crust (%)	>1mm	0.1-1	<0.1	>1mm	0.1-1	<0.1
1 (THM)	11	19	79	2	8	88	4
2a (BRF)	61	59	36	5	17	62	21
2b (BRFSH)	0	58	38	4	27	58	15
3a (BBG)	10	40	53	7	16	65	19
3b (BBGDF)	0	56	39	5	32	53	15
4 (UBH)	9	27	69	4	7	83	10
5 (UHT)	14	28	68	4	5	85	10
6 (ENG)	0	65	32	3	34	48	18
7 (ENT)	0	65	31	4	35	48	17
8 (ESG)	9	78	20	2	46	38	16
9 (EST)	6	79	19	2	42	41	17

3.1.4 Wind Erosion Measurements

Modified BSNE-samplers, developed by the USDA at Big Spring, Texas (Fryrear 1986) to collect airborne dust under natural field conditions and copied at the ICARDA/workshop, were used to measure wind erosion. Three such samplers were placed 100 m apart in a downwind direction on each experimental field. Each dust sampler (pin) collects windborne soil at five heights: 5, 10, 20, 50 and 100 cm, and vertical integration of the amounts collected at those heights is used to calculate the total quantity of soil passing the sampler.

The measuring periods and total amounts of collected soil are shown in Table 3.1.8. In fields marked (*), soil erodibility at the first pin had been reduced by tillage. At these pins, hardly any local erosion occurred, and the amounts of soil collected by them give background values for airborne material derived from other areas. An increase of collected soil at the second and third pin indicates erosion occurred downwind of the first pin. Examples of such erosion events are shown in Table 3.1.9, together with measuring period, highest average daily wind speed and wind direction for that day; and others have been included to afford comparison at the same location.

Table 3.1.8. Total amount of collected soil (kg/100 m width) at three pins in down wind direction for the 11 fields (erosive season, 1992)

Field	Period	Pin 1	Pin 2	Pin 3
1 (THM)	9/6 - 27/9	158	54	208
2a (BRF)	21/5 - 12/8	96	94	71
2b (BRFSH)	13/8 - 24/9	29*	21	23
3a (BBG)	23/6 - 12/8	40	24	82
3b (BBGDF)	23/6 - 24/9	21*	26	26
4 (UBH)	24/6 - 10/9	94*	1190	1725
5 (UHT)	24/6 - 10/9	250*	217	162
6 (ENG)	13/7 - 23/9	78*	93	143
7 (ENT)	13/7 - 23/9	82*	97	59
8 (ESG)	13/7 - 23/9	54*	41	26
9 (EST)	13/7 - 23/9	88*	52	69
10 (MNP)	18/6 - 28/9	57	27	91
11 (MIP)	18/6 - 28/9	114	65	75

Table 3.1.9. Measuring period, maximum average daily wind speed, wind direction and total amount of collected soil (kg/100 width) at three pins in down wind direction for the 11 fields (erosive season, 1992)

Field	Period	Max day	Dir.	Pin 1	Pin 2	Pin 3
1 (THM)	14/7-27/7	8.1	W	19	7	28
	15/9-22/9	5.1	NW	4	1	54
	22/9-27/9	3.5	NNW	62	12	78
2b (BRFSH)	13/8-18/8	5.8	W	3	6	8
3a (BBG)	23/6- 6/7	5.6	WNW	19	13	58
3b (BBGDF)	7/9-10/9	4.7	WNW	1	1	4
4 (UBH)	24/6- 6/7	5.1	WNW	24	476	739
	15/7-21/7	4.6	W	7	98	245
	21/7-28/7	5.6	W	13	99	154
	28/7- 4/8	5.3	WNW	9	145	222
	18/8-20/8	5.9	W	9	42	68
	20/8-24/8	3.9	W	0	2	26
	3/9- 8/9	4.3	WNW	1	1	25
4 (UHT)	24/6- 6/7	5.1	WNW	65	63	32
	15/7-21/7	4.6	W	16	21	13
	28/7- 4/8	5.3	WNW	19	44	11
6 (ENG)	13/7-22/7	5.0	W	28	23	31
	22/7-29/7	6.5	W	22	38	67
	5/8- 9/8	5.9	W	3	8	10
7 (ENT)	13/7-22/7	5.0	W	33	21	17
	22/7-29/7	6.5	W	18	45	20
	5/8- 9/8	5.9	W	5	4	3
10 (MNP)	9/7-30/7	6.6	SW	24	11	54
10 (MIP)	9/7-30/7	6.6	SW	62	29	37

3.1.5 Physical and chemical analyses

For each field, samples of airborne soil collected at the five heights on each pin were sieved to determine their particle-size distribution (Table 3.1.10). Analysis for organic matter and P-Olsen contents was carried out on some of these samples (Table 3.1.12) and on samples of field soil at each site (Table 3.1.11). Organic matter contents for the fractions larger and smaller than 0.1 mm are shown in Table 3.1.13. Physical and chemical analyses indicate the nature of the soil eroded, and can be used to interpret the process that moved the soil.

Table 3.1.10. Size distribution (%) of airborne material sampled at heights of 5, 10, 20, 50 and 100 cm at each pin in the 11 experimental fields

	Pin 1					Pin 2					Pin 3				
	5	10	20	50	100	5	10	20	50	100	5	10	20	50	100
THM															
> 1mm	<1	1	<1	2	2	1	8	1	1	1	1	1	<1	1	2
0.1-1mm	87	89	80	56	39	76	71	62	41	60	76	73	56	41	22
< 0.1mm	13	10	19	42	59	23	21	37	58	39	23	26	44	58	76
BBG															
> 1mm						1	1	<1	<1	<1					
0.1-1mm						43	42	30	17	20					
< 0.1mm						56	57	70	83	80					
UBH															
> 1mm	3	1	3	<1	-	1	<1	<1	<1	<1	<1	<1	<1	1	1
0.1-1mm	49	44	42	37	-	80	79	65	38	36	80	80	70	50	34
<0.1mm	48	55	55	63	-	19	21	34	62	64	20	20	30	49	65
UHT															
> 1mm	1	5	5	2	2	<1	2	1	2	1	<1	1	<1	<1	1
0.1-1mm	49	59	37	47	36	79	78	61	46	49	74	73	64	31	33
< 0.1mm	50	36	58	51	62	21	20	38	52	50	26	26	36	68	66
ENG															
> 1mm	<1	<1	1	<1	1	1	1	<1	<1	<1	<1	1	1	<1	<1
0.1-1mm	17	18	17	11	16	47	43	24	9	11	55	51	41	19	14
< 0.1mm	83	82	82	89	83	52	56	76	91	89	45	48	58	81	86
ENT															
> 1mm	1	2	<1	1	<1	1	2	2	1	2	1	<1	1	2	1
0.1-1mm	20	18	16	14	14	48	45	35	25	33	22	22	24	28	38
< 0.1mm	79	80	84	85	86	51	53	63	74	65	77	78	75	70	61
ESG															
> 1mm	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	5	<1	<1	<1
0.1-1mm	36	31	16	11	12	54	50	35	16	15	37	41	17	19	18
< 0.1mm	64	69	84	89	88	46	50	65	84	85	63	54	83	81	82
EST															
> 1mm	<1	<1	<1	<1	<1	3	<1	<1	<1	<1	<1	1	<1	<1	-
0.1-1mm	26	24	17	13	10	31	22	14	10	9	33	34	20	9	-
< 0.1mm	74	76	83	87	90	66	78	86	90	91	67	65	80	91	-
MNP															
> 1mm	2	4	2	<1	<1	1	5	8	1	1	2	5	3	2	<1
0.1-1mm	37	16	30	24	24	33	43	26	24	27	62	60	48	37	29
< 0.1mm	61	60	68	76	76	65	53	66	75	72	36	35	49	61	71
MIP															
> 1mm	1	<1	1	<1	<1	<1	<1	<1	<1	<1	1	1	<1	<1	<1
0.1-1mm	21	18	13	10	10	22	24	14	16	9	27	31	33	19	25
< 0.1mm	78	82	86	90	90	78	76	86	84	91	72	68	67	81	75

(Pin 1 is upwind; pin 3 downwind; pin 2 in between)

Table 3.1.11. Organic matter content (%) and Olsen-P (ppm) for the studied fields

Location	Depth	O.M. (%)	P-Olsen
Tel Hadya (THM)	0-15 cm	0.94	12.6
Breda (BBG)	0-15 cm	1.20	7.8
Urdjl (UBH + UHT)	0-15 cm	0.77	4.7
Urdjl (UBH + UHT)	0- 5 cm	0.75	5.2
Urdjl (UBH + UHT)	Surface	0.75	6.2
El Azami (ENG + ENT)	0-15 cm	1.64	15.8
El Azami (ESG + EST)	0-15 cm	1.90	14.9

Table 3.1.12. Organic matter content (%) and Olsen-P (ppm) of the collected soil at 5, 10, 20, 50 and 100 cm heights at three pins in down wind direction (Olsen-P in parentheses)

Location	Height (cm)	Pin 1	Pin 2		Pin 3	
THM	10	-	3.10		3.00	
	20	-	3.14		3.75	
	100	-	4.49		5.34	
BBG	10	-	3.69		-	
	20	-	4.45		-	
	100	-	4.28		-	
UBH	5	2.63	1.07	(7.3)	1.01	(8.7)
	10	2.57	1.18	(6.2)	1.18	(6.4)
	20	2.24	1.32	(11.4)	1.23	(11.5)
	50	2.38	1.73		1.42	(12.6)
	100	1.39	1.73		2.13	
ENG	5	3.42	3.41		3.03	
	10	4.48	3.87		3.44	
	20	4.32	3.97		3.54	
	50	4.06	3.70		4.32	
	100	4.39	2.86		4.05	
MNP	5	8.99			5.40	
	10	7.14			5.16	
	20	6.37			5.12	
	50	5.51			5.25	
	100	5.42			5.35	

Table 3.1.13. Organic matter content (%) for fractions larger and smaller than 0.1 mm

Sample		Height (cm)	<0.1 mm	>0.1 mm
UBH+UHT	P2+P3	5	1.32	0.88
UBH+UHT	P2+P3	10	1.48	1.05
UBH+UHT	P2+P3	20	1.63	1.05
UBH+UHT	P2+P3	50	2.29	1.77
UBH+UHT	P2+P3	100	2.49	1.77

3.1.6 Interpretation of wind erosion during the 1992 season, at the 11 fields

In early July there was some rainfall at Urdjl, resulting in a fragile surface crust (1 mm). This crust was gradually broken down by saltating particles. The non-erodible boundary (10 m wide strip of ducksfoot tillage) at the first pin, trapping soil particles in saltation, protected the surface downwind. By July 6, there was still 90% surface crust over the first 40 meters downwind of the non-erodible boundary, rapidly reducing to 20% further downwind. By August 13, crusting was reduced to 5% and by early September, almost all the crust had disappeared.

In the UBH field (hand-harvested barley), local erosion occurred with a soil loss equivalent to 816 kg/ha. From the top of the field (non-erodible boundary) to the second pin (100 m downwind), the loss was 1096 kg/ha; from the second to the third pin, 535 kg/ha. The loss was greater in the first sector because the wind's load of soil there was low (background value), facilitating uptake. In the second sector, the air-flow was saturated with airborne material, explaining the decrease in uptake. There was a clear lateral increase of collected soil for most dust events (Table 3.1.8).

In this field, with a surface cover of 1%, surface roughness 3.8, average surface crusting 9% and erodible aggregates 73%, erodibility was quite high. Average daily wind speeds over 4 m/s resulted in local erosion.

At the first pin, 37 to 49% of the background value material was in the saltation fraction and 48 to 63% in the suspension fraction (Table 3.1.10). The material was rather fine, and differences with height were not very distinct. At the second and third pin, where locally eroded soil was collected, 80% of the material found at 5 and 10 cm was in the saltation fraction, reducing with height to 35%.

In the Urdjl field soil, organic matter is distributed evenly within the 0 to 15 cm depth range (Table 3.1.11). Organic matter in the airborne material collected at the first pin was 2 to 3.5 times greater than that in the field soil but decreased with height (Table 3.1.12). The organic matter content of material collected at the second and third pin (that is locally eroded soil), increased with height and was 1.3 to 2.8 times greater than that of the field soil. It was also greater in the suspension fraction (< 0.1 mm) than in the saltation fraction (> 0.1 mm) (Table 3.1.13). P-Olsen values for the locally eroded material also increased with height and was 1.2 to 2.4 times greater than that of the field soil.

In the UHT field, , the total amount of soil collected at the three pins was 250, 217 and 162 kg/100 m width. Upwind from the first pin there was a large area under similar erosive conditions to those upwind of UBH. Serious erosion from this area resulted in a high background value at pin 1. Because of the conservation tillage, there was hardly any local erosion at UHT. The collected amounts represent a fading background value.

The fragile rain-formed crust covered 90% of this entire field on July 6, decreasing to 14% during the erosive season. But, despite a surface cover of 1%, surface roughness 3.5 and erodible aggregates 72% in between the tillage lines, the conservation tillage completely prevented local erosion and even trapped a substantial amount of soil derived from upwind.

At Tel Hadya, Breda, El Azami and Mragha hardly any erosion occurred. Fields BBG, MIP, ESG and THM were protected by a surface cover greater than 15% (Table 3.1.6). BRF was protected by extensive surface crusting. MNP and MIP were protected by the massive nature of their soil surface, and ENG, ENT, ESG and EST by a high percentage of non-erodible aggregates at the surface (Table 3.1.7).

In the THM field (medicago seed production), most of the erosion occurred in September, at the end of the erosive season. At this time, average wind speeds are already declining, but turbulent winds, related to the change of season, occur for short periods. Erosive winds occurred earlier (Table 3.1.4), and the percentage of erodible aggregates was high (81%); but vegetation cover (15%) and surface crusting (11%) apparently provided sufficient protection from large soil loss.

In the BRF field (fallow), erodibility was very low because of the extensiveness of surface crusting (61%), the low number of erodible aggregates (41%) and the moderately high surface roughness, 9.1. Spike-harrow tillage increased the erodibility by breaking the crust and reducing the surface roughness. It did not, however, increase the amount of erosion, probably because wind speeds were lower in the period after tillage.

On the BBG field, erodibility was low because of a surface cover of 30% and surface crusting of 10%. The ducksfoot tillage changed the erodibility by reducing surface cover (10%), but increased the surface roughness to 11.6. Hardly any wind erosion occurred under these conditions.

At El Azami, little wind erosion occurred at all. The amounts of soil collected downwind are only slightly higher than the background values (Table 3.1.8). Despite a surface cover of only 1%, surface roughness of 1.7 and no surface crusting, the erodibility of ENG was fairly low because of an erodible aggregate percentage of only 35%. Average daily wind speeds over 6.5 m/s are required to start some local erosion. Under these conditions, conservation tillage is not justified. The organic matter content of the locally eroded soil at this site increased with height and was 1.7 to 2.6 times higher than that of the field (soil (Tables 3.1.12 and 3.1.11).

At Mragha also there was hardly any wind erosion (Table 3.1.8). The massive soil structure meant that there were few loose soil particles at the soil surface. At the improved plot (MIP), some sedimentation may have occurred because of the vegetation cover.

3.1.7 Conclusions

Wind speeds during the erosive season of 1992 were substantially lower than the long-term average. In a year of average or high wind speeds, soil loss would have been greater under conditions which this year promoted only a little local erosion, and soil movement might have occurred on other fields which this year showed no loss. It should be noted, though, that it was not possible to study erosion in all the potentially highly erodible conditions, particularly over-grazed barley fields on the drier red soils.

Conservation tillage at Urdjl and El Azami prevented local erosion and trapped eroded soil from upwind. At Urdjl, total soil loss and differences in erodibility between tilled and untilled soil were large, justifying conservation tillage. At El Azami, total soil loss and differences in erodibility were low, making conservation tillage this year an unprofitable input. The value of conservation tillage depends on the amount of local erosion and the erodibility of the tillage lines compared with the unaffected soil.

At erodible fields with a non-erodible boundary, the soil collected at the first pin (background value) contained a relatively high percentage of suspension material. The size distribution was fairly constant with height. Locally eroded soil (second and third pin) contained a higher percentage of saltation material, decreasing with height.

The 'transport model for air-borne dust', frequently used in wind erosion studies, assumes that saltation occurs mainly in the first 20 cm above the soil surface. At the UBH field, 50% of the soil collected at a height of 50 cm and 34% at 100 cm was in the saltation fraction; at ENG, 19 and 14%. It seems that the assumption used in the model is only partly true and depends on the erodibility of the soil and the erosivity of the wind.

The organic matter and Olsen available-P contents of locally eroded soil increased with height and were higher than those of the field soil. However, enrichment in organic matter decreases with increasing total erosion. At the UBH field, where most local erosion occurred, enrichment in organic matter of the suspension fraction was 1.8 - 3.3; of the saltation fraction 1.2 - 2.4. ***K.B. Timmerman, with technical assistance from P. Hayek and Ali Haj Dibo.***

Reference

FRMP, 1992. Annual Report for 1991, Farm Resource Management Program, ICARDA, Aleppo, Syria.

3.2 Atriplex Hedge Trial, Ghrerife

3.2.1 Introduction

As outlined previously (FRMP 1992), this trial was established during the 1990/91 season on a 4 ha site at Ghrerife station. It consists of two replicates of a partial factorial combination of four designs of Atriplex halimus hedge and three widths of arable cropping. The general aims are to determine: how well crops grow between atriplex hedges; the yield of atriplex browse for small ruminants; and the overall productivity (in terms of biomass and, ultimately, economic value) of various crop:atriplex "intercrop" designs.

3.2.2 Treatments and methods

Hedges: There are four types of hedge, A, B, C, D, specified according to (a) number of rows of bushes, (b) distance between those rows, and (c) bush spacing within the row:

	(a) Rows of bushes	(b) Between rows, m	(c) Bush spacing, m	Total hedge* width, m
A	1	-	1	2
B	2	1	1	3
C	2	2	2	4
D	4	1	2	5

(* assumes each bush extends 1 m from the line of hedge planting at the hedge/crop strip interface.)

Arable strips: These are in three widths: (1) 4.25 m; (2) 8.5 m; (3) 17 m.

Crop rotations: There are two rotations:

BB barley-barley
BV barley-vetch (Vicia sativa), with both phases planted each year

Hedge fertilization: Each hedge (approximately 60 m in length) was subdivided into two halves:

- control
- triple superphosphate (25 g per hole at planting time (early 1991)

Design: Space does not permit the 12 factorial combinations of hedges and arable-strip widths. Instead, there are 6 hedge/arable treatments:

	Arable widths		
Hedges	1	2	3
A		A_2	
B	B_1	B_2	B_3
C		C_2	
D		D_2	

In the 1990/91 season, the atriplex hedges were established and a late crop of barley was sown to initiate the rotations. Other arable plots were left in bare fallow. In 1991/92, barley and vetch crops were sown in late October/early November, each with 30 kg P_2O_5/ha in the seedbed. All vetch crops were preceded by barley; barley was preceded either by fallow or by barley. Yields were determined at maturity (vetch and barley) by harvesting four, six or eight meter-square samples from each plot, the number depending on the width of the plot.

Atriplex "harvesting" was intended to simulate browsing by small ruminants. Since it was physically impossible to "browse" (by pruning) every bush, the following procedure was adopted: 1) six size categories of atriplex bush were established; 2) the size category of every bush in every hedge was recorded; 3) approximately 10% of bushes in each size category was pruned, and the pruned material was dried and weighed. Productivity of each individual hedge was determined by summing the products of the numbers of bushes in each size category and the estimated browse production values (per bush) in these categories. (Local livestock were subsequently allowed into the trial to complete the browsing and to graze crop stubble; but control of this, to prevent over-browsing in some parts of the field and underutilization elsewhere, was a problem.)

3.2.3 Results

It is useful to consider the yields of the system components, crops and hedges, separately first, on a pure crop basis; and then to put them together to obtain a value of total "intercrop" biomass.

Crop yields: The only significant treatment effect on barley yield was due to previous crop. Not surprisingly, barley after fallow significantly outyielded barley after barley, although the differences were not numerically very large (Table 3.2.1).

Differences between hedge-type/arable-width treatments approached significance ($p<0.05$) in respect of barley grain yield, but it is doubtful whether this effect was meaningful. Vetch yields showed no significant treatment differences.

Table 3.2.1. Yields of barley and vetch, t/ha of pure crop

	Barley			Vetch		
	Grain	Straw	Total	Grain	Straw	Total
Hedge type:	(*)	ns	ns	ns	ns	ns
A2	1.53	2.23	3.76	0.60	1.96	2.56
B1	1.41	2.02	3.43	0.58	1.94	2.52
B2	1.50	1.96	3.46	0.65	1.95	2.60
B3	1.44	2.07	3.51	0.68	2.08	2.76
C2	1.55	2.24	3.79	0.63	1.87	2.50
D2	1.63	2.09	3.72	0.61	1.92	2.53
SE (±)	0.046	0.092	0.130	0.068	0.137	0.183
Previous crop:	**	**	**			
Fallow	1.58	2.25	3.83	-	-	-
Barley	1.44	1.95	3.39	-	-	-
SE (±)	0.027	0.053	0.075			

Hedge yields: No statistical analysis of these data has been attempted, but the very large difference in yield values between the 'with' and 'without' phosphate treatment is evident (Table 3.2.2). As noted last year (FRMP 1992), the growth of atriplex shrubs was very slow where no superphosphate had been placed in the planting hole; values of Olsen available-P across the site in 1991 ranged from 1.8 to 5.2 ppm, mean 3.1 ppm. Smaller but appreciable differences between hedge types are attributable largely to treatment differences in the density of bushes on the ground.

Table 3.2.2. Estimated browse dry matter from atriplex hedges, t/ha of hedge bush area in relation to within-hedge bush density

Hedge type	P-fertilizer to hedge at planting: With	P-fertilizer to hedge at planting: Without	Theoretical density of bushes, number per m^2 of hedge area
A2	1.55	0.40	0.50
B1	1.49	0.60	0.67
B2	1.43	0.47	0.67
B3	1.30	0.45	0.67
C2	1.16	0.15	0.25
D2	0.93	0.19	0.40

Total biomass: Values of total biomass were calculated from crop and hedge yields in proportion to their relative areas on the ground; and these imposed treatment differences in area ratios were largely responsible for the appreciable differences found this year in total biomass (Table 3.2.3).

Table 3.2.3. Biomass production of hedge/crop systems, t/ha

Hedge type	Ground area ratios			Total biomass, t/ha, adjusted for area ratios					
				Barley + hedge			Vetch + hedge		
	Crop	:	Hedge	Barley	Hedge*	Total	Vetch	Hedge*	Total
A2	0.810	:	0.190	3.05	0.30	3.35	2.07	0.30	2.37
B1	0.586	:	0.414	2.01	0.62	2.63	1.48	0.62	2.10
B2	0.739	:	0.261	2.56	0.37	2.93	1.92	0.37	2.29
B3	0.850	:	0.150	2.98	0.20	3.18	2.35	0.20	2.55
C2	0.680	:	0.320	2.58	0.37	2.95	1.70	0.37	2.07
D2	0.630	:	0.370	2.34	0.34	2.68	1.59	0.34	1.93

* *Figure is for the P-fertilized hedge*

Even where phosphate fertilizer had been applied, atriplex biomass production was below that of barley or vetch, and treatments with a relatively high proportion of their area under atriplex were disadvantaged. This might be expected to change (at least where hedges have been P-fertilized) as the atriplex bushes mature and produce more branches and foliage.

3.2.4 Conclusions

There is no evidence so far that the presence of atriplex bushes is affecting the growth of the arable crops, either positively (through shelter) or negatively (through competition), but the bushes are still young and, in most cases, small. Yields differences this year were largely the product of relative area differences and of the spectacular effect of phosphate on the atriplex. ***M. Jones and H. Harris, with major technical input from Z. Arous and G. Kanjo***

Reference

FRMP, 1992. Annual Report for 1991, Farm Resource Management Program, ICARDA, Aleppo, Syria.

3.3 Evaluation of a Drip System for Supplemental Irrigation Trials of Field Crops at Tel Hayda

3.3.1 Introduction

In supplemental irrigation trials, the amount of irrigation water applied and the time of its application need to be accurately controlled to ensure reliable data. This is largely dependent on the irrigation system used. For the last 6 years at ICARDA a linesource sprinkler has been the system used for research trials. This system performs well under calm conditions, but such conditions are rare during the winter and spring at Tel Hadya. Experience indicates several difficulties affecting the outcome of these trials:

1) The wind speed often exceeds the rate under which a reasonably uniform application of water to small plots can be achieved by sprinkling. When irrigation is due, the choice is either to irrigate on time but with poor uniformity or to wait for calm

conditions; and in some instances it needed a few weeks to apply 50 mm with a linesource. In either case the accuracy of the data is affected.

2) For research, sprinkler systems have several management and technical problems. In standard systems, large plots are needed, which implies higher costs, for equipment, labor and water. The alternative, a linesource sprinkler system, sacrifices the randomization of water treatments, which gives difficulties in the statistical analysis.

Drip irrigation systems are already being used commercially for row crops and provide very high uniformity under climatic conditions similar to Tel Hadya. Wind does not affect their performance, and management is far easier and cheaper than that of sprinkler systems. The amount of water required can be applied very accurately and at the right time. Technically, the system can overcome all the problems associated with sprinkler systems. However, this system has not been used widely for field crops, largely because of its high initial investment cost.

Using drip systems as an experimental tool could, however, be the solution to sprinkler problems. One valid technical concern is whether the spacing between drippers ensures enough uniformity. The maximum spacing, that still gives uniform water application over the whole soil profile and provides similar conditions to those provided by sprinkler and surface systems, needs to be determined. Thus, the overall aim of this experiment was to provide information for designing a research drip system for SI trials at Tel Hadya. Specific objectives included:

a) To determine the maximum spacings between drip laterals and between drippers along the laterals that provide a uniform application with full coverage for SI trials of wheat.

b) To evaluate the wetting patterns under various dripper spacings and volumes of irrigation, and their effect on crop yield, ET and other production parameters.

c) To determine wheat evapotranspiration and yield under various rates of SI and compare that with rainfed conditions.

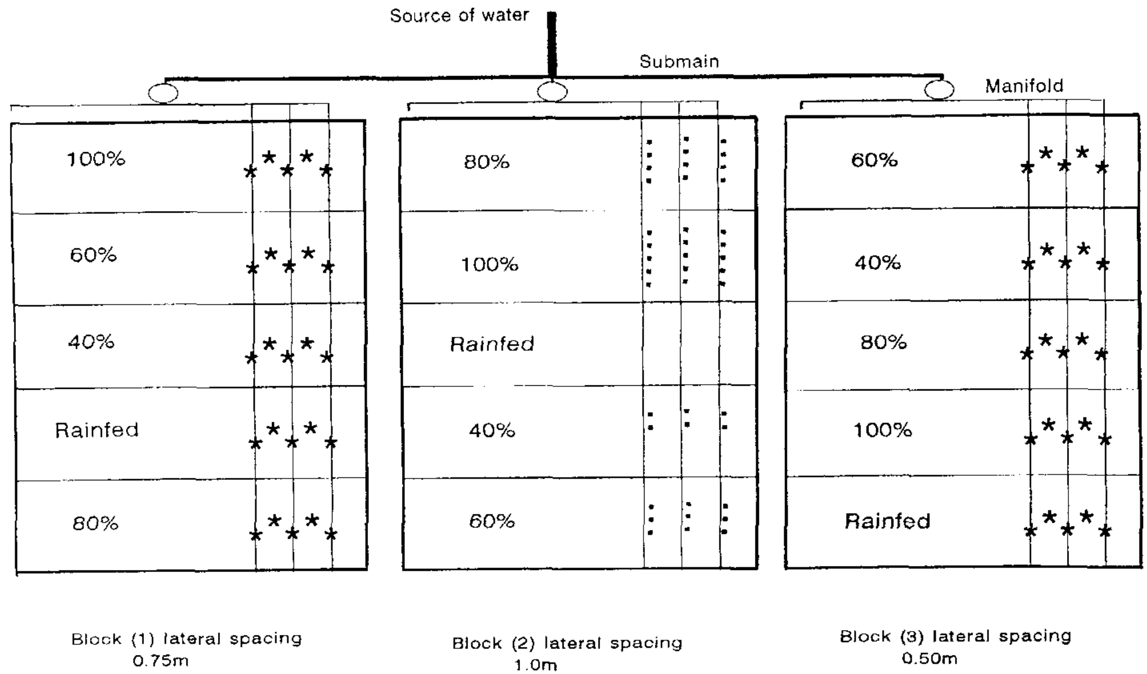
3.3.2 Methodology

The experiment was conducted on the B2 block at Tel Hadya. The average 150 cm soil profile texture is clay with about 62% clay, 29% silt and 9% sand. The soil is well drained, with a basic infiltration rate of 11 mm/hr and average water-holding capacity of 45% by volume.

Treatments comprised:

1. Three spacings between lateral lines, S1=50 cm, S2=75 cm, and S3=100 cm
2. Four dripper spacings along laterals, 50, 33, 25, and 20 cm (2, 3, 4, and 5 drippers/m)
3. Five supplemental irrigation rates:
   - W4 applying 100% of depleted soil moisture when it reaches 50% of the difference between field capacity and wilting point.
   - W3 applying 80% of W4 at the same time
   - W2 applying 60% of W4 at the same time
   - W1 applying 40% of W4 at the same time
   - W0 rainfed (no irrigation)

Irrigation system and experiment layout. Pressure compensating emitters of approximately 2 l/h discharge were installed along 40 m long polyethylene lateral pipes of 20 mm diameter. Drippers, spaced at 0, 2, 3, 4 and 5 per m, were installed in five randomized 8 m segments along each lateral to provide the 5 water treatments, 0, 40, 60, 80 and 100% SI. The laterals were grouped in 3 blocks, each of 20 m width and 40 m length, to provide the three lateral spacings of 50, 75 and 100 cm. Laterals of each block were connected by a manifold and the three manifolds were connected to the main water line. Figure 3.3.1 shows the experiment layout and the irrigation



* *Location of NP access tubes*
100% 5 emitters/m
80% 4 emitters/m
60% 3 emitters/m
40% 2 emitters/m
Rainfed none

Figure 3.3.1 Experiment layout and drip irrigation system

system components.

Water measurements and management. Soil moisture was measured at 15 cm interval down the soil profile with a neutron probe. For the top layer the gravimetric method was used. Measurements were taken weekly when conditions allowed, before and after irrigation, and after each rain event.

Access tubes were installed in each treatment in a layout designed to allow the wetting front to be determined after each irrigation: five tubes on a line across the three laterals, one adjacent to each of the three laterals and two in the middle of the spaces between them (Fig. 3.3.1). The wetting front was determined by detecting the depth at which a change in soil moisture occurred after each irrigation. The five points were then connected in an approximate curve that represents the shape of the usual drip wetting front.

Water was applied when the mean soil moisture of the three W4 treatments dropped to 50% of the available moisture (FC-PWP). The amount applied to the W4 treatment was calculated in terms of the period of application required to refill the root zone to field capacity. Other treatments received proportionately smaller amounts according to the number of drippers per meter of lateral.

ET for each period was calculated using a water balance equation based on changes in soil profile moisture, and rainfall and irrigation amounts.

Other practices. Durum wheat var. Cham 1 was plot drilled on 21 November 1991 in 17.5 cm rows at a seed rate of 125 kg/ha. 100 kg/ha N was applied as urea in two equal doses at planting and at tillering. Weeds were controlled chemically.

3.3.3 Results and Discussion

The rainfall total in 1991/92, 311 mm, was close to the long-term average. The first part of the season was reasonably wet, and no SI was needed until April when two irrigations were given. The resulting SI totals, ET and yield parameters for all treatments are summarized in Table 3.3.1. Mean seasonal ET ranged between 292 mm under rainfed conditions to 491 mm where no stress was allowed in W4. Total grain yield for the two extreme treatments were 2.4 and 7.5 t/ha, respectively.

Table 3.3.1. Yield and evapotranspiration under different drip lateral spacings and supplemental irrigation rates

Supplemental irrigation rate	Drip lateral spacings	Grain yield t/ha	Straw yield t/ha	Biomass t/ha	Weight of 1000 kernels (gr)	Seasonal Evapo-transpiration (mm)
W0	Block 1	2.6	6.2	8.8	30.2	289
Rainfed	Block 2	1.6	5.9	7.5	29.1	287
	Block 3	2.9	6.8	9.7	29.6	301
	Mean	**2.4**	**6.3**	**8.7**	**29.6**	**292**
W1	S1 (50 cm)	4.7	8.8	13.5	37.3	376
82 mm	S2 (75 cm)	4.6	8.5	13.1	37.7	364
(40%)	S3 (100 cm)	3.6	11.1	14.7	33.5	380
	Mean	**4.3**	**9.5**	**13.8**	**36.2**	**373**
W2	S1	5.1	10.7	15.8	39.1	402
123 mm	S2	6.3	10.3	16.6	39.5	427
(60%)	S3	5.9	11.0	16.9	37.5	410
	Mean	**5.8**	**10.7**	**16.5**	**38.7**	**413**
W3	S1	5.8	10.5	16.3	39.9	469
164 mm	S2	6.5	11.0	16.5	40.1	430
(80%)	S3	6.4	11.9	18.3	16.1	465
	Mean	**6.2**	**11.1**	**17.3**	**38.7**	**455**
W4 100%	S1	7.1	13.3	20.4	41.3	491
205 mm	S2	7.5	12.1	19.6	43.2	488
(100%)	S3	8.0	14.1	22.1	36.8	493
	Mean	**7.5**	**13.2**	**20.7**	**40.4**	**491**

<u>Effects of dripper spacing</u>. Changing drip lateral spacings from 50 to 100 cm had no detectable effect on crop ET or any yield parameter. Mean grain yields for S1 (50 cm), S2 (75 cm) and S3 (100 cm) were 5.68, 6.23, and 5.98 t/ha, respectively. Mean straw yields

for the same treatments were 10.83, 10.48 and 12.03 t/ha, respectively, and mean seasonal ET values were 434.5, 427 and 437 mm, respectively. However, it was observed during the growing season that crop height undulated where the relatively wide spacing of 100 cm was used.

The approximate wetting fronts 48 hours after each of the two irrigations were identified for all spacings and for two of the irrigation rates (Fig. 3.3.2, 3.3.3, and 3.3.4). The irregular pattern of the wetting front could be clearly seen where the 100 cm and 75 cm spacings had been used. In all cases the irregularity occupied a small portion of the root zone depth. Attempts to detect the wetting front by neutron probe one week after each irrigation were not successful. High capillary action in the heavy soil of Tel Hadya seems to have caused fast redistribution of soil water. Such

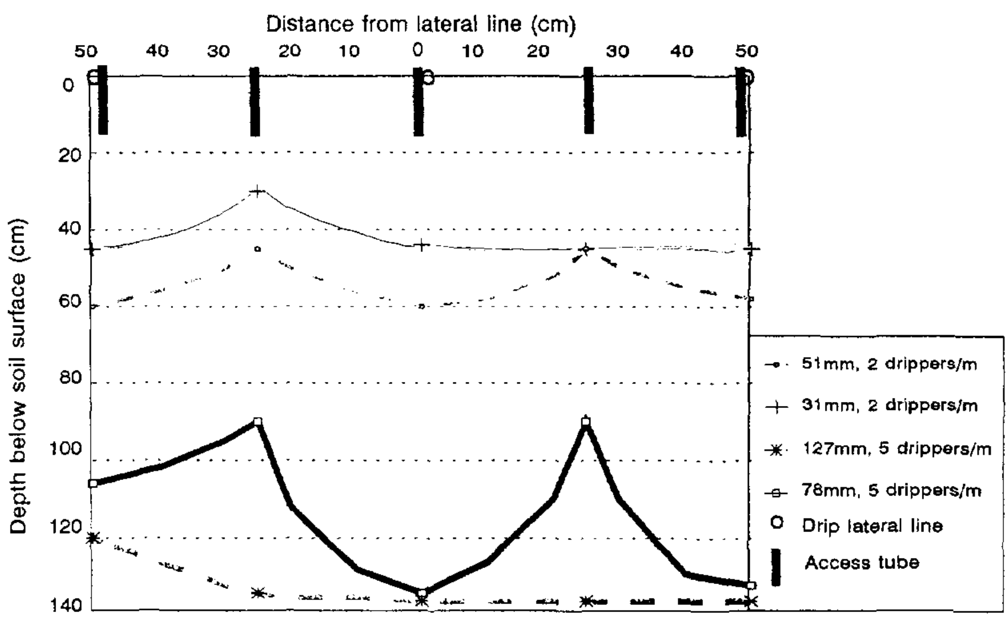


Figure 3.3.2 Location of the wetting front two days after irrigation with 50 cm lateral spacing and various irrigation amounts and dripper spacings

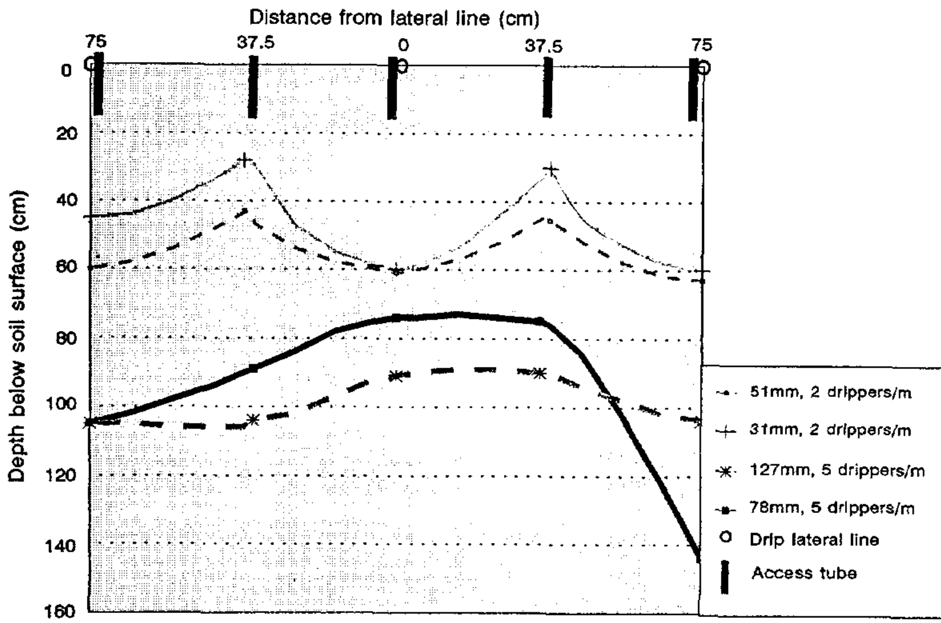


Figure 3.3.3 Location of the wetting front two days after irrigation with 75 cm lateral spacing and various irrigation amounts and dripper spacings

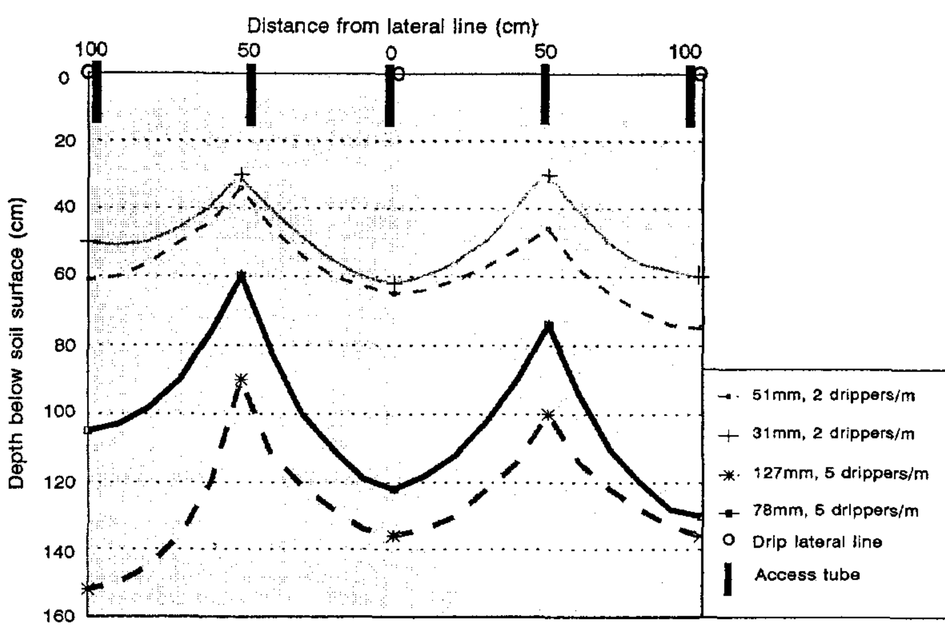


Figure 3.3.4 Location of the wetting front two days after irrigation with 100 cm lateral spacing and various irrigation amounts and dripper spacings

a change may reduce the effect of an irregular wetting front even when the relatively wide spacing of 100 cm is used, although factors such as moisture depletion by the crop and variations in matric potential after irrigation may have an effect also. Nevertheless, added to the evening effect of a uniform rainfall and the possibility that root distribution follows wetting patterns, it may help explain why wide spacing has not affected the crop ET and yield.

<u>Response to supplemental irrigation levels</u>. Crop yield parameters responded linearly to increasing ET and SI amounts. Figure 3.3.5

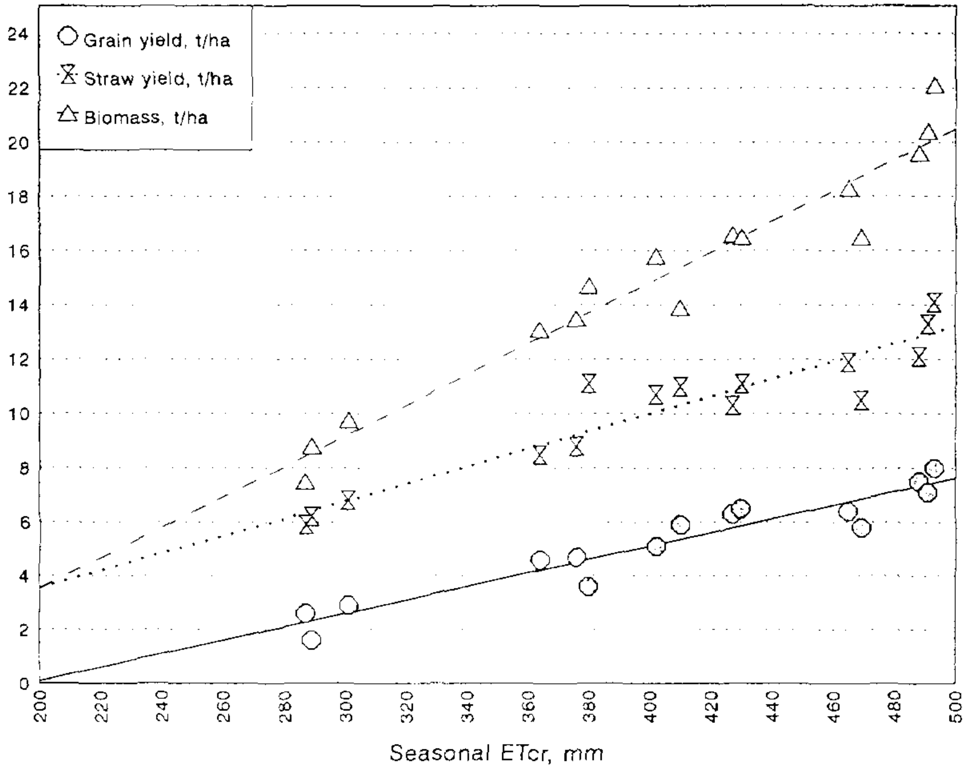


Figure 3.3.5 Wheat evapotranspiration production functions at Tel Hadya, 1991/92

shows the relationship between ET and grain, straw and biomass yields of Cham 1 wheat. The ET production functions are:

$Y_{grain} = -4.94 + 0.025\ ET \qquad R^2 = 0.98$

$Y_{straw} = -2.82 + 0.032\ ET \qquad R^2 = 0.87$

$Y_{bio} = -7.76 + 0.057\ ET \qquad R^2 = 0.94$

When yields were plotted against SI amounts, there were again linear relationships (Fig. 3.3.6):

$Y_{grain} = 2.41 + 0.025\ SI \qquad R^2 = 0.94$

$Y_{straw} = 6.52 + 0.032\ SI \qquad R^2 = 0.97$

$Y_{bio} = 8.93 + 0.057\ SI \qquad R^2 = 0.95$

where Y is the yield in t/ha; ET is the total seasonal evapotranspiration in mm; and SI is the amount of supplemental irrigation in mm.

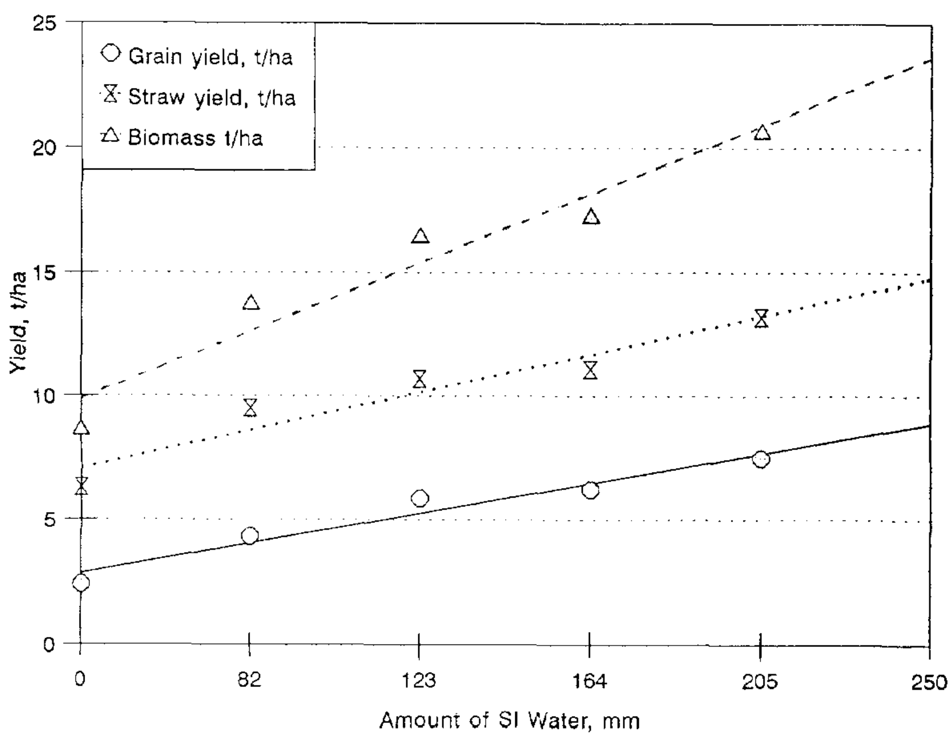


Figure 3.3.6 Wheat SI production functions at Tel Hadya, 1991/92

Water use efficiency. The Water Use Efficiency Index (WUE) was determined as the yield produced per cubic meter of water (kg/m^3), for SI water and for the combined SI and rainfall water (Table 3.3.2). The WUE of rainfall alone was 0.77 kg grain/m^3 and 2.03 kg straw/m^3, while for SI water values were 2.76 kg/m^3 and 3.58 kg/m^3, respectively. For rainfall and SI water together, WUE values were 1.45 kg grain/m^3 and 2.56 kg straw/m^3.

Table 3.3.2. Water Use Efficiency Indices for wheat under various levels of SI*

Treatment	Water amount (mm)	WUE of SI, kg/m^3		WUE of rain+SI, kg/m^3	
		Grain	Straw	Grain	Straw
W1	311 + 82	2.32	3.90	1.09	2.42
W2	311 + 123	2.76	3.58	1.34	2.47
W3	311 + 164	2.32	2.93	1.31	2.34
W4	311 + 205	2.49	3.37	1.45	2.56

* *Rainfed water use efficiency indices were 0.77 and 2.03 kg/m^3 for grain and straw yields, respectively.*

Comparison of the WUE values for irrigation water used for SI (2.76 kg/m^3) and for full irrigation (approx. 0.5 kg/m^3) argues strongly for a review of the present allocation of national water resources, based on relative productivity and economic viability. Rainfall WUE improved significantly when combined with SI water, increasing for grain from 0.77 kg/m^3 rainfed to 2.32 kg/m^3 when only 82 mm of SI water was applied. At the same time, WUE for straw improved from 2.03 to 2.42 kg/m^3.

Crop consumptive use. Total evapotranspiration over the growing season increased from 292 mm under rainfed conditions to 371, 413, 455 and 491 for W1, W2, W3 and W4 treatments respectively. Figure 3.3.7 shows the daily ET under rainfed conditions, various levels of

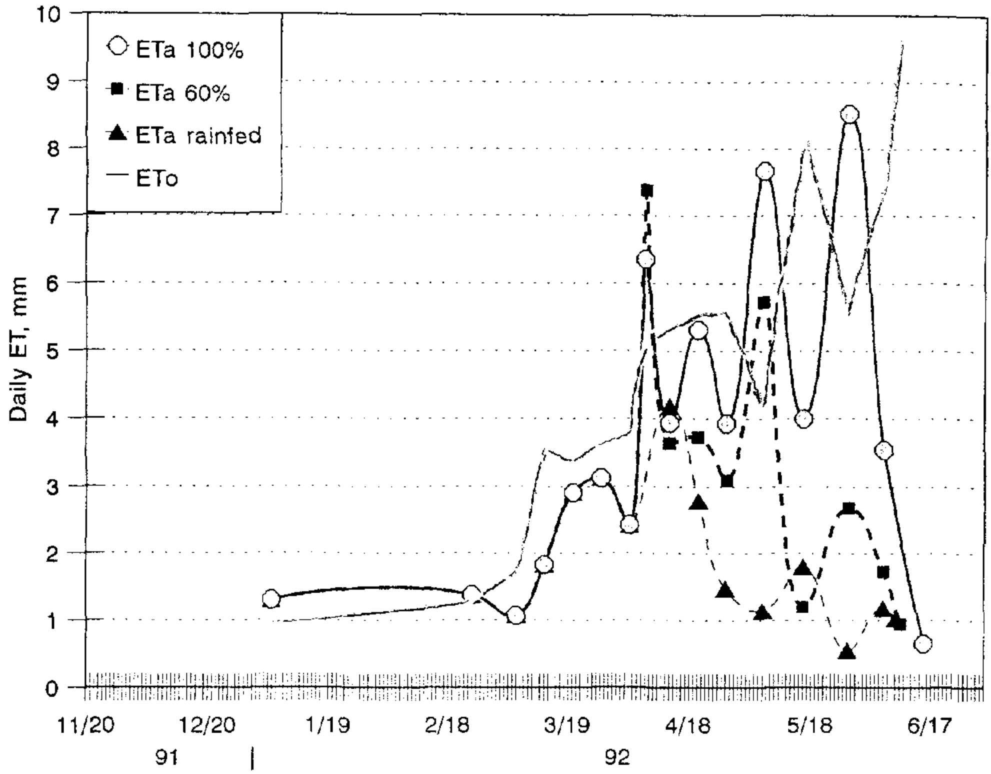


Figure 3.3.7 Daily actual wheat ET under various SI levels and reference pan ET for the 1991/92 season

SI and reference Class A-pan ET. The latter was determined by multiplying Class A-pan daily evaporation by an empirical coefficient of 0.75. Crop ET for the period from planting until the first irrigation was averaged from all treatments, since they were all rainfed at that stage.

3.3.4 Conclusions

1. Use of drip lateral spacings up to 100 cm, and dripper spacings along the lateral up to 50 cm, had no detectable effect on wheat ET or yield in heavy soils at Tel Hadya. The post-irrigation irregularities in the wetting front at the widest spacing seem

to be temporary. Drip irrigation systems with spacings of this magnitude or less can be used for SI trials without adverse effects on experimental parameters. The system could be an excellent experimental tool in areas where continual strong winds disturb sprinkler systems.

2. For the average rainfall season of 1991/92, wheat yield increased linearly with both ET and SI water until potential yield was reached.
3. Rainfall WUE can be increased significantly by applying SI water. The WUE of water used in SI may be as much as 5 times that achieved in full irrigation.

T. Oweis with major technical support from S. El Dehni and M. Tahhan.

3.4 Soil and Plant Nitrogen Studies in the Two-Course Wheat Rotation

While the 2-course wheat-based rotation has been described in detail before (FRMP 1990; and see also section 3.11, below), report of its soil and crop N status has previously been limited to preliminary observations on data obtained for the first time in 1989 (FRMP 1991). Since then we have had limited sampling of the plots in 1990 and a complete sampling after the 1990/91 and 1991/92 cropping seasons (data not yet available). This included determination of nitrate (NO_3^-), ammonium (NH_4^+), mineral N ($NO_3 + NH_4$), and total N, i.e. Kjeldahl N, which accounts mainly for the organic N fraction in the soil -- normally the largest one.

As NH_4 is readily transformed to NO_3 by microbial-induced nitrification and as both of these forms are readily absorbed by growing plants, it is convenient to consider total mineral N rather than the individual forms separately. Thus, mineral N values are presented for each rotation (Table 3.4.1) and for both phases of each rotation (Table 3.4.2) and each N level (Table 3.4.3).

Table 3.4.1. Topsoil (0-20 cm) mineral N concentration in a rotation trial with seven crop sequences

Year*	Crop rotation							S.E.	n
	W/F	W/W	W/L	W/C	W/S	W/V	W/M		
	ppm								
1989	10.2	9.9	9.7	9.8	11.1	11.9	15.8	0.69	48
1990	9.5			10.3			11.0	1.04	16
1991	10.6	7.9	8.3	10.4	10.4	10.3	14.9	0.88	48

Differences between rotation means: 1989, p<0.001; 1990, p=0.613; 1991, p=0.003.
** Samples were taken in October of each year*

Table 3.4.2. Topsoil (0-20 cm) mineral N concentration in two phases (B: after 'legumes'; A: after wheat) of a rotation trial with seven crop sequences

Year	Phase	Crop rotation							S.E.	n
		W/F	W/W	W/L	W/C	W/S	W/V	W/M		
		ppm								
1989	B	10.6	7.4	7.6	7.0	11.8	10.2	12.4	0.977	24
	A	9.8	12.4	11.7	12.6	10.4	13.5	19.2		
S.E. 1.48										
1991	B	12.7	6.6	7.2	7.3	12.1	10.1	13.7	1.249	24
	A	8.6	9.2	9.4	13.4	8.8	10.4	16.0		
S.E. 1.156										

Probability of F-Ratio: 1989=0.007; 1991=0.019

It was clear that mineral N was consistently higher in the medic rotation, while wheat after wheat or lentil tended to have lowest values (Table 3.4.1). Few differences were apparent between the other rotations. The same trend was again evident when measurements were made after each phase, i.e. wheat or alternative crops (Table 3.4.2). The impact of N fertilization was consistent after the wheat phase but less obvious after the unfertilized alternative phase (Table 3.4.3). This reflected residual fertilizer N which was

Table 3.4.3. Topsoil (0-20 cm) mineral N concentration in two phases (B: after 'legumes'; A: after wheat) of a rotation trial fertilized at four N levels in the wheat phase

		Fertilizer N applied (kg/ha)					
Year	Phase	0	30	60	90	S.E.	n
		ppm					
1989	B	8.34	83.45	10.63	10.95	0.830	42
	A	6.12	7.30	14.10	23.70		
S.E.	1.378						
1990	B	9.1			12.5	1.237	12
	A	7.2			12.3		
S.E.	0.935						
1991	B	8.36	10.34	9.86	11.36	0.724	42
	A	6.16	7.43	11.55	18.18		
S.E.	0.627						

Probability of F-Ratio: 1989=<0.001; 1990=0.509; 1991=<0.001

apparently used up by the alternative phase crops or, more likely, incorporated into soil organic forms.

As organic N is the dominant N fraction in soils, total soil N is an important observation. Interestingly, again, rotations with medics had significantly enriched soil N contents compared with wheat after either fallow, summer crop or wheat -- none of which sequences added to soil N (Table 3.4.4). Total N values for the other N-fixing legumes -- vetch, chickpea and lentil -- all showed some evidence of N enrichment. When the rotation effect was separated into phases, soil N values were consistently higher after the alternative crops. Nitrogen fertilization, at the 60 and 90 kg N/ha rates but not the 30 kg rate, tended to increase total N values also. This can be explained in relation to crop yield. The initial increment of N produced a proportionally larger yield response and was completely taken up by the crop; additional increments had less effect on yield and the unused N remained in the soils as residual N.

Table 3.4.4. Topsoil (0-20 cm) total N concentration in a rotation trial with seven crop sequences

Year	Crop rotation							S.E.	n
	W/F	W/W	W/L	W/C	W/S	W/V	W/M		
	ppm								
1989	686	698	737	716	668	739	806	10.5	48
1990	697			737			812	26.6	16
1991	688	678	718	696	651	738	792	12.8	48

Probability of F-Ratio: 1989=<0.001; 1990=0.085; 1991=<0.001

The content of organic matter in the top 20 cm soil layer is presented in Table 3.4.5 as a function of the overall effect of the differing rotations and in Table 3.4.6 as a function of the mean effect of N fertilization over all rotations and phases. In theory, the process of inducing changes in organic matter by varying management is relatively slow. However, there was evidence that some differences had arisen in the 7 years since the trial began. Notwithstanding the limited data for 1990, there was a general consistency in the data for the 3 years under consideration.

Table 3.4.5. Organic matter in the top 20 cm of soil in a rotation trial with seven crop sequences

Year	Crop rotation							S.E.	n
	W/F	W/W	W/L	W/C	W/S	W/V	W/M		
	%								
1989	1.03	1.05	1.12	1.09	1.02	1.13	1.26	1.019	48
1990	1.00			1.11			1.22	0.038	16
1991	1.03	1.05	1.09	1.07	1.02	1.14	1.21	0.022	48

Probability of F-Ratio: 1989=<0.001; 1990=0.038; 1991=<0.001

Table 3.4.6. Organic matter in the top 20 cm of soil of a rotation trial fertilized at four N levels in the wheat phase

Year	Fertilizer N applied (kg/ha) 0	30	60	90	S.E.	n
	----------------		%	----------------		
1989	1.06	1.07	1.12	1.14	0.016	84
1990	1.06			1.16	0.012	24
1991	1.05	1.08	1.11	1.11	0.015	84

Probability of F-Ratio: 1989=<0.001; 1990=0.001; 1991=0.008

When the crop rotations were considered, it was clear that the lowest values were associated with wheat after wheat and with wheat after fallow or summer crop, i.e. those rotations without an N-fixing legume. Among rotations that include legumes, that with medics produced the highest organic matter content, followed by rotations with vetch, chickpea, and lentil which were similar. An interesting feature of the data (Table 3.4.6) was the apparent increase in soil organic matter content with increasing rate of N application. This is probably attributable to enhanced root growth from the applied N.

The N supply to the soil, whether from added fertilizer or biological fixation, impacts not only on yield data but also on the N content of the biomass (Table 3.4.7). Higher N concentrations indicate higher grain protein contents and nutritional value and improved forage quality as well.

The N concentrations tended to be higher in the medic and, to a lesser degree, the chickpea and vetch rotations; lower values tended to be associated with the fallow and summer crop rotations. The trends were more evident with straw than with grain. However, as the N supply in the soil is diluted in plant biomass, the N concentration and yield tend to be inversely related. The N supply is more clearly seen by an integration of concentration and yield, i.e. N uptake or exportation (Table 3.4.8).

Table 3.4.7. Nitrogen percentage in wheat grain and straw in a rotation trial with seven crop sequences

Year	Rotation							S.E.	n
	W/F	W/W	W/L	W/C	W/S	W/V	W/M		
	----------------			%	----------------				
Grain									
1989	2.29	3.04	2.66	3.09	2.54	3.07	3.70	0.107	24
1990	2.13	2.63	2.58	2.55	1.95	2.57	3.10	0.083	36
1991	2.61	2.45	3.04	3.31	2.73	3.27	3.74	0.059	36
Straw									
1989	0.39	0.83	0.63	0.77	0.47	0.71	1.45	0.050	24
1990	0.45	0.72	0.64	0.64	0.37	0.63	0.89	0.056	36
1991	0.49	0.45	0.63	0.82	0.51	0.72	0.94	0.029	36

Table 3.4.8. Nitrogen in above-ground biomass of wheat in a rotation trial with seven crop sequences

Year	Crop rotation							S.E.	n
	W/F	W/W	W/L	W/C	W/S	W/V	W/M		
	----------------			kg/ha	----------------				
1989	58.5	15.6	38.0	19.7	39.6	41.6	26.7	3.82	24
1990	36.6	27.7	30.1	26.9	41.4	31.0	32.9	1.77	36
1991	60.8	37.7	60.3	55.4	68.4	63.8	71.5	3.39	36

In the above tables, data for 1989 are based on two of three replicates.

If soil N dynamics were not influenced by crop rotation, N uptake values would be inversely proportional to yield . However, this was not the case; the discrepancy between yield and N uptake data indicates a contribution of the legumes in the rotation to the N supply. For example, in 1988-89 season, the highest yield from the fallow rotation exceeded that with medics more than threefold, while

N uptake exceeded the value only twofold. Therefore, while N fixation by legumes contributed to N build-up in the soil, the overriding factor in dictating crop yield was soil moisture. *J. Ryan, H. Harris, A. Matar, with the technical assistance of S. Garabet and S. Masri.*

References

FRMP, 1990. Productivity of crop rotations. FRMP Annual Report for 1989, p. 137-166.

FRMP, 1991. Soil nitrogen status in two-course rotations: a preliminary assessment. FRMP Annual Report for 1990, pp. 126-133.

3.5 Fixation and Cycling of Nitrogen in a Dryland Legume/Cereal Production System

A collaborative project* between ICARDA and Reading University, UK, has begun, with the overall objective of assessing the long-term sustainability of rainfed legume/cereal production systems in dry environments. Specifically, a systematic monitoring of nitrogen balances and flows will be carried out within the two-course wheat rotation (described in section 3.11). Ultimately, quantitative data on nitrogen cycling and mechanistic models formulated from them will underpin empirically derived models and allow for extrapolation of information in space and time. During this, the first year of the project, two experiments were carried out:

Experiment One. A detailed nitrogen cycling study in the wheat phase of the rotation, under zero-grazing management. Labelled urea fertilizer (^{15}N) was applied at planting to wheat following fallow (W/F), lentil (W/L), chickpea (W/C) and continuous wheat (W/W) at a

* The project is funded by the Overseas Development Administration, UK.

rate of 30 kg N/ha. The ^{15}N was used as a tracer to evaluate plant nitrogen uptake, fertilizer-use efficiency and partitioning of nitrogen in the various soil nitrogen pools (organic, inorganic and biomass) at tillering (March 1992) and harvest (June 1992). In the W/F rotation the effect of fertilizer rate was assessed by labelling with ^{15}N the three fertilizer rates (30, 60 and 90 kg N/ha) currently used in the rotation; in addition, the effect of split-dose application of fertilizer was measured using paired micro-plots in the 60 kg N/ha treatment.

Experiment Two. Biological dinitrogen fixation by lentil and chickpea in the legume phase of the rotation was estimated using ^{15}N methodology. A comparison was carried out between the classical isotope dilution method and the A-value technique; several different control crops (wheat, barley and non-nodulating chickpea) were also evaluated.

Results. Statistical analysis of data and detailed interpretation are currently being carried out. Preliminary assessment indicates some differences between the rotations investigated, both in terms of soil and fertilizer nitrogen uptake by the crop and immobilization of fertilizer nitrogen by the soil organic matter. Estimates of nitrogen fixed by each legume crop varied depending on the method used and the control crop, with lentil fixing more nitrogen than chickpea.

Future work. The two experiments carried out in the past season (91/92) will be repeated in the 1992/93 season in the alternate phases of the rotation. In addition, the fate of nitrogen in the ^{15}N-labelled wheat and legume residues (root, plus stubble in wheat) from the first season will be monitored. Measurements will also be made of soil carbon and nitrogen in both zero and heavy-grazing treatments to provide data for testing carbon and nitrogen models being developed in the UK for predicting the long-term sustainability of such rotations. *A. McNeill (Reading University), H. Harris, D. Beck (LP), with technical assistance from Ali Haj Dibo and S. Garabet.*

3.6 Nitrogen Fertilizer Use Efficiency by Wheat Under Different Water Regimes

This work, which constitutes a major component of Ms Sonia Garabet's MSc thesis project, was conducted at Tel Hadya during 1991/92 in collaboration with Reading University. Its aim was to explore the possibility of improving the efficiency of use of limited water and nutrient resources in the drier areas of rainfed agriculture by following the fate of nitrogen fertilizer added to the soil under different water regimes. Nitrogen fertilizer-use efficiency (NFUE) under different nitrogen and water levels was assessed by two different methods (a) Difference (Dif) and (b) Direct (Dir), using ^{15}N:

a. $$\text{NFUE \% (Dif)} = \frac{N_{(f)} - N_{(0)}}{N_{(F)}} \times 100$$

b. $$\text{NFUE \% (Dir)} = \frac{\text{at. \% excess}\,^{15}\text{N(plants)}}{\text{at. \% excess}\,^{15}\text{N(fert.)}} \times \frac{N_{(f)}}{N_{(F)}} \times 100$$

where: $N_{(f)}$ = kg/ha N uptake in fertilized plots

$N_{(0)}$ = kg/ha N uptake in unfertilized plots

$N_{(F)}$ = kg/ha rate of N fertilizer used

3.6.1 Materials and Methods

The experimental design was a randomized complete block design with two treatment factors with four replicates. The first factor was four rates of nitrogen fertilizer as ammonium sulfate. All fertilized plots had a 2 m^2 area of micro-plots, where labelled ammonium sulfate was added as follows:

N0 = unfertilized

N1 = 50 kg N/ha with 2.5 at. % ^{15}N

N2 = 100 kg N/ha with 1.0 at. % ^{15}N

N3 = 150 kg N/ha with 1.0 at. % ^{15}N

The second factor was water treatment with four rates as follows:

W0 = rainfed

W1 = 33% of amount of water given to W3

W2 = 66% of amount of water given to W3

W3 = represented the maximum irrigation, where the soil is given the amount of water required to compensate for total consumption (evapotranspiration), restoring it each time to 100% of field capacity.

These treatments were given twice during the season, when the content of available water in the W3 soil had fallen to 50%, coinciding approximately with heading and anthesis. (Two access tubes had been placed in each plot of W3 and W0 treatments to monitor the water changes in the soil profile to a depth of 180 cm by neutron probe and determine the time and the amount of water needed for each irrigation.) The wheat variety used was Cham 4, a local bread wheat; the seed rate was 120 kg/ha. Plant samples were taken from selected treatments (N0W0, N0W3, N2W0 and N2W3) nine times during the growing season; their ^{14}N and ^{15}N contents were measured and NFUE values estimated by the two methods.

3.6.2 Results

The development of nitrogen fertilizer-use efficiency in selected treatments (N2W0 and N2W3) is represented in Fig. 3.6.1 for both the Difference and Direct methods. In the first three plant harvests NFUE calculated by the Difference method was lower than that calculated by the Direct method. Later, with increased plant N uptake, NFUE values increased and those from the Difference method

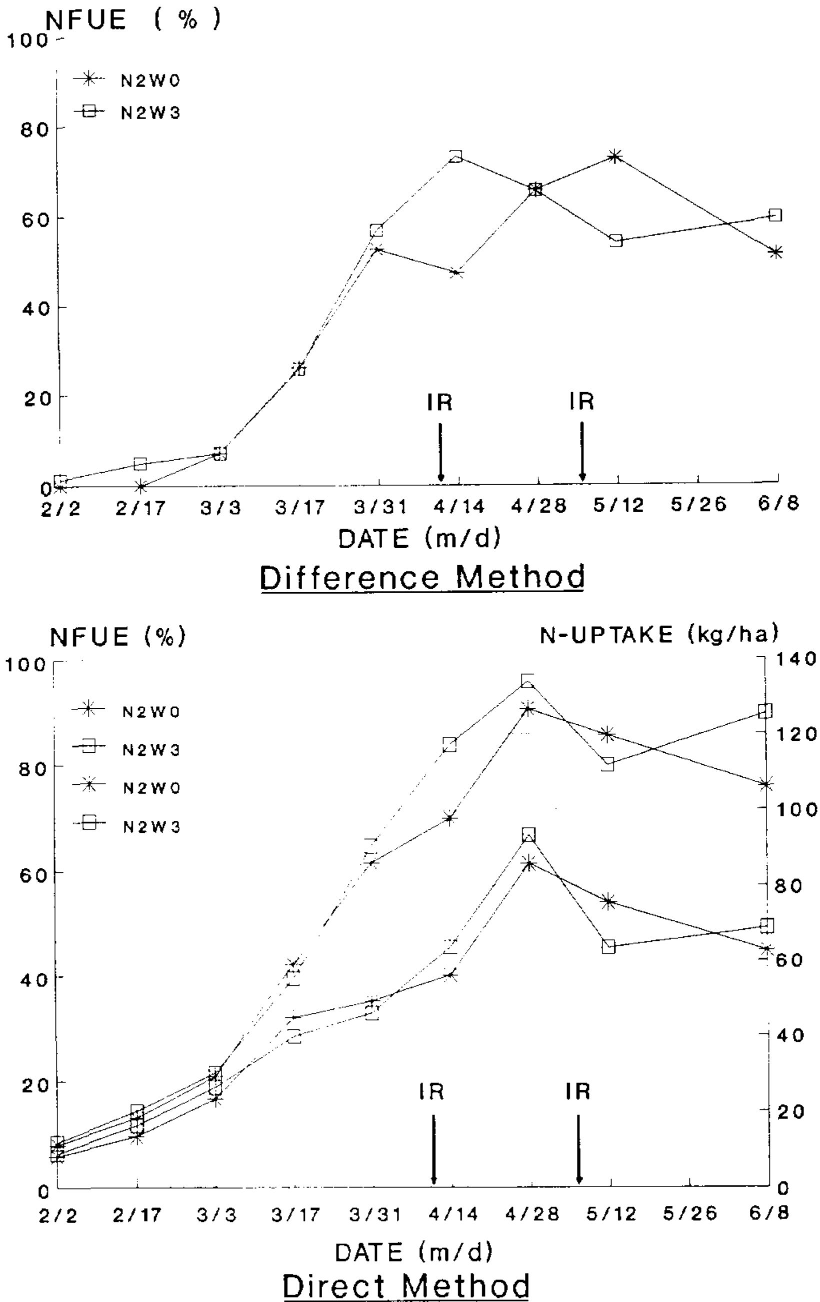


Figure 3.6.1 Development of nitrogen fertilizer use efficiency for selected treatments at Tel Hadya during 1991/92 season (Difference and Direct methods)

were higher than those from the Direct method. Differences in NFUE values was between the rainfed and irrigated treatments were observed after each irrigation, but only where the Difference method was used.

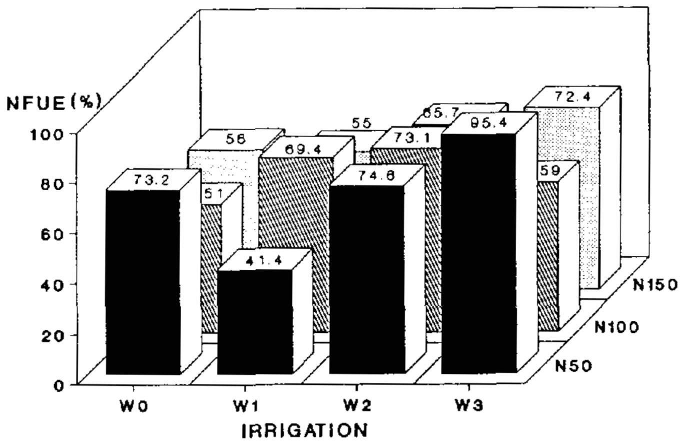
Nitrogen uptake was plotted for the nine plant harvests during the season (Fig. 3.6.1). It showed that the NFUE values by the Direct method had the same pattern of N uptake as the selected treatments. The NFUE values by the Difference method did not have a clear pattern.

NFUE values from both methods for all treatments at harvest are compared in Fig. 3.6.2. The variation was high among Difference method values (CV=24%), and there was no clear increasing or decreasing trend. The Direct method showed a significant increase in NFUE values with increased N fertilizer rates ($p>0.05$). NFUE values also increased with irrigation rate, but the trend was not statistically significant because water was relatively available during the season, while the soil was poor in available nitrogen. The variation was smaller (CV=11%) among Direct method values. Overall means of NFUE (65.5%) by Difference method substantially overestimated the NFUE values compared with the Direct method (44.9%).

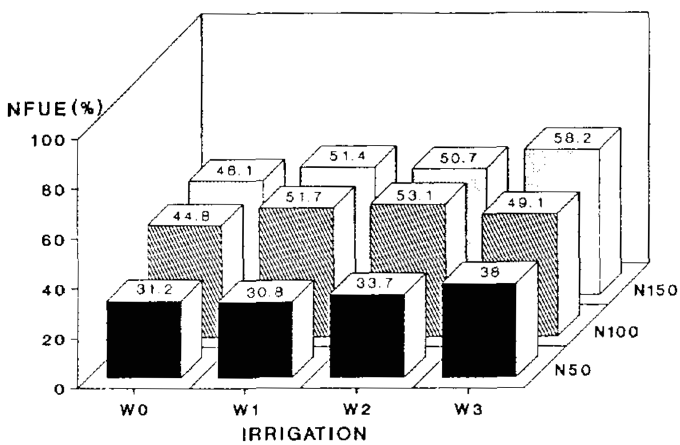
The experiment is being repeated during the cropping season of 1992-93. *S. Garabet, M. Wood (Reading University) and J. Ryan.*

3.7 Regional Soil Fertility Network: A Perspective

As the mandate of ICARDA is to promote agricultural research on dryland crops, through collaboration with national scientists, and its application at farm level in countries of the WANA region, a network was developed to facilitate communication and joint effort on soil fertility, with a specific emphasis on soil-testing for available phosphorus and nitrogen to promote efficient fertilizer use.



Difference Method



Direct Method

Figure 3.6.2 Nitrogen fertilizer-use efficiency by wheat as related to applied nitrogen fertilizer and irrigation at Tel Hadya 1991/92 season (Difference and Direct methods)

The initial meeting in Aleppo in 1986 (Soltanpour 1987) was jointly sponsored by ICARDA, the Mid-America International Agricultural Consortium (MIAC) in Morocco, and the International Development Research Center (IDRC). Along with some general background papers, reports dealt with P tests and the responses of cereals and legumes in Morocco, Cyprus, Syria, Jordan, Turkey, and Pakistan. Most reports illustrated consistent crop responses to P fertilizer. Several ongoing investigations of soil-test methods for N for field crops were reported, along with a review of N use and crop response in Mediterranean environments in relation to rainfall. Protocols for conducting fertilizer trials for participating scientists were established, implementing a factorial N-P design with the main focus on wheat.

A second meeting in 1987 in Ankara (Matar et al. 1988) brought an expanded range of participants. Papers considered issues such as residual P for barley (Cyprus), plant P diagnostic norms (Tunisia), calibration of different P tests for cereals, legumes, and oilseeds (Pakistan), P fertilization of legumes (Syria), and wheat responses in Morocco, Jordan, and Syria. The protocols for P trials were expanded; standardized procedures were developed for site selection, soil sampling and analysis, fertilizer treatments and experimental design. A procedure was developed for quality control with the region's soil-testing laboratories.

Several field studies from northwestern Syria, Jordan, and Morocco demonstrated the almost universal response to applied N when rainfall was adequate. The importance of crop rotations, particularly involving legumes, and of soil type, notably involving depth, was highlighted. It was emphasized that soil testing for nitrate (NO_3) could give a reliable indication of N fertility in rainfed soils. Research with ^{15}N at ICARDA in conjunction with the International Fertilizer Development Center (IFDC) showed that N losses through volatilization were not significant.

The third meeting of the Network took place in Amman in 1988

(Ryan and Matar 1990). Additional national delegations attended, including representatives from Iraq and Yemen for the first time. In addition to P calibration studies with cereals and soil testing procedures, topics included modeling of residual P responses, fertilizer P placement, i.e. banding vs broadcasting, P in relation to rotations, and the use of isotherms to evaluate crop P requirements. The protocols were modified to have separate P trials with basal N, rather than more elaborate and expensive factorial trials, since many sites are not consistently responsive to both elements.

The importance of N was again stressed by reports from Morocco, Jordan, Pakistan, Cyprus, and Iraq. A more in-depth assessment of the various forms of N in soils along with residual N was made; the significance of mineralization potential was introduced in a laboratory-greenhouse study from Morocco. Similarly, the concept of N in the regions' farming systems and the role of organic matter was also introduced.

A fourth meeting of the Network was held in Agadir, Morocco, in May 1991 (Ryan and Matar 1992). New participants came from Iran, Libya, Algeria and Spain. The meeting was the first to have a significant contribution from researchers at regional universities. This introduced a theoretical dimension, which had been lacking in previous meetings and which helped to explain observations previously made from a diversity of field trials.

Some presentations dealt with the basic behavior and mineralogy of P in Mediterranean-region soils (Spain), notably buffering capacity in relation to soil P tests and the distribution of P forms within soil profiles (Morocco). A spin-off of this effort was a recent review of soil P in Mediterranean soils by scientists from ICARDA, Spain and Morocco (Matar et al. 1992). A new soil test for P, using dye-impregnated paper strips, was presented (Egypt), while a modification of the standard Olsen bicarbonate method, i.e. NH_4HCO_3-DTPA, was seen as being useful (Pakistan).

Again, the importance of N was clear from field responses with several cereals - wheat, barley, and triticale (Morocco) -- along with emphases on rainfall and temperature in crop response (Syria, Jordan). The issue of mineralization was developed further by a consideration of the various fractions of N in soils. While reports from Cyprus pointed to the significance of soil NO_3 measurement, a novel approach to fertility assessment involved the use of tissue-testing for NO_3.

Other items included, for the first time, potassium and its possible significance in the region (Morocco). The general consensus was that K is adequate in rainfed soils but would be needed under irrigated conditions, especially in sandy soils. A new dimension to soil testing involved the idea of spatial variability; this has important implications for field sampling and subsequent test values. In this meeting also more emphasis was placed on economic considerations, eg. assessing strategies for fertilizer allocation and evaluating the N fertilization of barley. The concept of N in relation to crop rotations was also to the fore.

After these regional meetings, the Network agreed to adopt the $NaHCO_3$ or Olsen procedure as the official soil P test for the region and to consider 5 to 7 ppm as the critical value below which a response to fertilizer is likely. The convention of taking soil samples to a depth of 20 cm was adopted. Fertilizer P rates of 10 to 20 kg P/ha are recommended, depending on the extent of deficiency. While similar criteria have been developed for NO_3, the test is less reliable than that for P, since it is influenced by cropping systems, mobility of NO_3 with varying soil moisture regime, and with the soil's mineralization potential. Recommendations for the N fertilization of cereals range from little or none after legumes, 20 to 30 kg/ha under normal dryland conditions, and up to 90 kg N in high-rainfall years. The many "grey" areas of current knowledge were identified and will provide the core of the Network scientists' concerns in the coming years.

In demonstrating the benefits of soil testing, the Network can serve as a catalyst for governmental institutions and the private sector to provide such services. In most countries of the region, few farmers test soils. Indeed, facilities for testing are poorly developed and often too expensive for the small farmer. Future Network efforts will be as much in the educational domain as the technical. It will continue to be a forum for dryland soil scientists and agronomists of the region to share information and enhance their professional development. The initial phase has been funded by UNDP and IMPHOS. It is hoped that continued funding will be forthcoming for a second phase to build on the very successful foundations that have been laid. *J. Ryan.*

References

Matar, A.E., Soltanpour, P.N., and Chouinard, A. (ed), 1988. Proc. Second Regional Soil Test Calibration Workshop, 1-6 September 1987, Ankara, Turkey. ICARDA.

Matar, A.E., Torrent, J., and Ryan, J., 1992. Soil and fertilizer phosphorus and crop responses in the dryland Mediterranean zone. Adv. Soil Sci., 18:82-146.

Ryan, J. and Matar, A.E., 1990. Proc. Third Regional Soil Test Calibration workshop, 3-9 September 1988, Amman, Jordan. ICARDA.

Ryan, J. and Matar, A.E., 1992. Fertilizer-use efficiency and rainfed agriculture in West Asia and North Africa. Proc. Fourth Soil Test Calibration workshop, Agadir, Morocco, 5-10 May 1991. ICARDA.

Soltanpour, P.N., 1987. Proc. First West Asia and North Africa Soil Test Calibration workshop, 23-25 June, 1986, ICARDA, Aleppo, Syria.

3.8 Oilseed Crops

3.8.1 Introduction

Current production of edible oils in the WANA region is seriously inadequate. Local production from olives, cotton seed, and other oilseeds supplies only about 20% of the demand. Most of the countries in WANA are importing edible oil. Total imports in 1990 were more than 4.41 million tonnes, costing more than 2.258 billion US dollars. Pakistan, Egypt, Turkey and Iran were the major importers (67%), followed by Algeria, Morocco and Tunisia.

The agroclimate of most Mediterranean and West Asian countries is suitable for the production of winter oilseeds (rapeseed and mustard, safflower, linseed) and/or spring oilseeds (sunflower, sesame), although spring crops may require supplemental irrigation in low rainfall years. Small areas of these oilcrops are already widely grown in the region, and some countries have initiated research. The need is to provide them with improved varieties and suggest improved production practices.

Research objectives. ICARDA started a small oilseed research program a couple of years ago and expanded this in January 1992 with the appointment of a visiting oilcrops agronomist. Crops selected for research are: rapeseed, *Brassica napus* and *B. campestris*, safflower, *Carthamus tinctorius*, sunflower, *Helianthus annuus*, and sesame, *Sesamum indicum*.

Good quality varieties of rapeseed, low in undesirable erucic acid in the oil and low in toxic glucosinolate in the meal, are available. Rapeseeds are drought- and cold-tolerant and give economic yields under low to medium rainfall. Desirable varieties will be selected from among the introductions acquired from Canada, Europe, Australia and USA.

Safflower is also cold- and drought-tolerant and can germinate at low temperatures. Evaluation of the world collection, which has been acquired and planted, will be carried out at ICARDA stations, and suitable material may be sent to NARS. Sunflower will be researched for spring planting. It is highly adaptable and is credited with considerable drought resistance and tolerance to low temperatures and poor soils. It gives a high oil yield per unit area, and its seed also contains good quality protein.

Sesame is already widely grown in many WANA countries, but yields are low (around 150 to 300 kg/ha) due mainly to a lack of improved varieties and to poor cultural practices. Sesame produces good quality oil and good quality protein, most suitable for human food. A summer crop, it has two major problems: susceptibility to shattering, and non-uniform maturity, both resulting in seed loss before harvest. Germplasm from sesame growing countries of the world will be screened to find desirable varieties for the WANA region.

Production constraints. The main WANA countries growing oilseed crops (rapeseed and mustard, sesame, groundnut, sunflower) are Turkey, Iran, Egypt, Morocco, Ethiopia, Sudan and Pakistan. Their production constraints include:

- Oilseeds have always been considered minor crops and have never been given much attention in agricultural research and development. Selection and improvement of varieties for yield and quality, and research into improved production practices, have been only on a small scale.
- Farmers always allocate oilseeds to marginal lands, with low inputs and limited management, because of the risks of insect pests, unpredictable rains, widely fluctuating prices and poor marketing infrastructure.
- No reliable local sources of improved seed.
- Appropriate machinery for sowing, harvesting or threshing has not yet been developed, constraining production.

Research priorities. The research priorities for the four crops ICARDA has chosen to work on are:

- Collection, from inside and outside the region, of old and new varieties and cultivated landraces; and screening, selection and increase of the promising lines for distribution.

- Evaluation and development of production practices, such as optimum sowing dates, fertilizer needs, seed rates, supplemental irrigation requirements and control of prevalent insects, diseases and weeds.
- Determination of the appropriate place of oil crops in crop rotations to ensure minimum disturbance to the production of major crops, wheat, barley, chickpea or lentil. The idea is that oilcrops should diversify the rotations and, in particular, utilize land that is currently fallowed. Inclusion of an oilseed crop should give economic benefits to the farmers.

However, increases in edible oil production in WANA countries will require both research and development actions. Enterprises utilizing crop products will need guidance and encouragement to use the whole oilseeds, oils, and by-products like meal, seed cake and straw. To make the cultivation of oilcrops attractive and to increase their economic value, every plant part should be utilized. Pilot projects for the development of oilseed industries will therefore be required, encompassing research, seed production, crop production, processing, packaging and marketing.

3.8.2 Field experiments at ICARDA, 1991/92

3.8.2.1 Performance of rapeseed and mustard

Materials and methods. The trial, at Tel Hadya, compared twenty varieties from three oilcrop brassicas, fourteen from *B. napus* species (12 spring type and 2 winter type), five from *B. campestris* and one from *B. juncea*. *Napus* and *campestris* varieties are low in erucic acid and glucosinolate. *Juncea* is high in erucic acid, and its oil is used for industrial purposes. These varieties come from Australia (7), Canada (10), and Germany (3).

Planting was on land under chickpea the previous year. The plot size was 9.5 x 2.1 m, with twelve rows per plot, spaced 17.5 cm apart. Treatments were arranged in a complete randomized block design with three replications. Seed rate was 8 kg/ha. Fertilizer was applied at the rate of 50 kg/ha each of N and P as TSP and ammonium nitrate before sowing, with an additional 20 kg N/ha side-dressed in early February. Weeds were controlled manually.

The crop was sown on 15th October and emerged on 3 Nov 1991. Early sowing and emergence was possible due to 25.9 mm rain in October before sowing and 54.4 mm after sowing and before emergence. The data collected were: days to 50% flowering; days to physiological maturity, when plants are ready for swathing, when about 25% grains have turned brown; plant population density, branches and number of pods per three plants, height at maturity, 1000-grain wt (TGW) and grain yield per plot. Additionally, a square meter of crop was harvested from each plot to estimate biological yield and harvest index. Total rainfall received by the crop was 349 mm.

Results. *Grain yield*: The average yield of five campestris varieties was 1020 kg/ha, with Jumbuck highest at 1254 kg/ha (Table 3.8.1). The average yield of 12 spring-type napus varieties was 1136 kg/ha, with Westar highest at 1483 kg/ha, but in fact the nine top-yielding varieties all gave similar yields. The 2 winter-type napus varieties averaged 734 kg/ha, suggesting that these are less suitable for the Syrian environment. In contrast, the one juncea variety tested, Cutlass, yielded 1425 kg/ha, indicating that juncea may well be more suitable for the environment. Good quality is not yet available in this species, but it should be considered for industrial purposes.

These yields are comparable with yields obtained in Canada (Bowren and Pitman 1975), indicating the suitability of rapeseed as an oilcrop for areas with a Syrian-type environment. However, good yields were made possible this season by early sowing following sufficient rain in October. The crop emerged early and had made good growth before the severe winter set in. Rapeseed is more

Table 3.8.1. Rapeseed and mustard variety differences in seed yield and other seed and plant characters

Varieties	Grain yield kg/ha	1000-grain weight	Harvest index (%)	Pods p/plant	Plant pop. (/m²)	Plant height cm	Total dry matter (g/m²)	Grain g/m²	Branch p/plant
<u>B. campestris</u>									
1. Jumbuck	1254	1.94	17.7	240	148	106	706	125	9
2. Parkland	885	1.94	17.7	189	159	94	608	108	9
3. Rex	1025	1.96	18.8	210	126	111	644	120	8
4. Titan	980	2.06	17.2	201	129	111	556	96	7
5. Tobin	958	1.91	15.8	191	128	103	615	94	8
<u>B. napus</u>									
1. ACS1	982	3.12	19.6	106	129	92	802	153	7
2. ACS3	1125	3.14	19.6	105	127	96	778	151	6
3. Eureka	1115	3.01	27.3	161	100	87	757	206	7
4. Maluka	1274	2.93	20.0	121	117	90	671	135	6
5. Pivot	1162	3.18	18.5	136	148	95	695	129	6
6. Regent	917	2.00	20.2	131	148	98	539	108	6
7. Shiralce	1036	3.32	21.9	170	103	87	898	197	8
8. Taparoo	1020	1.95	24.4	145	89	82	563	162	6
9. Wesreo	1073	3.11	17.5	124	115	98	599	106	6
10. Wesroona	1297	3.08	19.4	136	133	97	722	140	6
11. Westar	1483	3.58	19.3	130	131	97	687	133	5
12. Wesway	1151	3.23	23.4	112	111	95	467	110	5
<u>B. napus W.T</u>									
1. Ceres	758	2.89	17.3	116	111	90	606	107	5
2. Cobra	709	3.18	19.0	87	103	93	522	102	5
<u>B. juncea</u>									
1. Cutlass	1425	2.17	17.1	128	135	117	493	87	7
S.E.	183	N.A.	2.02	24.6	22.1	5.0	116.95	27.2	N.A.
LSD 5%	370		4.09	49.9	N.S.	10.0	N.S.	55.0	

(Grain yield and 1000-grain weights were measured from whole-plots; other parameters from a 1 m² sample area). <u>N.B.</u> <u>B. campestris</u> and <u>B. napus</u> in vernacular language are called rapeseed, while <u>B. juncea</u> is called mustard.

tolerant to cold at the rosette stage than at earlier stages of growth.

1000-grain weight (TGW): Most of the B. napus varieties, whether spring or winter type, had higher and similar TGW values, around 3.15 g (range, 2.89 to 3.58 g), and only two napus varieties, Taparoo and Regent, had TGW values around 2 g, which is similar to those of campestris varieties, which averaged 1.96 g. TGW of the juncea variety was 2.17 g. In general, high TGW was associated with high yield in napus varieties, but this was not true for the juncea variety. The highest yielding Westar variety also had the highest TGW of 3.58 g. These TGW values obtained are similar to those reported by Weiss (1983) in Australia.

Harvest index (HI): Napus varieties had generally higher HI values than campestris varieties, and three of them, Eureka, Taparoo and Wesway had values significantly higher than most others; but there was little relationship between HI values and yields. Pod number per plant was also apparently unrelated to yield.

Plant population was measured to assess its effect on yield and yield components. The average count was about 124 plants/m^2 giving 1,240,000 plants/ha, which is an appropriate population for optimum yields. However, a seedrate of 8 kg/ha should have produced double this population (Bowren and Pitman 1975). The range of values found (averaged over 3 replications), 89 to 160 plants/m^2, indicates an appreciable varietal difference.

Plant height differences (range, 82-117 cm) were significant. Most of the campestris varieties (average, 105 cm) tended to be taller than the napus varieties (average, 92.5 cm). Cutlass (B. juncea) was the tallest, at 117 cm. There was no definite correlation of height with yield. In general, dwarf high-yielding varieties are preferred, being less prone to lodging. However, no lodging was observed in this trial. Also there was no shattering, although napus is prone to shattering. Campestris tends to be shorter (50-125 cm) than napus (75-175 cm) under Canadian conditions

(Bowren and Pitman 1975).

Total dry matter/grain yield/m^2/branch per plant: Total (above-ground) dry matter (TDM) from a 1 m^2 area was used to estimate potential yields, HI, pods per plant, branches per plant and plant population. TDM values ranged from 467 to 898 g/m^2, but varietal differences were non-significant due to greater variation and error. The grain yield obtained from this square meter sample tended to be higher than that estimated for the whole plot. The yield range, 873 to 2057 kg/ha, possibly indicates greater yield potential with improved management, as the sample areas were usually harvested from spots with adequate population. Values of branch numbers per plant ranged from 5 to 9 (based on 3 plants per plot), but there seemed to be little correlation between the number of branches and yield.

3.8.2.2 Rapeseed and mustard performance under different levels of supplemental irrigation

Materials and Methods: Five rapeseed (3 napus, Westar, ACSN$_3$, Maluka, and 2 campestris, Rex and Parkland) and one mustard (juncea, Cutlass) variety were grown with five levels of irrigation and a rainfed treatment in a trial of split-plot design in three replicates. Main plots were assigned to varieties and split-plots to irrigations. Each sub-plot was 3x2 m. Water rates were rainfed (W0) and (W1) 18.5, (W2) 60.7, (W3) 110.6, (W4) 163.2, and (W5) 207.3 mm. Irrigation was applied on April 4 and May 11, 1992. The plots were treated with fertilizer N and P each at the rate of 40 kg/ha before planting. The crop was seeded in 16 cm rows on November 24, 1991, and emergence of all the varieties was complete by December 10. All varieties were harvested on June 3 with a small-plot grain combine when the crop was fully dry. Grain yield was recorded from the whole plot. Data were recorded for 1000-grain weight (TGW), plant height at harvest, pod number per plant (PPP). Harvest index was estimated from one square meter harvested from each sub-plot.

Results and Discussion: Highest yields were obtained from Cutlass (686 kg/ha) and Westar (623 kg/ha) (Table 3.8.2a). Among the two campestris varieties, Rex (585 kg/ha) yielded better than Parkland (412 kg/ha). No significant difference due to irrigation rate was found, but the variety x irrigation rate interaction was significant (Table 3.8.2b). The yield of Cutlass increased with increasing water, while that of Westar increased only from W1 to W3 indicating that additional irrigation was not needed. In contrast, the yields of Maluka and Parkland decreased with irrigation but not significantly. In general, yields were lower than those obtained in the other rapeseed trial this year due to late planting. Thousand-grain weights (TGW) differed between varieties. The largest seeds were those of Westar (3.6 g), the smallest those of Parkland (2.0 g)

Table 3.8.2a. Effect of variety and rates of supplementary irrigation on the yield and other agronomic traits of rapeseed and mustard, Tel Hadya, 1991-92

Treatments	Yield kg/ha	1000-grain weight (g)	Harvest Index (%)	Number of pods/plant	Plant height in cm
Varieties					
Cutlass (juncea)	686	2.1	15.1	124	142.8
Westar (napus)	623	3.6	16.4	100	102.8
Rex (campestris)	585	2.2	19.7	100	117.5
ACSN$_3$ (napus)	548	2.9	15.6	115	95.6
Maluka (napus)	522	2.9	18.7	130	91.1
Parkland (campestris)	412	2.0	18.9	114	96.6
S.E.	33.8	-	3.6	-	-
LSD 5%	75.3		N.S.	-	-
Water levels					
W0 (rainfed)	547	2.4	17.5	100	89.1
W1, 18.5 mm	564	2.4	17.5	115	97.5
W2, 60.7 mm	577	2.7	16.1	122	108.6
W3, 110.6 mm	585	2.7	16.8	126	118.3
W4, 163.2 mm	530	2.7	17.4	116	120.1
W5, 207.3 mm	570	2.8	19.2	104	112.8
S.E.	34.1	-	2.6	-	-
LSD 5%	N.S.	N.S.	N.S.	-	-

(Table 3.8.2). Harvest index, number of pods/plant and plant height varied considerably between varieties but had no discernable effect on yield. Further studies are required on the need of supplementary irrigation for rapeseed, especially its need before sowing when rains are delayed.

Table 3.8.2b. Effect of rates of supplementary irrigation on the yield of 5 rapeseed and a mustard varieties, Tel Hadya, 1991-92

	Water levels (yield in kg/ha)						
	W0	W1	W2	W3	W4	W5	Average
Cutlass	518	586	809	648	661	894	686
Westar	600	793	669	676	472	528	623
Rex	556	638	508	464	564	781	585
$ACSN_3$	580	465	523	734	539	445	548
Maluka	611	538	578	522	473	410	522
Parkland	416	367	375	466	474	372	412
Average	547	564	577	585	530	570	562
S.E. for interaction W2 x var			83.4				
LSD 5%			170.0				

3.8.2.3 <u>**Performance of Safflower: varieties x dates of sowing**</u>

Materials and Methods: This trial, conducted at Tel Hadya, compared three Turkish safflower varieties, S.541-2, Dincer and Yenice across three planting dates, late November (24/11), January (26/1) and March (23/3).

A split plot design was used. Main plots, consisting of planting dates, were split into sub plots (10 x 1.8 m) for varieties. There were six rows in each plot, 30 cm apart. Sowing was done with a small plot drill, at a seed rate of 20 kg/ha. All plots received 50 kg N/ha broadcast as ammonium nitrate before seedbed preparation. Since the soil-test value was 10 ppm P (Olsen), no additional phosphorus was applied. The first planting emerged in 21 days, the second in 33 days and the third in 20 days. Weeding was done manually. Aphids, which appeared in early May, were controlled by a single spray of Pirimor. Harvesting was done by combine, variety S.541-2 on 15 July, the other two on 30/7/1992. In fact, physiological maturity had been reached by mid-June in early maturing and by the end of June in late maturing varieties, but the stems took longer to dry sufficiently for combining. There was no lodging, which was an advantage for combining.

Grain yield: Yield differences between varieties and between dates were statistically significant, but the variety x date interaction was non-significant. Variety S.541-2 gave the highest yield, 1600 kg/ha averaged over three dates of planting, with 2104 kg/ha from the November planting (Table 3.8.3). This indicates a very good yield potential for an early winter sowing of safflower under rainfed conditions. Yield decreased considerably with delay in planting, although it might be useful to examine a range of dates with smaller intervals between them.

Table 3.8.3. Effect of varieties and date of sowing on yield and other agronomic characteristic of safflower

Treatments	Yield, kg/ha	1000-grain wt, g	Heads/ plant	Seeds/ head	Plant height, cm	Branch/ plant
S.541-2	1600	37.4	25.5	28	95.0	11
Dincer	1353	40.2	22.5	37	99.5	14
Yenice	728	37.1	10.0	30	134.0	16
S.E.	234					
LSD 5%	649					
Dates						
November 1991	1618	38.9				
January 1992	1263	37.1				
March 1992	800	38.6				

S.541 is a spiny variety, comparatively short in height (95 cm). In this trial it had the largest number of heads per plant but fewer seeds per head (28) than the other two varieties. 1000-grain weights of S.541 and Yenice were equal (37 g); that of Dincer higher (40 g). We may note that safflower has the capacity to withstand low temperatures and drought; the severe winter weather in 1991/92 did not affect its growth in any way. Planting earlier than late November, with appropriate plant population and adequate fertilizer, may further improve yields in rainfed culture.

3.8.2.4 Performance of sunflower: varieties x water regimes x population

Material and methods: This trial, at Tel Hadya, included four rates of supplemental irrigation in addition to population and variety variables. The two varieties were a nonoil edible type grown commercially in Syria and an open-pollinated oiltype variety, VINIIMK, from Turkey. Sowing on April 1, 1992, in a dry soil, was followed by 30 mm supplemental irrigation, applied uniformly to all the treatments for germination and emergence. There were four populations, 10, 20, 30, and 40 thousand plants/ha. To obtain these populations, hills were planted 160, 80, 53 and 40 cm apart on 60 cm rows. Main plots were assigned to water rates and were split into eight subplots for 2 varieties x 4 plant spacings. Subplot size was 8 x 3 m, and each subplot had five rows. There were two replicates.

The water rates were: rainfed except 30 mm for emergence (W0), 173 mm (W1), 245 mm (W2) and 317 mm (W3). Irrigation was applied when soil moisture content decreased to 50% availability. Soil moisture was measured by neutron probe via access tubes in each water rate treatment in one replicate. Each treatment was achieved by irrigating three times, (W1) applied in the quantities, 50, 50, 43 mm; (W2) applied as 75, 75, and 65 mm; and (W3) applied as 100, 100, and 87 mm. Irrigation dates were June 9, July 2 and July 14.

All plots received 50 kg N and 50 kg P/ha, broadcast as ammonium nitrate and triple superphosphate a day before sowing. Seed was dibbled manually, 3-4 seeds per hill. When seedlings were about 5 cm high, plants were thinned to one healthy vigorous seedling per hill. Three central rows were harvested in the middle of August. Data were taken during growth on plant population, height at full bloom, days to flowering, leaf numbers at full bloom, head diameter before harvest, grain yield, 1000-grain weight and kernel percentage. Sunflower heads were mesh-bagged when seeds were fully formed to prevent bird depredation. Harvesting was done by hand, heads were dried in the sun, and threshing was done manually.

Results and discussion: Effects of water and population on grain yield were statistically significant, but the difference between varieties was not. Average grain yields of the two varieties were almost equal (Table 3.8.4). There were no significant interactions. Grain yield responded strongly to water up to the highest rate of application. The yield obtained from W3 (317 mm), 1382 kg/ha, was 28% greater than that of W2 (245 mm), 41% over that of W1 (173 mm)

Table 3.8.4. Effect of varieties, water rate and plant population on agronomic traits of sunflower, Tel Hadya, 1992

Treatments	Yield, kg/ha	TGW[a]	HD[b]	Height[c]	Kernel %[d]
<u>Varieties</u>					
Non oil Syrian	1003	109	18.6	132.5	56.3
VINIIMK	1016	85	17.7	132.0	67.7
LSD 5%	106.5	0.215	0.352	0.41	1.4
<u>Water rates (mm)</u>					
30	597	89.7	16.0	124.0	63.6
173	977	97.3	18.2	133.2	61.6
245	1081	99.3	18.3	130.3	61.4
317	1382	101.9	20.3	141.6	61.3
LSD 5%	228.6	0.3	0.46	1.24	5.0
<u>Plant population/ha</u>					
10000	872	99.9	20.2	140.9	60.6
20000	1028	101.7	18.8	133.3	62.3
30000	1117	94.7	16.9	130.5	62.3
40000	1019	91.8	16.8	124.4	62.9
LSD 5%	150.6	0.3	0.50	0.58	1.9

a) TGW=1000-grain weight in g; *b) Head diameter in cm*
c) Height in cm *d) Kernel percentage average*

and 131% over that of the rainfed treatment. These results are in agreement with those of Pala (1990), although the rainfed yield (597 kg/ha) was 165% higher than that obtained previously (225 kg/ha). Differences due to plant population indicate an optimum around 30,000 plants/ha, under the conditions of this trial. This result is also in agreement with previous research results at Tel Hadya. Brief observation on other agronomic characters are as follows:

Average 1000-grain weight (TGW) tended to increase with the application of water. TGW was similar in the two low populations (P1 and P2) but decreased significantly with each increase in population in P3 and P4. The nonoil variety had a lower kernel percentage than the oil type. Water rates did not affect kernel percentage. Head diameter increased significantly with increasing water. Increase in population significantly decreased head diameter, but there was no difference between P3 and P4. Varieties had similar heights, and height increased significantly with each increase in water rate. There were no significant interactions for any of the characteristics studied.

Irrigation certainly increased yield, but the critical stage when water is needed needs to be decided each season by the prevailing conditions at different growth periods. The critical stage for adequate moisture is from 20 days before flowering to 20 days after flowering. The yield ranges obtained in this trial show that a rainfed crop can give yields around 1 t/ha when management practices are optimal; the yield ranges for the different rates of water were:

W0 364 - 930 kg/ha
W1 496 - 1395 kg/ha
W2 482 - 1468 kg/ha
W31114 - 1874 kg/ha

A. Beg, M. Pala, with major technical assistance from L. El-Mahdi and A. Baset Khatib.

References

Bowren, K.E. and Pitman, U.J., 1975. Production of mustard and rapeseed. 229-253. In oilseeds and pulse crops in western Canada - a symposium. Ed. J.T. Harapiak.

Pala, M., 1990. The performance of oilseed crops under different moisture regimes, pp 74-80. Annual report, FRMP, ICARDA.

Weiss, E.A., 1983. Rapeseed. pp 161-215, in "Tropical Oilseed Crops".

3.9 On-Farm Barley Trials, 1989-1992:

3.9.1 Introduction

In many breeding programs, selection is conducted on experimental stations with improved agronomic practices; but it may be argued that, with the exception of disease resistance, genetic differences expressed under high levels of inputs are irrelevant to target environments with low inputs (Ceccarelli et al. 1993). This joint CP/FRMP study was designed to test that hypothesis.

Over three seasons, 1989-92, a total of 32 trials were planted (29 on farmers' fields, 3 on the ICARDA site at Breda) along a rainfall transect running from 10 km east of Tel Hadya (dry end of Zone 2) to the steppe fringes south-east of Khanasser (edge of Zone 4). Treatments comprised: 22 barley lines, 11 adapted to moderate rainfall (Group I), 11 to low rainfall (Group II), but only 10,10 in 1989/90; absence or presence of fertilizer (40 N + 18 P, kg/ha); and high and low seed rate (120,80 kg/ha). Each trial, a single replicate of a full factorial combination of the 22 varieties, two fertilizer rates and two seed rates, was drill-planted, with an individual plot size of 7.5 x 2.5 m.

3.9.2 Results

Rainfall in the three experimental seasons was, respectively, very low, low and low average, without any regular trend along the transect except in 1989/90. Ranges for growth-season totals (pre-planting to harvest) were:

1989/90	116 - 185 mm (mean:154 mm)
1990/91	195 - 244 mm (mean:214 mm)
1991/92	204 - 270 mm (mean:237 mm)

In consequence, yields were very low or low, with dry-matter means across sites of 0,99, 2.50 and 3.40 t/ha in the three years, respectively. Four sites in 1989/90 recorded mean grain yields of 0.05 t/ha or less.

Nevertheless, genotype differences were statistically significant at most sites each year, as were positive responses to fertilizer; but the higher seed rate had a positive effect only on straw and only at about half the sites. Summarizing by years across sites (Table 3.9.1), we see that barley selection for low rainfall (group II) had a significant positive effect on grain but not straw yield; and the higher seed rate increased straw yield, although it may be doubted whether the mean increase of 100 kg straw/ha justifies the use of an extra 40 kg seed/ha.

As is usual in this environment, the largest yield increases were from fertilizer application, with means of 35% for grain and 70% for straw. These figures need to be regarded with some caution: in absolute terms, the mean grain increase was only 170 kg/ha, and this would almost certainly be less important to farmers than the straw increase of nearly 1 t/ha. This perhaps calls into question the superiority of group II ("dry-selected") barley lines over group I (i.e. from the farmers's point-of-view). However, there was a significant interaction between barley group and fertilizer for grain (but not straw) yield, slightly favoring the "dry-selected" lines:

Group	- Fertilizer		+ Fertilizer
		**	
I	0.44		0.58
II	0.54		0.73
		± 0.007	

Table 3.9.1. Summary of treatment effects on barley grain and straw yields (t/ha), by years across sites

		Year and number of sites			
Factor		1989/90 (9)	1990/91 (11)	1991/92 (12)	Means (32)
Variety group*		***	***	***	***
I	Grain	0.14	0.54	0.75	0.51
II		0.20	0.67	0.89	0.63
		±0.006	±0.008	±0.011	±0.005
		**	***	ns	*
I	Straw	0.80	1.99	2.60	1.91
II		0.85	1.83	2.55	1.85
		±0.013	±0.028	±0.035	±0.017
Fertilizer		**	***	***	***
-	Grain	0.16	0.48	0.73	0.49
+		0.18	0.73	0.91	0.66
		±0.006	±0.008	±0.011	±0.005
		***	***	***	***
-	Straw	0.60	1.32	2.00	1.39
+		1.04	2.50	3.15	2.37
		±0.013	±0.028	±0.035	0.017
Seed Rate		*	ns	ns	ns
low	Grain	0.18	0.60	0.81	0.572
high		0.16	0.62	0.82	0.576
		±0.006	±0.008	±0.011	±0.005
		***	**	**	***
low	Straw	0.79	1.84	2.51	1.83
high		0.68	1.97	2.64	1.93
		±0.013	±0.028	±0.035	±0.017

* *Group I, barley lines selected for moderate rainfall; Group II, selected for low rainfall.*

As noted already, grain and straw yields of groups I and II apparently responded differently to the rather dry environment of the 32 sites. This is detailed more clearly in Table 3.9.2, which ranks the individual lines according to the numbers of occasions their grain yields and their straw yields fell appreciably below the site mean yield. Group II lines filled 10 of the top 11 places in the grain reliability "league" (with the landrace Arabi Aswad and

Table 3.9.2. Ranking of barley lines, according to the reliability of their grain and straw yield in 32 trials

Grain			Straw		
Occasions below site mean yield	Line	Selection group	Occasions below site mean yield	Line	Selection group
0	Arta	II	0	Rihane-03	I
	SLB 39-10	II	1	As46/Aths*2	I
1	Tadmor	II		Iris/Nopal'S'†	I
	SLB 39-60	II	4	Deir Alla/DL71	II
	Wadi Hassa	II	6	Arabi Aswad	II
	Arabi Aswad	II	7	Zanbaka†	II
	Zanbaka†	II	8	Cm/3/Api/-	I
6	Harmal	II	9	Tadmor	II
	WI 2291	II		WI 2291	II
7	ER/Apm	I	13	Roho Mazurka	I
	WI 2269	II	16	Arta	II
9	Roho/Mazurka	I		SLB 39-10	II
10	CI08887/CI05761	I	17	SLB 39-60	II
13	Rihane-03	I	18	Giza 121/-	I
17	Iris/Nopal'S'†	I	21	Pitayo/-	I
20	Pitayo/-	I	23	CI08887/CI05761	I
	As46/Aths*2	I		Wadi Hassa	II
24	Salmas	I	25	ER/Apm	I
27	Giza 121/-	I		Salmas	I
30	Cm/3/Api/-	I	26	Harmal	II
31	Deir Alla/DL71	II		WI 2269	II

† Grown in 1990/91 and 1991/92 seasons only (23 sites). Arabi Abiad omitted here, as seed contaminated in 1990/91 season

five selections from landraces filling the 6 top places) but were much more scattered in respect of straw reliability. Scoring highest (in total) on both counts - and the farmer is interested in both - were Arabi Aswad (the local landrace) and Tadmor and Zambaka (selections from it).

The scatter of straw reliability was associated with two groups of genotypes, namely the Group I six-rows and the Group II landraces derived from Arabi Abiad. Four of the six genotypes with six rows were in the top 4 places for straw reliability. This is likely to be due to their thick stems, often of lower palatability. On the other hand, the landraces derived from Arabi Abiad (Arta and the two SLB's) lost their top places because they become very short under drought. This explains why farmers' preference in dry areas is for black-seeded landraces.

Increasingly, in dry areas, farmers are growing barley nearly every year on the same fields. Among the 32 fields used for the present trials, 11 had been fallowed the previous season, 22 had grown barley. Mean yields of total dry matter, 2.70 and 2.33 t/ha, respectively, suggest that preceding barley depressed current barley production, but rainfall values were also different. For barley following fallow (F-B) they were: mean, 221 mm; range, 157 - 270 mm. For barley following barley (B-B), mean 198 mm; range, 116-270 mm. To take account of this, regression functions were calculated, barley yield as a function of rainfall, fertilizer, rotation, seed rate and first-order interactions of those factors. That for grain yield (kg/ha) is:

Y = - 1055 + 7.429 Rain (mm) - 168.8 Fert - 2158 Crop seq.
+ 1.752 (Rain x Fert) + 10.55 (Rain x Crop seq)
- 111.6 (Fert x Crop seq)

[Adjusted R^2 = 0.7535; all terms significant at 5% level; for Fert, with = 1, without = 0; for Crop sequence, F-B = 1, B-B =0]

When this is plotted out (Fig. 3.9.1), we see that:

- yields in the F-B sequence were apparently lower than those in the B-B sequence under low rainfall conditions;
- response to rainfall increase was much steeper in the F-B sequence; and
- fertilizer response was greater in B-B than F-B sequence across the rainfall range and increased with increasing rainfall.

The regression for straw is similar, though more complex because of additional significant terms involving seed rate. It shows a much greater response to fertilizer, particularly for the B-B sequence, and implies that the fertilized F-B sequence did not exceed the fertilized B-B sequence in straw yield until the rainfall exceeded about 250 mm. *M. Jones and S. Ceccarelli (CP), with full technical management by H. Salahieh.*

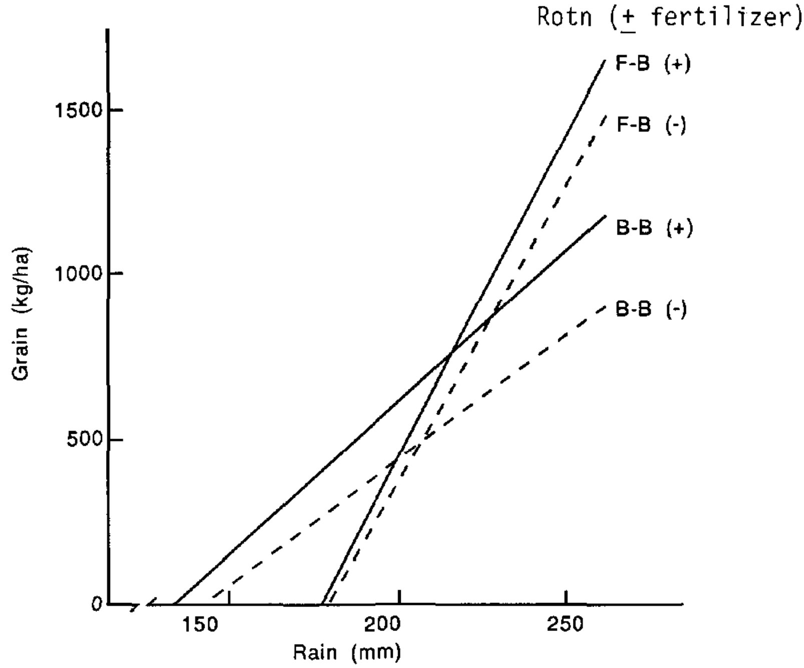


Figure 3.9.1 Grain yield response of barley after fallow (B-F) and barley after barley (B-B), with and without fertilizer (±), to total seasonal rainfall (from regressions based on 32 on-farm trials)

References

Ceccarelli, S., Grando, S. and Hamblin, J., 1993. Relationship between barley grain yield measured in low- and high-yielding environments. Euphytica (in press).

3.10 Wheat Monitoring Study In Farmers' Fields of Northwest of Syria

3.10.1 Introduction

Wheat is the dominant crop in the relatively wetter areas of Syria (average annual rainfall, 350 to 600 mm). Potential crop production in the wheat-based farming systems is high, farmers are financially more secure than those in drier areas, and SMAAR has rightly focussed its research and extension on these higher potential systems. However, even after the wide adoption of high-yielding wheat varieties, average yields are still only 50% of those obtained in researcher-managed on-farm trials (Mazid 1992). These low yields are attributed to the unimproved cultivars still grown by many farmers, to poor management practices, or to both.

To date, there has been no systematic study of the yields of local and improved wheat cultivars under farmers' management practices. Nor is much known about how farmers decide their management practices, particularly in relation to cultivars and environmental differences. The objectives of the present two-year project were threefold:

- An understanding of how farmers' management practices interact with the local and improved wheat cultivars under different agro-ecological conditions in zones 1b and 2*.
- The identification of the problems/reasons for low/high adoption rates by farmers for certain technologies, to indicate new research areas and help to prioritize them.
- The assessment of how farmers make decisions about certain management practices, to allow us to reconsider the recommended management practices (eg. re-study or modify the technologies).

---

* Zone 1b is defined as the area where annual rainfall ranges between 350 to 600 mm but is not less than 350 mm in two out of three years, and zone 2 is defined as the area where the annual rainfall ranges between 250 to 350 mm but is not less than 250 mm in two out of three years (AASA 1987).

3.10.2 Activities

- Forty-five farmers were selected in Aleppo, Idleb and Hama provinces on the basis of previous contact in wheat surveys and on-farm wheat fertilizer studies during the period 1985-1990.
- Raingauges were installed for groups of farmers, identified on the basis of similar conditions and geographical proximity.
- Cultivars: Cham 1, Cham 3, and Lahn (Triticum durum) and Cham 4, and Cham 6 (Triticum aestivum) in addition to farmers' own cultivars. Enough treated seed was provided to farmers to sow 0.1 ha of each cultivar, and chemical for seed treatment of their local cultivar, again for 0.1 ha.
- Farmers planted during November-December 1991, and a systematic monitoring of their management practices began at that time.
- Regular visits (every 4 or 6 weeks) were made to monitor farmers' practices and to collect information on farmers' decision making, in cooperation with the local extension staff.
- Plant samples were collected for grain and straw yield and for quality analyses (N% in grain and straw, 1000-grain weights, grain vitreousness %, sedimentation value, baking quality, color, etc.)

3.10.3 Farmers' practices

At each farm, information was collected from the largest wheat plot, the mean sizes of which were 8.1 ha (range 1.0 to 100 ha), 4.7 ha in Idleb, 7.3 ha in Aleppo and 13.2 ha in Hama provinces. Plots were larger (9.7 ha) in zone 1b than in zone 2 (6.0 ha), and three times as large (17.4 ha) under irrigated conditions as under rainfed conditions (5.1 ha). Most commonly, the soils used were deep, clean, and flat. There was a strong correspondence between stoniness and topography (Table 3.10.1).

Table 3.10.1. Soil characteristics of largest wheat plots (% of plots)

Depth (cm)		Stoniness		Topography	
< 50	-	Clean	68	Plain	64
50-100	23	Moderate	27	Rolling	29
>100	77	Stony	5	Sloping	7

Machinery ownership is variably distributed among the farmers involved: 64% own a tractor, 61% a cultivator, 36% a moldboard plow, 21% a disc plow, 11% a disc harrow, 16% a drill, 55% a spinner, 16% a water tank, 9% a sprayer, 16% a thresher and 7% a combine harvester. In addition to agricultural activities, tractors are often used for transportation. The small ownership of drills indicates a high frequency of custom operations for sowing.

3.10.4 Rotational practices

Farmers often own more than one wheat field (50, 20 and 10% owned a second, a third or a fourth wheat field). Only 20% of farmers practice the same rotation (in different combination) on two wheat fields. The rest have different crop rotations, depending on their capital, labor and degree of fragmentation of land holdings.

A wheat-summer crop rotation is the commonest (46% of surveyed farmers) and is mostly concentrated in zone 1b. Wheat-lentil rotation is next commonest (27%) and is equally important in zones 1b and 2. A wheat-lentil-summer crop rotation is followed by another 27% of farmers, mostly in zone 2. Wheat-chickpea is also important but only in zone 1b, and wheat-fallow and wheat-barley rotations are each conducted by 12% of the farmers, mainly in zone 2. Wheat is thus grown in a range of rotations, chosen by farmers according to local conditions: a two-course rotation, mainly with chickpea, under more favorable conditions (zone 1b); a three-course rotation, mainly with lentil, in drier environments (zone 2).

3.10.5 Tillage

Farmers differed in both the equipment and the number of tillages used (Table 3.10.2). Deep tillage was practised by 27% of farmers (20% once; 7% twice). Half of them use a moldboard, half of them a disc plow. Most of this deep tillage is in zone 1b where conditions are more favorable. Those few farmers undertaking deep tillage in zone 2, where the soils are more fragile, are operating mainly under irrigated conditions. The first deep tillage is done, on average, during the first week of August, and those few farmers undertaking a second deep tillage go back to field about two weeks later.

Table 3.10.2. Tillage and equipment

No. of deep tillages	% of farms	No. of secondary cultivations	% of farms	Equipment used	Percent of tillage
0	73	0	23	Deep till.	
1	20	1	50	----------	
2	7	2	20	Moldboard	50
		3	5	Disc plow	50
		4	2		
				Cultivation	

				Ducksfoot	97
				Disk harrow	3

Secondary cultivations start in the last week of September and are repeated every two to three weeks, as needed. One or two cultivations is desirable to minimize soil degradation; the physical effect of machinery on the soil is much reduced if there are fewer passes. The use of a ducksfoot cultivator for secondary tillage is also better for soil structure and aggregate stability than that of a disk harrow.

3.10.6 Varieties used

Most of the farmers grow durum wheat, but only 32% of them grow improved new varieties while 45% grow old local or old improved varieties (Table 3.10.3). Several years of extension programs should have resulted in a much greater adoption of new improved varieties, at least to the level of replacing old improved varieties. Another interesting finding is that 55% of the farmers grow only a single variety, which is probably more risky than having several varieties in their fields. A range of varieties would likely provide greater insurance against cold, frost, pest or drought damage than a single cultivar. It is well recognized that Cham 1 has been reaching some farmers in recent years; and it is to be hoped that other varieties, improved in cooperation with NARS, will eventually follow.

Table 3.10.3. Wheat varieties used by monitored farmers

Varieties	Users* %	No. of varieties	Users %	Varietal unit (**)	Users %
Durum wheat		1	55	Old (local)	20
Cham 1	25	2	32	Old improved	25
Bayadi	23	3	9	New improved	32
Behouth 1	16	4	2	Mixed	23
Haurani	14	5	2		
Hamari	11				
Jezira 17	11				
ACSAD 65	11				
Jouri 69	9				
Bread wheat					
Mexipak	25				
Cham 4	7				

* *Users percentage is more than 100% in total because may farmers grow more than one variety.*

** *Old varieties are Bayadi, Haurani and Hamari; Old improved ones are Jouri 69, Jezira 17, and Mexipak; New improved varieties are Cham 1, Cham 4, Behouth 1, and ACSAD 65; Mixed ones are any combination of above mentioned varieties*

Farmers, when asked to indicate their top four preferred varieties, recorded Cham 3 (54%) the best, then Cham 1 (38%), Cham 4 (36%) and Cham 6 (48%). Lahn was rated the best variety by six of the 13 farmers who tested it. Local varieties were scored by 24% of farmers as third best after Cham 4. It seems farmers are aware of the desirable characteristics of the improved varieties, but for some reason they are not fully utilizing them. Farmers choosing Cham 3 as the best variety mentioned grain yield (100%), grain quality (87%) and drought tolerance (18%) as its most desirable characteristics. (Here and subsequently, percentages add to more than 100 because farmers supplied more than one response per question.)

When farmers were asked what characteristics they would like to see in a new variety, all of them mentioned higher grain yield, 84% resistance to shattering, and 77% larger grain size (Table 3.10.4). Resistance to diseases and insects, early emergence, straw quality, straw yield, and heat resistance were given lower importance (less than 40%). Farmers differentiated between cold and frost, giving frost resistance greater importance.

3.10.7 Sowing

For sowing, 45% of farmers broadcast their seed, 55% use a drill. Most (75%) of those broadcasting ridge up the soil (Ayar), broadcast seed and fertilizer over the ridges and then split the ridges (Rdad) to cover them. Ridging is usually done with a single set of ducksfoot cultivators (88%) with 45 to 47.5 cm row-spacing, but a few farmers use a faddan. Seeds and fertilizer are broadcast about 70% by hand and 30% by spinners. The use of spinners probably improves the uniformity of spreading and with good adjustment may save some seed. For splitting or just covering the seeds and fertilizer, 70% of farmers use a ducksfoot cultivator, with moldboard and disc plow, disk harrow and faddan being almost equally utilized by the rest. Drill use has increased greatly over the 5%

Table 3.10.4. Farmers' scoring of importance of characteristics for new varieties

Characteristics	Frequency of mention (%)			
	Not important	Important (a)	Very important (b)	(a)+(b)
Grain yield	0	0	100	100
Straw yield	67	12	21	33
Grain size	23	63	14	77
Grain color	49	46	5	51
Grain quality	51	40	9	49
Straw quality	77	16	7	23
Early emergence	95	5	0	5
Early maturity	58	30	12	42
Drought resist.	53	35	12	47
Diseases	98	2	0	2
Insects	77	18	5	23
Shattering resist.	16	56	28	84
Lodging resist.	44	44	12	56
Cold resistance	56	44	0	44
Frost resistance	33	61	7	68
Heat resistance	61	39	0	39

of farmers reported by an earlier survey in the same region (Rassam and Tully 1986).

Asked why they broadcast their seeds, 56% farmers said "drill is not available", 35% "size of the field is not suitable for drill use", 24% "it allows me to use the land more uniformly", and 12% said either "broadcasting is more suitable for wetter soil during sowing compared with drill", or "it is easier for adjusting seed rate", or "it is easier for irrigation".

When asked why they used a drill, 86% farmers stated that the "drill covers the field uniformly", 69% that "it provides uniform crop stand", 62% that "it results in higher yield", 45% that "it provides easier combine harvesting", and 38% that "it helps in saving seed". Only 7% suggested that mixing fertilizer with the seed was a favorable side of drill use. (Field observations have shown that a uniform mixing of fertilizer with seed is not possible because of their different densities and particle size. This type of sowing is unlikely to result in either uniform stand establishment or uniform fertilization.)

Seed rates varied from 120 to 300 kg/ha (Fig. 3.10.1). Many farmers (45%) use 175 to 200 kg/ha, quite a high rate for mild lowland conditions (Pala 1991); and the seed rate is not reduced when a drill is used, as would be expected from research results (Ghazal et al. 1988).

When asked why high seed rates were used, 56% farmers said "high soil fertility allows a higher seed rate", 47% "higher seed rate can compete with the weeds", and 25% "higher seed rate provides higher yield". Only 6% of farmers mentioned that a high seed rate is traditional. Of all these reasons, only "competition with weeds" appears reasonable, but a reduction in seed rate could reduce production costs and save seed. Most farmers (74%) sowed treated seeds, indicating a high farmer awareness of the value of seed treatment.

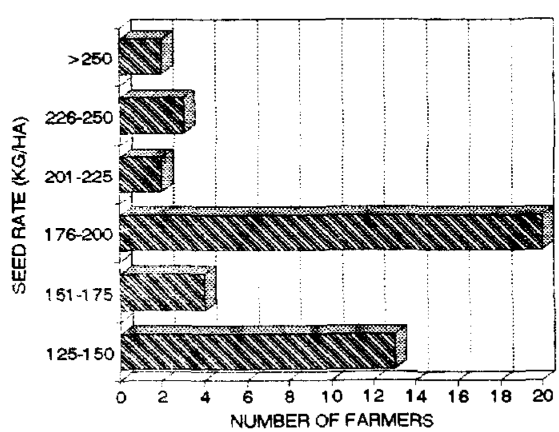


Figure 3.10.1 Distribution of wheat seed rates used by farmers, 1991/92

Wheat was sown before the third week of November by about 52% of the farmers (Fig. 3.10.2); about 20% delayed sowing until December, mostly during the first week. Results from previous work suggest that sowing after the second week of November leads to lower water-use efficiency and lower yields (Pala 1991; Acevedo et al. 1991). Farmers might increase production to some extent by modifying their sowing date.

Sixty percent of farmers said they waited for the first rain before planting to ensure emergence, while 40% wanted to utilize the first rain by earlier, dry sowing, and 26% did not want to be delayed later by continuing rain and wet soil. More than half of the farmers who waited for the first rain said that weeds were controlled better by later sowing. Only a few early-sowing farmers mentioned that earliness results in a better initial crop establishment and earlier maturity.

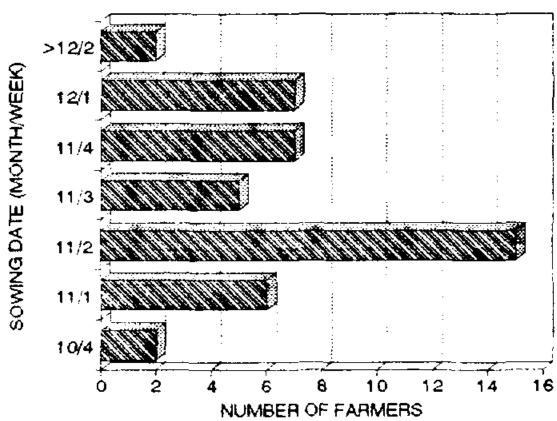


Figure 3.10.2 Distribution of wheat sowing dates, 1991/92

3.10.8 Fertilizer use

Fertilizer use is variable. Three farmers do not use any fertilizer at all, and surprisingly two of them are in zone 1b of Aleppo province. However, both those farmers sow only local varieties, such as Bayadi, Hamari or Haurani, which their experience suggests do not need any fertilizer.

Rates of phosphate and nitrogen applied differed with rotation (Table 3.10.5). Fertilizer use on wheat was lower in rotations with either barley, lentil or fallow, most probably because of the environmental limitations in zone 2 where these rotations are dominant. It appears that fertilizer use is determined more by zone or supplementary irrigation than by preceding crop. More of both phosphate and nitrogen are applied in zone 1b than in zone 2. This suggests an excessive use of fertilizer in more favorable areas, since results from earlier on-farm trials do not support heavy fertilizer use in zone 1b (Pala et al. 1991).

Table 3.10.5. Phosphate and nitrogen fertilizer rates applied to wheat in different rotation systems

	P_2O_5 (kg/ha)	--------- N (kg/ha) ---------			No. of farmers
		At sowing	At tillering	Total	
Wheat/s. crop	69	21	50	71	20
Wheat/lentil	83	19	59	78	12
Wheat/chickpea	96	14	57	71	11
Wheat/barley	46	25	40	65	6
Wheat/lentil/sc	58	6	45	51	12
Wheat/fallow	20	15	20	35	5
zone 1	76	16	55	66	25
zone 2	48	19	30	49	19
S. irrigation	98	28	57	85	11
Rainfed	52	13	41	54	33
Aleppo	56	16	31	47	22
Idleb	62	12	63	75	11
Hama	80	24	53	77	11
Mean	64	17	45	62	44

Every farmer using phosphate applied it at sowing as triple super phosphate. Every farmer also using nitrogen (80% urea; 20% ammonium nitrate) put on 16 to 39% of his total seasonal application at sowing and the rest between tillering and flowering, depending on the conditions (eg. zone or supplementary irrigation). This topdressing was by hand in 69% of the cases, or by spinner (31%). Some farmers who irrigated their wheat split their nitrogen into equal amounts for each irrigation believing that this would improve grain yield and quality.

In general, wheat growers do not have serious problems with fertilization, except that some of them use higher rates than necessary.

3.10.9 Weed control

Farmers know that weeds are one of the important yield-limiting factors, and 66% of farmers control weeds with herbicides. The other farmers do not apply any control measure because of lower weed densities in their fields, due either to effective crop rotation or later sowing (after weed-control tillage). Sixty-five percent of weed-controlling farmers use tractor-mounted sprayers for herbicide application, and 35% use knapsack sprayers. The main herbicides are 2,4-D + MCPA (50% farmers) and 2,4-D (17% farmers), which control only broadleaf weeds. However, where grasses are a serious problem, grass killers are applied, such as Illoxan during the early growth stages of wheat or Avenge at later stages. Farmers check their fields carefully for the seriousness of the problem before deciding whether they should control weeds or not.

3.10.10 Supplementary irrigation

Only 11 farmers applied supplementary irrigation; one farmer irrigated 4 times, two farmers 3 times, four farmers twice, and the other four farmers once only. The number of irrigations depended mainly on the local rainfall conditions, although farmers' enthusiasm for higher yields may sometimes also be a driving force.

The amount of irrigation applied (additional to rainfall) ranged between 60 mm to 500 mm with a mean of 207 mm. It was applied either by flood (50% of cases) or sprinkler (50%). According to Tel Hadya results, wheat grain yield increased linearly from 2.5 t/ha under rainfed conditions (311 mm) to 7.5 t/ha where rainfall was supplemented by 204 mm two irrigations from a high-efficiency drip system (see section 3.3 of this report). Under similar environments in Saraqeb district, one farmer at Afes, using 117 mm water in 2 sprinkler applications, and another in Jobas (400 mm from 5 flood applications) reached yield levels similar to those obtained at Tel Hadya. Survey results show that farmers are aware of the rainfall limitation on yield and apply 1 to 3 supplementary irrigations depending on local and seasonal conditions. However, the efficiency of irrigation needs to be improved and the volume of each irrigation considered more critically in relation to the limited water resources.

3.10.11 Harvesting

Harvesting of wheat is extensively mechanized; only 16% of sampled farmers harvested their crop by hand, usually in steep and stony fields or on small holdings. This is a similar figure to that obtained in an earlier survey (Rassam and Tully 1986). Straw and stubble is usually rented to livestock producers after harvest or burned to facilitate field preparation for the subsequent crop.

3.10.12 Yields

Farmers expect to harvest an average of 1.7 t grain/ha in normal years, 0.7 t in bad years and 3.4 t in good years (Table 3.10.6). These values are well above the national means and the means of other developing countries (FAO 1991). In 1990/91, the average yield of sampled farmers was about 1.7 t/ha, matching their yield rating for a normal year. Surprisingly, only 21% of farmers rated the season a normal one; the rest said it was either good or bad, depending on their locality. While the wetter part of the wheat-growing areas received normal rainfall, well distributed, the drier areas received less than their average rainfall.

Table 3.10.6. Farmers' estimate of wheat grain yield (t/ha) in different types of season and their estimate for last year (1990/91)

	Provinces			Zones		Conditions			
Years	Aleppo	Idleb	Hama	1	2	Irr.	Rf	Mean	SD
Good	3.0	3.5	3.9	3.9	2.6	4.4	3.0	3.4	1.3
Normal	1.5	1.9	1.9	2.1	1.2	2.3	1.5	1.7	0.7
Bad	0.6	0.8	0.7	0.9	0.4	1.1	0.5	0.7	0.5
1990/91	1.2	2.2	2.1	2.1	1.1	2.2	1.5	1.7	1.1
Farmers' rating for 1990/91	Frequencies							Total	%
Good	9	2	8	11	8	6	13	19	44
Normal	1	5	3	6	3	1	8	9	21
Bad	11	4	-	8	7	4	11	15	35

Yields of all varieties were satisfactory under the prevailing conditions of the 1991/92 season (Table 3.10.7). The weather was very cold early in the growth period, and below-average temperatures continued until spring. As a result, crop growth was delayed one month compared with normal years. Fortunately, the spring was also cool and this kept the evaporative demand relatively low, and the crop was not forced into early maturity, which might have depressed the yield.

Table 3.10.7. Farmers' average wheat grain yields (t/ha) for the tested varieties, 1991/92

Var.	Provinces			Zones		Conditions		Mean	SD
	Aleppo	Idleb	Hama	1	2	Irrig	Rainf.		
Cham 1	2.00	2.86	2.68	3.03	1.57	4.66	1.94	2.36	1.46
Cham 3	2.12	3.69	3.22	3.63	1.76	5.16	2.19	2.80	1.72
Cham 4	2.18	3.71	3.08	3.55	1.86	5.24	2.16	2.80	1.79
Cham 6	2.09	4.12	3.13	3.59	1.94	5.30	2.17	2.84	1.80
Lahn	3.64	4.22	4.32	4.05	5.01	4.89	3.52	4.21	1.75
Farmers'	1.65	3.12	3.38	3.11	1.86	4.58	2.02	2.64	1.60
Mean	2.05	3.61	3.10	3.46	1.79	5.07	2.10	2.72	1.64
SD	1.19	1.98	1.62	1.33	1.55	1.31	1.08		

The yield values reported here for "farmers' varieties" are means of the several different cultivars grown by each farmer. Where these were old local cultivars yields tended to be low. Where they were old improved or new improved cultivars, their yields approached those of the tested varieties (Cham 1, 3, 4, 6). However, each of the tested varieties yielded more than the average of farmers' cultivars, by 2-16% under irrigation, and (except Cham 1) by 7-74% under rainfed conditions. For the tested varieties the main significant differences were (i) between irrigated and rainfed conditions, and (ii) between zones 1B and 2 (Table 3.10.8), differences attributable in both cases to differences in water availability to the crop. Lahn did not show similar differences because of the smaller sample size. An inadequate supply of seed caused Lahn to be grown mainly in favorable environments.

The tested varieties were a source of local interest. An average of 24 non-participating farmers visited each experiment, and 65% of the participating farmers were asked to provide seed from the tested varieties.

Table 3.10.8. Statistical summary of tested varieties, 1991/92

	Provinces			Zones		Conditions	
Var.	Aleppo	Idleb	Hama	1b	2	Irrig.	Rainf.
Cham 1		NS		**		***	
Cham 3		+		***		***	
Cham 4		*		**		***	
Cham 6		**		**		***	
Lahn		NS		NS		NS	
Farmers'		*		*		***	
Mean		*		***		***	

*+ p<.10   * p<.05   ** p<.01   *** p<.001*

3.10.13 Production costs

Large differences in estimated gross revenue (Table 3.10.9) arose from the large difference in average yields between irrigated (5.1 t/ha) and rainfed (2.1 t/ha) conditions. If farmers with irrigation used 207 mm/ha, the gross margin of each additional mm of water was 136 SL/ha. Gross margins under irrigated conditions were 2.6 times greater than under rainfed conditions. The net benefit:cost ratios were 2.9 and 5.6, respectively.

Because of the number of crop rotations practised by an average farmer and the fragmentation of landholdings, the estimates of gross revenue, production cost and gross margin, as calculated here, do not provide enough information for conclusions to be drawn about how farmers decide whether to use improved wheat varieties. What was clear in this first season's work is that irrigation has a major effect on input use, productivity and gross margins.

Production costs were higher under irrigation, due mainly to greater fertilizer application (P and N were applied at 2.2 and 1.7 times the rainfed rates, respectively), to irrigation costs (about "3500 SL/ha) and to harvesting costs, which were more than double

Table 3.10.9. Average gross revenue, total costs and gross margins for the farmers in north west Syria under rainfed and irrigated conditions

	rainfed n=31	irrigated n=9	total n=40
	----------	SL/ha	----------
Gross revenue[1]	22,965	53,206	29,558
Total costs[2]	5,904	8,059[3]	6,683
Gross margin	17,021	45,147	22,875

1) From the average yields of improved and local varieties, revenue from straw was not included,
2) Tillage, seed and seeding, phosphorous, nitrogen, herbicide, irrigation and harvesting costs; land rent was excluded,
3) Estimated irrigation costs averaged 3565 SL/ha, ranging from 286 to 10,000 SL/ha)

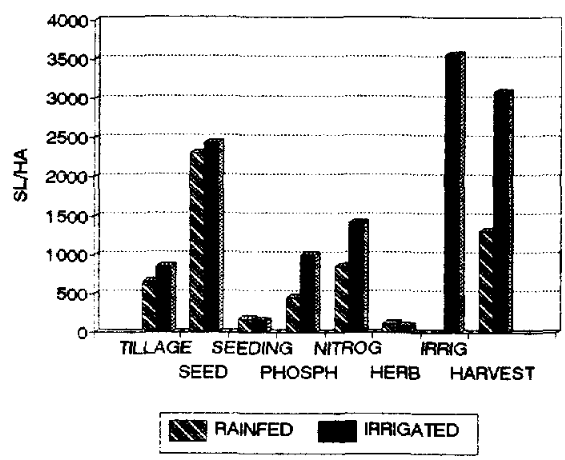


Figure 3.10.3 Wheat production costs in northwest Syria, 1991/92

those for the rainfed crop (Fig. 3.10.3). The irrigation costs include only the cost of pumping, not the cost of the water. This poses serious questions about the sustainability of the higher yields obtained under irrigation, since what is currently paid for irrigation is below the true cost; and the lack of water pricing hinders the achievement of an efficient production system in areas where fertilizer is applied. Farmers with irrigation use excessive quantities of nitrogen and phosphorus, but the potential savings that might be made on fertilizer application are overshadowed by the wasteful use of water.

3.10.14 Future research

The same farmers will be visited again during the 1992/93 season and asked more detailed questions to amplify the previous results and to ascertain the socio-economic background of the farmer as well as his managerial practices. In addition, the role of livestock in the farming system will be studied. Through this study we hope to establish a fruitful linkage between research and extension and to define some of the important technical as well as socio-economic problems of wheat farmers in the study area, to help focus future research. ***M. Pala and A. Rodriguez, with grateful acknowledgements to the farmers for their cooperation in conducting the trials and for providing much invaluable information during the survey work; to Messrs A. Dakermanji, Haitham Halimeh and A. Haddad for hard work, long days of travel under very cold and hot conditions and the establishment of successful social relations with the farmers; and to Mr A. Dakermanji for his patience in data entering.***

References

AASA, 1987. The Annual Agricultural Statistical Abstract. Damascus, Syria: Department of Planning and Statistics Division of Agricultural Statistics, Ministry of Agriculture and Agrarian Reform.

Acevedo, E., Harris, H.C. and Cooper, P.J.M. 1991. Crop architecture and water use efficiency in Mediterranean environments. Int. Workshop on Soil and Crop Management for Improved WUE in Rainfed Areas (Eds H.C. Harris, P.J.M. Cooper, M. Pala), pp. 106-118, MAFRA/ICARDA/CIMMYT, 15-19 May, 1989, Ankara, Turkey, ICARDA-247/500, Aleppo, Syria.

FAO (Food and Agriculture Organization) 1991. FAO Production Year Book, Vol. 45, Rome, Italy.

Ghazal, H.M., Pala, M. and Dahroug, H.M. 1988. The effect of sowing methods and seed rate on yield components of durum wheat cultivars. Research Jour. of Aleppo University, No.11:131-153.

Mazid, A. 1992. Impact assessment of new technology on wheat in Syria. ICARDA Seminar, 13/5/92, Aleppo, Syria.

Pala, M. 1991. The effect of crop management for increased production through improved water use efficiency at sowing. Int. Workshop on Soil and Crop Management for Improved WUE in Rainfed Areas (Eds H.C. Harris, P.J.M. Cooper, M. Pala), pp. 87-105, MAFRA/ICARDA/CIMMYT, 15-19 May, 1989, Ankara, Turkey, ICARDA-247/500, Aleppo, Syria.

Pala, M., Matar, A., Mazid, A. and El Hajj, K. 1992. A study on wheat response to nitrogen and phosphorus fertilization under various environmental conditions of northern Syria. Proceedings of the Fourth Regional Workshop on Fertilizer Use Efficiency (Eds J. Ryan, A. Matar), pp. 92-105, ICARDA/UNDP, 5-10 May, 1991, Agadir, Morocco.

Rassam, A. and Tully, D. 1986. Wheat production practices in NW Syria. ICARDA Annual Report 1985, p. 43-56, Aleppo, Syria

3.11 The Productivity of Wheat Cropping Systems at Tel Hadya

3.11.1 Introduction

We reported previously (FRMP 1990) four years' data from a large two-course rotation trial established to evaluate the long-term productivity of new technologies as they are developed. The purpose of this report is to present a further three years' data and to discuss developments in the trial.

Details of the trial design and management were given in the earlier report (FRMP 1990). In summary they are:

Rotations: Wheat following fallow (W/F), wheat (W/W), lentil (W/L), chickpea (W/C), summer crop (sparse water melon) (W/S), vetch (Vicia sativa) (W/V), and medic (Medicago spp.) pasture (W/M). Plot size is 0.54 ha and both phases of the rotations are included each year. Lentil and chickpea are harvested for seed yield, lentil by removal of the total biomass by hand harvesting and chickpea with a combine, residues being retained. Vetch and medic are grazed, vetch in the spring at ca 30 weaner lambs per ha and medic for as long as possible at ca 10 ewes and their followers per ha. Stocking rates vary somewhat with seasonal conditions. Water melon is planted only when there is at least 1 m of wet soil in the spring (≈ 100 mm of stored water); otherwise the plots are fallowed.

Both **phases** of the rotations are included in the design. Each phase for each crop in any rotation occupies a full year, but both crops in each rotation are included every year.

Ancillary treatments: **Nitrogen** is applied, in a split plot design, to the wheat phase only, at 0, 30, 60 and 90 kg/ha. Using a superimposed strip plot design, **wheat stubbles** are either grazed heavily, grazed at a moderate level, or retained ungrazed.

Management: Minimal **tillage** is practised, a tyned cultivator and spike-toothed harrow being used to prepare a seed bed in the wheat phase. Legumes, and wheat in the second phase, are direct drilled into the stubble. Improved **cultivars** are introduced as they become available. **Phosphate** fertilizer is applied uniformly in the wheat phase, and **weed**, **pest** and **disease** control measures are applied to all crops as necessary in each season.

The rotations were established in the 1983/84 season, and the ancillary treatments and current management were introduced in 1985/86.

3.11.2 Seasonal conditions

Weather conditions in the last three crop seasons are illustrated in

Figs. 3.11.1, 3.11.2 & 3.11.3. Seasonal rainfall (from September to August) varied from 220 mm in 1989/90, the lowest value in the Tel Hadya record (14 years), to 327 mm, the 14 year average, in 1991/92. Variations in intra-seasonal rainfall distribution are apparent. There were adequate opening rains for crop establishment in November of 1989 and 1991, but in the 1990/91 season the early rainfall was ineffective and germination was delayed until the end of January. Excellent follow-up rain in late March and early April carried crops through the latter season, but in other two seasons there was little effective rain after the end of February.

The winters of 1989/90 and 1991/92 were both quite severe for the environment. A late frost (-9.5°C) in mid-March of 1990 caused considerable damage. Several snowfalls occurred in January and February of 1992. Cool conditions throughout the spring of 1992 (Figs. 3.11.2 & 3.11.3) led to efficient water use and promoted yields of cereals but adversely affected lentil growth.

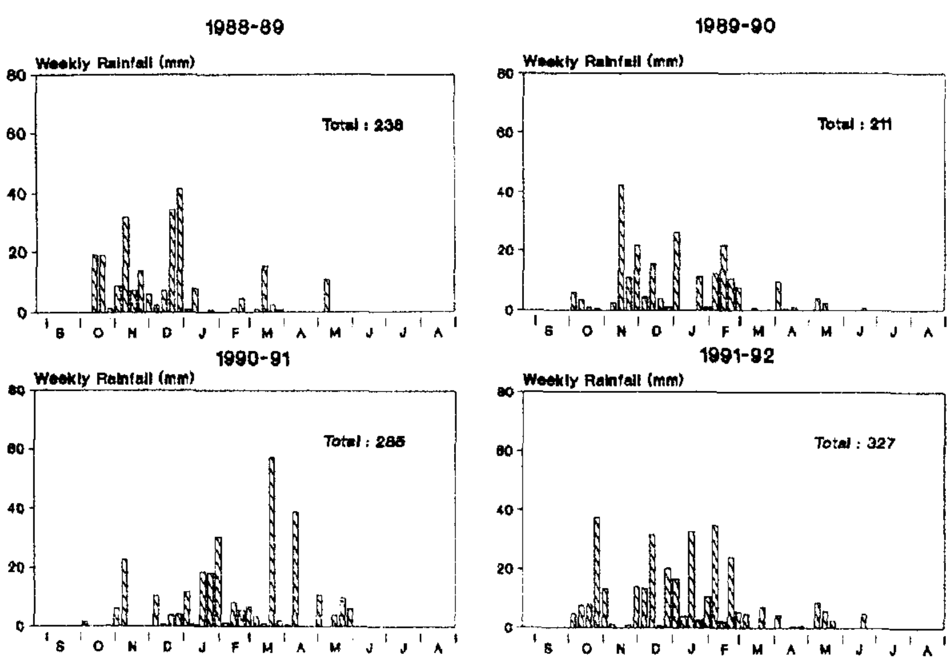


Figure 3.11.1 Weekly rainfall (mm) for four crop seasons (September to August) on Block C, Tel Hadya, NW Syria

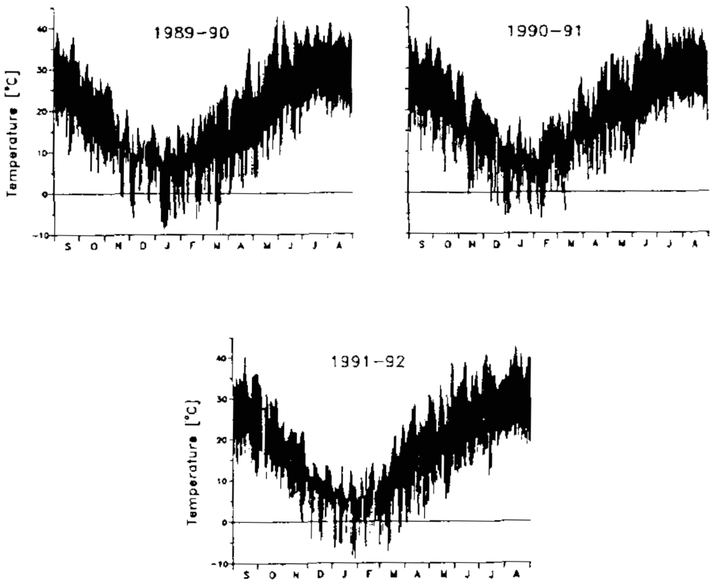


Figure 3.11.2 Daily maximum and minimum temperature for four crop seasons (September to August) at Tel Hadya, NW Syria

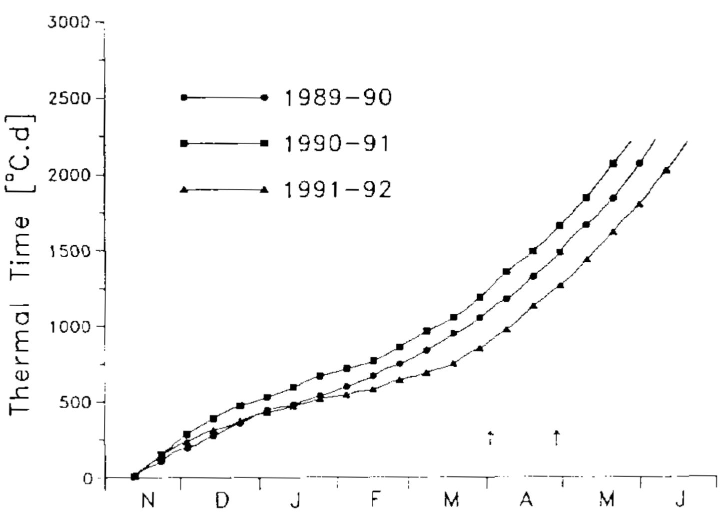


Figure 3.11.3 Cumulative thermal time (°C.d) during three crop seasons (November to June) at Tel Hadya, NW Syria. Arrows indicate approximate time of anthesis of wheat in the warmest and coolest seasons

3.11.3 Crop yields

Wheat: Wheat yields from the seven crop rotations for the last three years, together with the seven-year average, are shown in Table 3.11.1. In general, the relative order of the yields has been maintained as W/W ≤ W/M ≈ W/C < W/L ≈ W/V < W/S ≈ W/F. Continued monitoring of the soil water balance of crops in this and other two course rotation trials has confirmed that the major factor dictating this pattern is the ability of the alternative crop in the rotation to dry the soil profile. Chickpea and medic regularly extract as much water from the profile as does wheat, whereas lentil and vetch, being shorter season crops, do not dry the soil to the same extent, especially at depth in the profile. Water remaining after lentil and vetch benefits the succeeding wheat crop, but wheat following chickpea or medic is dependent solely on the current season's rain. The similarity of wheat yields in all rotations, except those with fallow, in the 1991/92 season is a reflection of the low rainfall in the preceding years during which the depth of wetting of the soil did not exceed 60-75 cm.

Table 3.11.1. Wheat grain and above-ground biomass yields (t/ha) in seven two-course crop rotations at Tel Hadya, N.W. Syria from 1989/90 to 1991/92.

Season	Crop Rotation								
	W/F	W/W	W/L	W/C	W/S[1]	W/V	W/M	s.e.	n
Grain									
89/90	1.14	0.55	0.73	0.62	1.60	0.74	0.54	0.074	36
90/91	1.56	0.97	1.25	0.76	1.64	1.17	0.93	0.086	36
91/92	2.70	1.92	2.21	2.19	2.77	2.31	2.24	0.123	36
Mean 85-92	**2.26**	**1.00**	**1.81**	**1.47**	**2.19**	**1.84**	**1.39**		
Biomass									
89/90	4.45	2.59	3.07	3.13	4.98	3.10	3.38	0.130	36
90/91	5.52	3.91	4.86	4.46	6.08	4.77	4.89	0.384	36
91/92	6.44	5.20	5.71	5.25	5.97	5.36	5.34	0.172	36
Mean 85-92	**6.31**	**3.07**	**5.24**	**4.44**	**5.93**	**5.44**	**4.45**		

F=Fallow; L=Lentil; C=Chickpea; S=Water Melon; V=Vetch; M=Medic
s.e.=Standard Error of the mean; n=No. of Observations in the mean.
1. *Wheat was preceded by fallow in these three years due to insufficient storage of soil water for planting of water melon.*

In these years of low or moderate rainfall the response to applied **nitrogen** has been only to 30 kg/ha (Table 3.11.2), in all years for biomass and in the third year for grain. Significant rotation by nitrogen interactions occurred only in the biomass in 1990/91, when the there was a response to 30 kg/ha in the rotations with fallow, but none otherwise, and in grain yield in 1991/92 when there was a response to 30 kg/ha in all rotations except those with medic and lentil.

Table 3.11.2. Wheat grain and above-ground biomass yields in response to nitrogen in two-course rotations at Tel Hadya, NW Syria from 1989/90 to 1991/92.

Season	Nitrogen Applied				s.e.	n
	N_0	N_{30}	N_{60}	N_{90}		
Grain						
89/90	1.06	1.10	1.05	1.01	0.013	63
90/91[1]	1.12	1.20	1.20	1.20	0.023	63
91/92	1.93	2.37	2.48	2.55	0.053	63
Mean 85-92	**1.50**	**1.78**	**1.91**	**1.99**		
Biomass						
89/90	3.07	3.57	3.72	3.77	0.086	63
90/91	4.52	4.94	5.03	5.22	0.075	63
91/92	5.05	5.62	5.95	5.82	0.143	63
Mean 85-92	**4.22**	**5.07**	**5.50**	**5.71**		

1. Some hail damage just prior to harvest

Alternative crops The seed yield of lentil and chickpea (Table 3.11.3) has been particularly affected by adverse weather conditions. Both crops suffered frost damage, as well as drought stress in 1989/90. In 1991, a hailstorm just prior to harvest caused damage to chickpea, estimated at about 25%. The persistence of low temperatures, and especially low daytime temperatures through most of February appears to be a main reason for poor lentil yields, relative to yields of the other crops, in 1992.

Table 3.11.3. Seed yield (t/ha) of lentil, chickpea, wheat and water melon in rotation with fertilized wheat at Tel Hadya, NW Syria from 1989/90 to 1991/92.

Season	Nitrogen Applied to Preceding Wheat					
	N_0	N_{30}	N_{60}	N_{90}	s.e.	n
Lentil						
89/90	0.20	0.18	0.19	0.24	0.022	9
90/91	1.22	1.14	1.11	0.95	0.038	9
91/92	0.65	0.93	0.93	0.81	0.073	9
Mean 86-92	**0.83**	**0.89**	**0.86**	**0.78**		
Chickpea						
89/90	0.30	0.39	0.42	0.46	0.036	9
90/91	0.90	0.77	0.78	0.72	0.044	9
91/92[1]	1.35	1.22	1.68	1.36	0.124	9
Mean 86-92	**0.81**	**0.81**	**0.86**	**0.81**		
Wheat[2]						
89/90	0.36	0.35	0.32	0.29	0.010	9
90/91	0.56	0.59	0.87	0.92	0.074	9
91/92	1.23	1.05	1.26	1.73	0.108	9
Mean 86-92	**0.59**	**0.55**	**0.68**	**0.79**		
Water Melon[3]						
91/92	0.81	0.79	0.89	1.56	0.334	9
Mean 86-92	**1.01**	**1.20**	**1.16**	**1.58**		

1. Cultivar Ghab 2 introduced.
2. In the alternate phase wheat is treated as a 'legume' and direct drilled without fertilizer.
3. Insufficient stored soil water for planting in 1988/89 and 1989/90.

A new cultivar of chickpea, Ghab 2, introduced in 1992, gave the best yield yet recorded in the trial. Attempts to quantify the yield loss due to nematode infestation of chickpea (FRMP 1990) have not succeeded, largely because of water limitations. In 1992, greater plant vigour in strips treated with nematocide caused earlier drought-induced maturity which suppressed the expression of the better yield potential. The Tel Hadya environment is marginal for chickpea, as it lies below the rainfall limit (ca 400 mm) normally accepted as suitable for even winter sowings.

Water melon was planted only in the 1991/92 season. In line with farmer practice, the crop is sown only when there is enough stored soil water to guarantee an economic yield. This did not occur in either of the first two seasons under consideration. Even in the third year the quantity of water stored was marginal and this, coupled with maximum temperatures in excess of 40°C in the week prior to harvest, led to disappointing yields.

Vetch and medic: The 'yield' of vetch and medic pasture is measured as grazing days and animal production (Tables 3.11.4 & 3.11.5). The productivity of vetch has been reduced proportionally less than other crops by the droughts. This is because, as a short season crop, its overall performance is less influenced by stress in late spring than later crops. Medic pastures have been heavily grazed in these dry years but retain an adequate seedbank, and the productivity in the last season was close to the mean for all years.

Table 3.11.4. Grazing days[1] and liveweight gain (kg/ha) of lambs grazing forage vetch in two course rotations at Tel Hadya, NW Syria, 1989/90 to 1991/92.

Season	Grazing days (/ha)	Liveweight gain (kg/ha)
89/90	860	219
90/91	1320	231
91/92	1645	403
Mean 85-92	**1590**	**314**

1. Number of animals x days of grazing

3.11.4 Water use and water use efficiency

Water use is monitored in three of the rotations, W/F, W/C and W/M, using neutron scattering techniques and permanently installed access tubes. A measurement is made at the end of the summer, before the start of the rainfall season, and all income and loss of water from that time is included in the seasonal balance (Table 3.11.6).

Table 3.11.5. Grazing days[1], liveweight gain of lambs and milk production of ewes grazing medic pasture, Tel Hadya NW Syria, 1989/90 to 1991/92

Season	Stocking Rate (ewes/ha)	Grazing Days[1] Ewes	Grazing Days[1] Lambs	Liveweight gain of Lambs (kg/ha)	Milk production (kg/ha)
89/90	8	776	352	109	296
90/91	8	648	424	112	60
91/92	10	1470	770	262	146
Mean 87-92		**1480**	**595**	**171**	**166**

1. Number of animals x days of grazing

Table 3.11.6. Water use (WU) (mm), and water-use efficiency (kg/ha/mm) for grain (WUE_G) and above ground biomass (WUE_B) production of wheat in three two-course rotations at Tel Hadya, NW Syria, 1989-1992

Season	N	F	W/F[1]			W/C			W/M		
		WU	WU	WUE_G	WUE_B	WU	WUE_G	WUE_B	WU	WUE_G	WUE_B
89/90	0	172	249	2.0	7.6	221	3.3	11.9	208	2.7	13.6
(221)	90		265	2.2	9.6	223	2.5	12.8	206	2.4	15.8
90/91	0	244	275	3.8	10.9	246	6.3	19.9	250	3.6	16.8
(285)	90		271	3.8	13.9	253	5.4	18.7	244	3.7	18.8
91/92[2]	0	197	302	4.3	11.4	289	7.1	18.2	268	8.2	20.0
(327)	90		341	5.5	12.6	299	8.0	17.7	278	7.8	20.0

Figures in parentheses are seasonal rainfall.
1. The water used by the preceding fallow has been included in the estimation of water use efficiency of wheat in this rotation.
2. Water use data not complete. See comment in text.

Fallow efficiencies ranged from 39% in 1991/92, reflecting the relative low evaporative demand of the season, to 22% in 1989/90 and 15% in 1990/91. Water-use efficiency (kg/ha/mm) of wheat after fallow has been calculated by inclusion of the water 'use' of the previous year's fallow as well as use during the crop season.

Regardless of the total seasonal rainfall, WUE for both above-ground biomass and grain was greater in the rotations with legumes than with fallow. Nitrogen application generally increased efficiency of biomass production, but depression of the WUE for grain in the drought years indicates greater stress during the grain-filling period in fertilized crops. Data for 1991/92 must be treated with reservation, as a run-on event from the first rain of the season has precluded the estimation of a total seasonal water balance. The efficiency values are slightly elevated by this.

3.11.5 Additional studies

The trial not only is providing useful agronomic data but also has become a venue for studies of a more fundamental nature on nitrogen cycling and the effect of stubble retention on soil physical conditions. Aspects of the work on nitrogen are to be found in sections 3.4 and 3.5 of this report. Soil physical studies are in their early stages and will be documented as they mature.

The major objective of the trial is to examine the biological productivity of the systems (FRMP 1990), and the management, in general, seeks to maximize this without considerations of costs. However the trial does provide an opportunity to examine the longer-term economics of new practices, and to quantify the risks of older ones, such as nitrogen fertilizer use. Economic analyses of the systems therefore are being carried out and will be reported in future publications.

3.11.6 Conclusion

Currently, with the pressures of population expansion on land resources, government policies are driving production systems in the region towards more continuous cropping with cereals. The data from this trial illustrate that this is a retrograde trend, the mean yield for continuous wheat being 40 to 100% less than that from the other rotations.

It is to be expected that, eventually, the data will provide a sound basis for considering questions of the sustainability of the various systems. Given that year-to-year variability in yields, resulting from seasonal weather variability, has been as great as a factor of 10, the detection of trends from yield data alone is difficult. Other indicators such as soil nitrogen and organic matter, however, are beginning to help us to clarify our perceptions of longer-term prospects. *H. Harris, J. Ryan, A. Rodriguez, R. Makboul, H. Jokhadar, M. Labibidi, M. Karram, I. Halimeh, A. Haj Dibo, S. Masri, S. Garabet (FRMP); F. Bahhady, T. Treacher (PFLP); D. Beck (LP).*

3.12 Barley Rotation Trials at Tel Hadya and Breda

3.12.1 Introduction

These trials were initiated in the 1982/83 season. Earlier results have been presented previously (FRMP 1989; 1990), and changes made to some of the treatments were outlined last year (FRMP 1992). The present report summarizes data from the last five years, 1987-1992 (6-10th seasons) to compare four (unchanged) rotations:

Barley-lathyrus (Lathyrus sativus)	[B-L]
Barley-vetch (Vicia sativa)	[B-V]
Barley-fallow	[B-F]
Barley-barley	[B-B]

Both phases of each rotation are grown each year; and each rotation is conducted under both fertilized and unfertilized conditions. The fertilizer treatment comprises an N and P addition to the phase 1 barley crop only. Comparisons are made here in terms of barley yields; total rotation output of crop dry matter; total rotation output of crop nitrogen, and barley quality (N%). These give different perspectives of the relative values of the four rotations. The report also summarizes results from the first two years of treatments amended in 1990.

3.12.2 Five-year rotation comparisons

Barley yields varied greatly according to season, especially at Breda. Mean annual values of total dry matter ranged: 4.06-6.65 t/ha at Tel Hadya and 1.65-6.90 t/ha at Breda. Highest barley yields were almost always obtained following fallow, and frequently (though not invariably) barley yields following vetch or lathyrus were higher than those following barley. These trends, summarized in Table 3.12.1 by a comparison of the five-year yield totals, were largely independent of site and fertilizer regime.

Table 3.12.1. Five-year yield totals of grain and straw from phase 1 barley crops in four different rotations, expressed on a percentage basis

Fertilizer	Preceding crop	Tel Hadya		Breda	
		Grain	Straw	Grain	Straw
NP	Lathyrus	80	82	81	95
	Vetch	84	83	84	96
	Fallow	100	100	100	100
	Barley	69	66	64	67
0	Lathyrus	75	75	82	86
	Vetch	78	80	84	89
	Fallow	100	100	100	100
	Barley	46	47	55	66

However, these yield trends are from a single-year viewpoint. On a whole rotation basis, greatest output of barley came from the barley-only rotations, B-B and B-F. That from B-B rotation was high because all the cropped area produced barley every year; but comparison of the annual grain yield means (Table 3.12.2) shows that any advantage over B-F rotation was small, and the annual variability tended to be greater. If a high value is placed on growing as much barley as possible, then it makes sense to grow it exclusively, in either B-F or B-B rotation, which produce, very approximately, 20-30% more barley grain than rotations involving legumes; but, given the inevitably higher production costs that a doubled area entails (and the greater difficulty of harvesting larger areas of poorer crop) these results demonstrate no advantage to B-B over B-F rotation.

Table 3.12.2. Five-year barley grain yield means (t/ha) from four rotations on a whole-rotation basis, with coefficients of variation as indices of annual variability

		Tel Hadya		Breda	
Fertilizer	Rotation	Mean	CV %	Mean	CV %
NP	B-L	2.24	30	1.49	79
	B-V	2.33	33	1.55	78
	B-F	2.78	20	1.83	53
	B-B	3.09	32	1.89	58
0	B-L	1.68	27	1.00	86
	B-V	1.75	26	1.02	79
	B-F	2.23	17	1.21	76
	B-B	2.03	26	1.32	80

Total rotation dry matter production was often greatest in barley-legume rotations, although this was not consistent in all years at both sites (Fig. 3.12.1). Five-year totals imply that rotations with legumes outyielded barley-only rotations (Table 3.12.3), but all the differences between the two could be said to have arisen in 1987/8, which was an unusually wet season. There is little quantitative difference between the rotations in a normal year to convince a farmer that he should plant legumes.

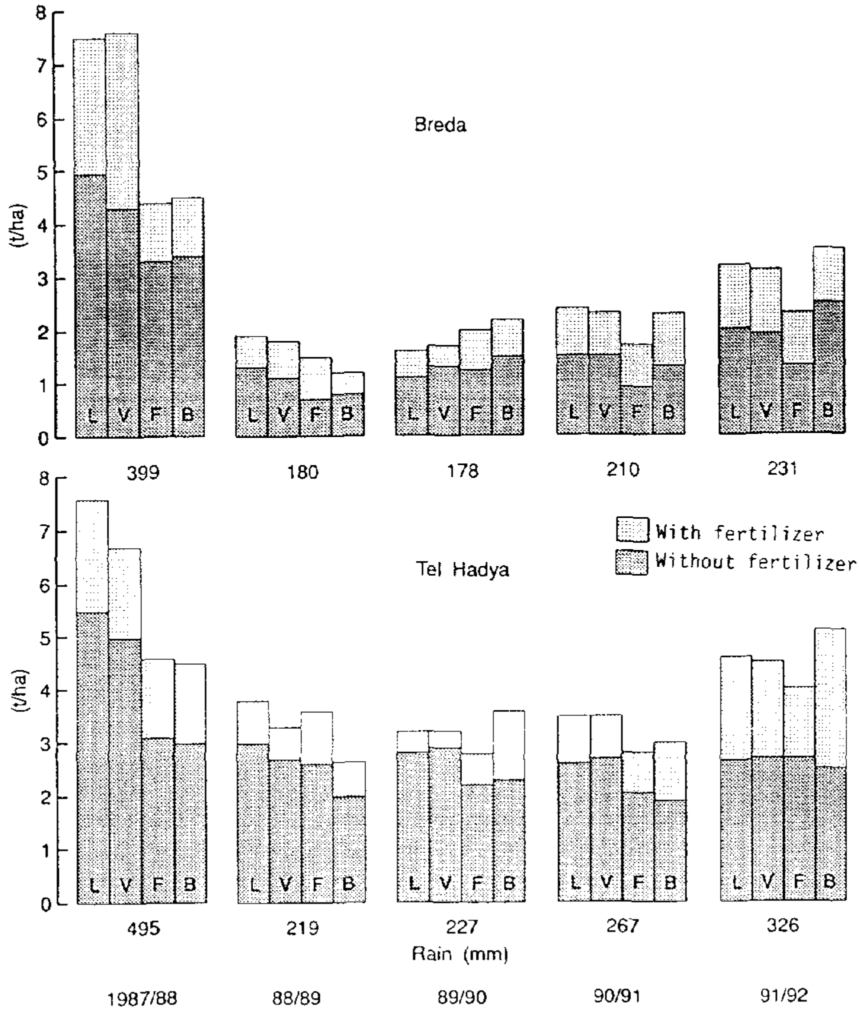


Figure 3.12.1 Annual dry matter production (t/ha) in four rotations at Breda and Tel Hadya, 1987-1992, with fertilizer and without fertilizer . (Rotations: L is barley-lathyrus; V, barley-vetch; F, barley-fallow; B, barley-barley).

Table 3.12.3. Effect of rotation on total crop dry matter production, five-year totals, t/ha*

		Tel Hadya			Breda		
Fertilizer	Rotation	Total	Mean	Difference	Total	Mean	Difference
NP	B-L	22.8	22.1	4.00	16.7	16.6	3.80
	B-V	21.3			16.5		
	B-F	17.4	18.1		11.9	12.8	
	B-B	18.8			13.7		
0	B-L	16.7	16.3	3.90	10.8	10.5	1.90
	B-V	15.9			10.1		
	B-F	12.8	12.4		7.6	8.6	
	B-B	11.9			9.5		

** Total dry matter is the sum of barley grain and straw and legume grain and straw, as appropriate*

Total rotation crop nitrogen output, in contrast, does show large differences between rotations (Fig. 3.12.2) unfortunately invisible to farmers. Over five years, the presence of a legume in the rotation was on average worth 28-33 kg N/ha/annum at Tel Hadya (Table 3.12.4). At Breda, the figure was 27 kg N/ha/annum in the fertilized situation, 15 kg N/ha/annum in the unfertilized situation.

Barley quality. The extra nitrogen output of the barley-legume rotations was not located solely in the harvested legume crops. There was a fairly general tendency for the nitrogen content (%) of the barley grain and straw from B-L and B-V rotations to be higher than that from the barley-only rotations, especially the B-B rotation (Fig. 3.12.3; Table 3.12.5). Improvement in N-content relative to B-B values amounted to 15 and 13% for grain, and 4 and 17% for straw, for Tel Hadya and Breda, respectively.

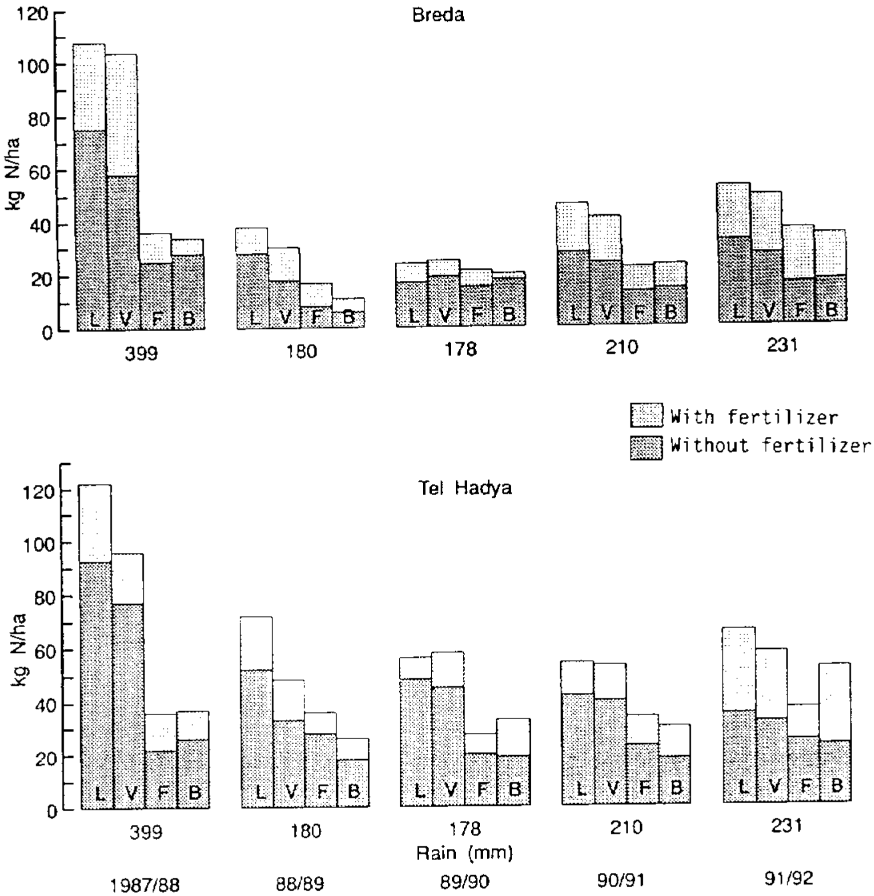


Figure 3.12.2 Annual crop nitrogen output (kg/ha) of four rotations at Breda and Tel Hadya, 1987-1992, with fertilizer and without fertilizer. (Rotations: L is barley-lathyrus; V, barley-vetch; F, barley-fallow; B, barley-barley).

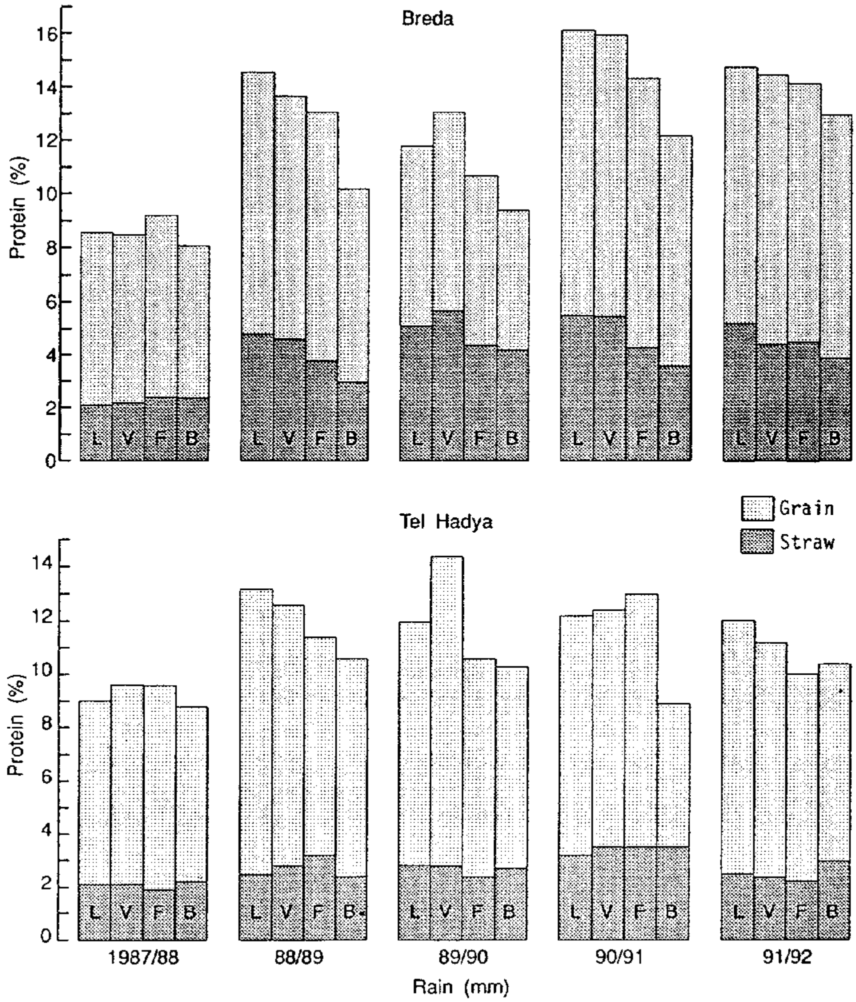


Figure 3.12.3 Annual values of barley grain and straw protein contents (N% x 6.25) in four rotations (with fertilizer) at Breda and Tel Hadya, 1987-1992. (Rotations: L is barley-lathyrus; V, barley-vetch; F, barley-fallow; B, barley-barley).

Table 3.12.4. Effect of rotation on total crop nitrogen output, five-year totals, kg N/ha*

		Tel Hadya			Breda		
Fertilizer	Rotation	Total	Mean	Difference	Total	Mean	Difference
NP	B-L	270.0	240.1	166.3	219.2	209.7	135.7
	B-V	210.2			200.2		
	B-F	70.2	73.8		77.2	74.0	
	B-B	77.3			70.7		
0	B-L	271.2	249.4	138.3	178.9	163.2	76.6
	B-V	227.6			147.4		
	B-F	117.2	111.1		79.0	86.6	
	B-B	105.0			94.2		

* *Total dry matter is the sum of barley grain and straw and legume grain and straw, as appropriate*

Table 3.12.5. Effect of rotation on percent protein content (N% x 6.25) of barley grain and straw (5-year mean values)

		Tel Hadya		Breda	
Fertilizer	Rotation	Grain	Straw	Grain	Straw
NP	B-L	11.7	3.2	13.2	4.5
	B-V	12.1	3.4	13.1	4.5
	B-F	11.0	3.0	12.3	3.9
	B-B	10.0	2.9	10.6	3.4
0	B-L	10.1	2.6	12.0	4.6
	B-V	10.5	2.7	11.6	4.2
	B-F	9.9	2.7	12.2	4.2
	B-B	9.3	2.8	11.4	4.2

These results show that there are real advantages in barley-legume rotations over barley-only rotations but that those advantages exist largely and most consistently in two factors that are not evident to farmers:

- higher total N output per rotation
- higher percentage N content of the barley component

They are therefore unlikely to encourage farmers to introduce forage legumes into barley rotations. What is needed is more visible evidence of greater output where legumes are included, eg. greater legume bulk and/or higher barley yields following legumes (that is, barley yields at least equal to those following fallow).

3.12.3 Results from amended treatments

For the last two seasons, the barley rotation trials at Tel Hadya and Breda have included two amended rotations, one involving another promising forage legume, narbon vetch (Vicia narbonensis) harvested mature, the other growing common vetch (Vicia sativa) harvested early by simulated green grazing. It is hoped that the narbon vetch will be more productive than the other two legumes used (without prejudice to the subsequent barley crop). The green grazing treatment, which can be a profitable mode of utilization (lamb fattening, enhanced milk production), has been shown in other trials to affect the soil in a similar way to a bare fallow, leaving more available water and/or available nitrogen than a forage legume grown to maturity.

Results to date show that narbon vetch produced significantly more dry matter than either common vetch or lathyrus, at both sites in both years (Table 3.12.6). The advantage amounted to about 30% at both sites in 1990/91 and 57% and 47%, at Tel Hadya and Breda respectively, in 1991/92. However, it is important to check whether this increased productivity had any adverse effect on the following barley crop. So far, this can be done only for the 1991/92 season, when the barley grain yield after narbon vetch was slightly lower than that after the other two mature-harvested legumes at Tel Hadya and slightly higher at Breda, in neither case significantly so

(Table 3.12.7). At the same time, barley after "green-grazed" common vetch produced grain yields comparable with those from the B-F rotation, 25 and 13% higher than yields after mature common vetch (Tel Hadya and Breda, respectively).

Table 3.12.6. Two-season comparison of narbon vetch (Vicia narbonensis) with lathyrus and common vetch, in respect of total mature dry matter production (t/ha)

Legume	Tel Hadya		Breda	
	90/91	91/92	90/91	91/92
	***	***	***	***
Lathyrus sativus	2.16	2.14	1.62	2.23
Vicia sativus	2.17	2.09	1.45	2.07
Vicia narbonensis	2.86	3.32	1.97	3.16
SE/mean	± 0.063	± 0.123	± 0.045	± 0.044

Table 3.12.7. Effect of preceding crop on barley grain yields (t/ha) in 1991/92†

Preceding Crop	Tel Hadya	Breda
	*	ns
Lathyrus (mature)	2.46	1.05
Common vetch (mature)	2.49	1.08
Narbon vetch (mature)	2.40	1.14
Common vetch (green)	3.11	1.22
Fallow	3.04	1.28
SE/mean	0.191	0.065

† Values are means of NP and zero fertilizer treatments. The fertilizer effect was significant at both sites, but there was no interaction with preceding crop treatment.

Again for the 1991/92 season only, values of the rotational output of crop nitrogen show only small differences between the four barley-legume rotations (Table 3.12.8). The narbon vetch-based rotation was marginally the most productive of nitrogen. Green grazing of common vetch had little effect on rotational nitrogen output but caused a greater proportion of that nitrogen to be found in the barley (79% versus 60% at Tel Hadya, and 65% versus 53% at Breda).

Table 3.12.8. Effect of different legume-based rotations on total crop nitrogen output (kg/ha) in 1991/92*

Legume component of rotation	Fertilizer:	Tel Hadya		Breda		Mean
		NP	0	NP	0	
Lathyrus (mature)		65.9	35.4	52.3	31.8	46.4
Common vetch (mature)		58.1	32.6	48.7	27.3	41.7
Narbon vetch (mature)		60.8	37.4	58.2	34.9	47.8
Common vetch (green)		63.2	37.4	45.4	27.2	43.3

* *Total N in barley grain and straw and legume grain, straw or clipped green material, as appropriate.*

These results give some support to the hope that visible, quantitative increases can be achieved in yields of barley-legume rotations through the introduction of more vigorous legume material and/or by utilizing the legume at an earlier stage of growth. ***M.J. Jones, with major technical input from N. Chapanian.***

References

FRMP, 1989, 1990, 1992. Annual Reports for 1988, 1989, and 1991. Farm Resource Management Program, ICARDA, Aleppo, Syria.

4. ADOPTION AND IMPACT OF TECHNOLOGY

Introduction

The long-term goal of this project is to assess factors related to the acceptability of new technologies and develop methods to predict, monitor and improve the adoption and impact of technology at the national, community and farm level. Such a goal implies a potentially very broad mandate -- the terms adoption and impact often appear to mean very different things to different people -- with major linkages to and fertile overlaps with technical research.

One mode of activity is that of ex-post studies of farmer acceptance of new technology, from ICARDA and from national programs. Though often perceived primarily as exercises to demonstrate research effectiveness and to justify more of the same, more importantly such studies should provide feedback to technical scientists about the real needs and constraints of their clients. So far, most adoption studies have focussed on improved germplasm, e.g. winter-sown chickpeas in Morocco and Syria (FRMP 1991) and wheat in Syria (FRMP 1992). This is because germplasm improvement has the largest history of development and transfer. However, techniques for improved crop and soil management and for efficient and sustainable resource utilization will increasingly become valid subjects of adoption studies. An impact assessment of supplemental irrigation on rainfed wheat in Syria (FRMP 1992) perhaps falls into this category, as do ongoing studies of fertilizer adoption by barley farmers (to be presented in a later report).

However, it is not essential that all adoption and impact work sequentially follows technology transfer. Ex-ante studies or proactive research of an exploratory or diagnostic nature, which may eventually initiate technical studies, can in some situations be more appropriate. Although presented in this report under Agroecological Characterization, "yield-gap estimation with crop-growth simulation" (2.2) and the Dryland Resource Management case studies (2.4) perhaps fall into this mode. And a recent publication of the Pasture, Forage and Livestock Program (Nordblom et al. 1992) provides an example of predictive farm modelling based on research trials which FRMP hopes to follow using the large data base of the Tel Hadya wheat trial (3.11).

Work reported here in the present chapter has a strong outreach flavor. Three short accounts of activities in Balochistan arise from Abelardo Rodriguez' previous residence there, but they also serve to indicate the intention that FRMP will continue to support, as best it can, the work of the Arid Zone Research Institute (AZRI) in Quetta. Highlights of the water-harvesting research on wheat and barley are presented first, and results from a new study on farmers' perceptions of water-harvesting techniques are briefly outlined (4.1). The findings of this research, together with our knowledge of the technical aspects of water-harvesting, provide a framework to assess the economic and social sustainability of this technology. Highlights on livestock marketing are presented to answer a question from livestock producers (4.2). Results show how the lack of market information may bias the perceptions of those involved in livestock production and marketing. It is foreseen that improved extension services and pricing policies could have a positive impact on rangeland resources. And a note on the marketing of skins outlines what needs to be done in the livestock sub-sector to assure the sustainability of the Balochistan leather industry.

Two reports from Tunisia, on the potential effects of the adoption and winter chickpea technology on women (4.4) and on triticale production and utilization by Tunisia farmers (4.5), might be said to illustrate, respectively, ex-ante and ex-post approaches. In the first, a rapid appraisal indicates that the adoption of winter chickpeas will likely mean more work for women, though depending on their background in landless, small-farm or large-farm families. More work has negative and positive aspects, more tedious labor but also more income. In the second study, a survey of triticale growers showed that this crop, though still largely confined to large farms, is perceived to have a clear yield advantage over barley. Further expansion of production is, however, limited by the reluctance of the poultry industry to utilize the grain. An alternative strategy to promote triticale as a livestock feed requires more research.

Migration and livestock feeding patterns of semi-nomadic bedouin in northern Syria (4.6) is a diagnostic study with a historic perspective. Over the last ten years, some bedouin families have become more sedentary; others, usually those with larger flocks, have become more nomadic, driven by the need to find cheaper feed to replace the dwindling supply on the rangeland; and residues of irrigated crops are of increasing importance to them.

Finally, in response to a new political and agricultural situation, a rapid appraisal of wheat production systems in Lebanon has been conducted (4.7). It is anticipated that this will lead into a farm survey, that will indicate the constraints to an improvement in the production of basic food commodities in Lebanon.

4.1 The Economics of Water Harvesting: Analysis on Wheat and Barley in Balochistan

4.1.1 Introduction

The most limiting factor for crop production in the rainfed areas of Balochistan is the skewed distribution of rainfall in both time and space (Kidd et al. 1988). Annual rainfall in highland Balochistan ranges from 175 to 200 mm in the southern districts of Khuzdar and Kalat and 300 to 350 mm in the northern districts of Loralai and Zhob. Crop production in non-irrigated areas is either totally dependent on rainfall (*khushkaba*) or dependent on run-off water from non-cultivable land to supplement rainfall (*sailaba*).

In an attempt to demonstrate a better utilization of rainwater on *khushkaba* land, AZRI has been growing cereals, lentils and forage legumes under water-harvesting techniques in highland Balochistan since 1986. The preparation of small catchment basins on rainfed valley-bottom soils represents a low-cost method of generating run-off and increasing crop yields within the cropped areas (Rees et al. 1991). The run-off area is formed by ploughing, cultivation with a tined implement to break up the soil aggregates, levelling with a wooden beam, and sprinkling with water, the impact of drops sealing the soil surface into a crust. The proportions of water catchment area and crop area investigated by AZRI scientists are: for the control treatment the entire area is cropped; in the 1:1 treatment, half the area is used for water catchment, half for crops; in the 2:1 treatment, two thirds of the area is used for water catchment and one third for crops.

The economic feasibility depends on the following inter-related questions:

1. Whether or not the crop area of a water-harvesting treatment yields more than that of both crop and catchment areas without treatment (control). For example, does the 1:1 treatment yield more than double that of the control or does the 2:1 treatment yield more than three times that of the control?
2. Whether there are reductions in the fixed and variable costs associated with the proportions of the crop and catchment areas.
3. Whether there is an increase in the value of outputs (grain and straw) relative to the costs of inputs.

The rationale behind the first question is that no planting in the catchment area has an opportunity cost, and this cost needs to be taken into account. Data on land tenure, as reported by Nagy and Farid-Sabir (1987), Masood et al. (1987) and Farid-Sabir et al. (1991), does not suggest that *kuskhaba* land is unlimited, and the only *information available on cropping intensity in highland* Balochistan (Rees et al. 1987) is not very complete. So it cannot be assumed that the opportunity cost of *khushkaba* land is very low or negligible.

The objectives of this study were twofold: (i) to compare water-harvesting techniques with the existing farming practices and (ii) to determine to what extent the economic benefits are increased and their associated risks are decreased.

4.1.2 The trials

This study comprised six seasons of wheat trials (1986/87 to 1991/92) and four seasons of barley trials (1988/89 to 1991/92). The local wheat landrace was planted during the first two seasons, Pak-81 in the next two seasons, Punjab-85 in the fifth season and Pak-81 again in the last season, all at a seed-rate of 100 kg/ha. In the case of barley, the local landrace was planted in 1988/89 and Arabi Abiad in the last three seasons, again at a seed-rate of 100 kg/ha. Yields of grain and straw, and rainfall during the trials, are reported elsewhere (Rodríguez et al. 1993). Yields for the treatments 1:1 and 2:1 were adjusted for the total area, crop + catchment area (ICARDA 1989, p. 42), to account for the opportunity cost of not planting the catchment area.

Partial budgets were developed for each crop, season, location and trial to calculate the benefits and the costs associated with the treatments. They reflect the conditions of traditional farming in rainfed areas of highland Balochistan, with camels used for land preparation, ploughing, harvesting and threshing (AZRI/ICARDA 1992). Budgets for all trials are reported in Rodríguez et al. (1993).

4.1.3 Results and discussion

Wheat: The control treatment yielded 345 Rs/ha (net benefit), the 1:1 treatment 422 Rs/ha and the 2:1 treatment 230 Rs/ha, with coefficients of variation of 177%, 138% and 160%, respectively (Table 4.1.1). In other words, the 1:1 treatment had 22% higher net benefits than the control with a 22% reduction in the CV; the 2:1 treatment had 33% lower net benefits than the control and a 10%

reduction in CV.

Table 4.1.1. Gross benefits, costs and net benefits (Rs/ha) of wheat grown with different treatments of water harvesting for the years 1986-92 in highland Balochistan

Treatment		All seasons		Relative to control (%)	
		Avg[1]	CV[1]	Avg	CV
Control[2]	GB[3]	1185	59		
	TC[3]	839	19		
	NB[3]	345	177	100	100
1:1[4]	GB	986	67		
	TC	564	20		
	NB	422	138	122	78
2:1[5]	GB	669	63		
	TC	438	19		
	NB	230	160	67	90

1) Avg = average; CV=coefficient of variation (%).
2) Grain yield = 205 kg/ha, straw yield=827 kg/ha.
3) GB = gross benefits; TC=total costs; NB=net benefits.
4) Grain yield = 200 kg/ha, straw yield=637 kg/ha (adjusted to total area).
5) Grain yield = 123 kg/ha, straw yield=459 kg/ha (adjusted to total area).

Barley: The control treatment yielded 421 Rs/ha, the 1:1 treatment 291 Rs/ha and the 2:1 treatment 251 Rs/ha (Table 4.1.2). The 1:1 treatment yielded 31% less net benefits than the control and increased the variation by 6%. Treatment 2:1 had 14% less net benefits than the control and 19% more variation.

4.1.4 Discussion

The relative responses of the local landraces and improved varieties of wheat and barley to above-average rainfall (above 250 mm) under the weather conditions that prevail in highland Balochistan are not clear. The water-use efficiency coefficients estimated by Rees et al. (1989a and 1989b) for wheat and barley were derived from data in which only 28% of the observations had a water availability index (soil water at planting plus rainfall during the rest of the season) between 250 and 350 mm. Given the additional water collected in the catchment areas, it would be worthwhile to estimate the response of these local varieties to above-average moisture supplies. A major assumption in this economic analysis is that the variety effect (local landraces vs improved varieties) is negligible compared to the effect of the water-harvesting treatments.

Table 4.1.2. Gross benefits, costs and net benefits (Rs/ha) of barley grown with different treatments of water harvesting for the years 1988-92 in highland Balochistan

Treatment		All seasons		Relative to control (%)	
		Avg[1]	CV[1]	Avg	CV
Control[2]	GB[3]	1131	38		
	TC[3]	890	14		
	NB[3]	421	94	100	100
1:1[4]	GB	862	41		
	TC	663	27		
	NB	291	99	69	106
2:1[5]	GB	721	50		
	TC	470	16		
	NB	251	118	86	119

1) Avg = average; CV=coefficient of variation (%).
2) Grain yield = 211 kg/ha, straw yield=902 kg/ha.
3) GB = gross benefits; TC=total costs; NB=net benefits.
4) Grain yield = 284 kg/ha, straw yield=607 kg/ha (adjusted to total area).
5) Grain yield = 122 kg/ha, straw yield=546 kg/ha (adjusted to total area).

4.1.5 Conclusions

The results of these wheat and barley trials suggest that there are still some technical problems to be overcome before sustainable increases in crop production and net returns can be ensured; either too little or too much water is harvested and transferred to the cropped area, and only a small reduction in economic risks is achieved (Rodríguez et al. 1993). At best, the 1:1 treatment increased wheat net benefits by 22% compared to the traditional practice with a 22% reduction in economic risk. The adjustment of yields and costs on an area basis compounded the low economic performance of the water-harvesting treatments. Because of the adjustment, yields in the 1:1 treatment need to be twice as high and yields in the 2:1 treatment three times as high as those of the control to be superior to traditional farming (assuming proportional costs for the treatments). The total costs for different treatments increased more than proportionately to the cropped area, i.e. total costs of the 1:1 or 2:1 treatments were more than a half or a third, respectively, of those of the control. Thus, more than technical factors and land tenure, the requirements of labor and capital to set up the catchment area are likely to hinder acceptance of the current water-harvesting design.

4.1.6 Farmers' perceptions of water-harvesting techniques

A burning question in the economic analysis of water-harvesting has been whether or not land is a limiting factor in the *khushkaba* systems of highland Balochistan. The adoption potential of water-harvesting techniques does not depend only on their technical merits to improve production and decrease risks but also on farmers' freedom to expand their area of wheat production or to spare cultivable land for use as a catchment.

A survey was conducted to assess farmers' perceptions of water-harvesting techniques and to gauge those factors limiting farmers' agricultural activities. Representative districts of different mean annual rainfall were selected, from Zhob and Loralai in the northeast with 275-325 mm to Khuzdar and Kalat with 150-225 mm. On average, each farmer plants three to five ha to wheat every year, but farmers reckon that 13-17 ha are required to provide enough wheat flour for each household. This implies that, on average, farmers in highland Balochistan are producing only 25-33% of the wheat they consume. Farmers are aware of traditional *khushkaba* systems and are conscious of the investment (capital and labor) required to build bunds to contain and divert runoff water. When the water-harvesting techniques used by AZRI were explained to them and they were asked if they would adopt these techniques, one half responded affirmatively. The frequency of farmers who responded positively was 25% higher in the wetter northern areas than in the southern areas. Of those farmers that responded negatively, 33% did not believe in water-harvesting techniques, 31% mentioned capital as a limiting factor, and 14% gave other reasons. Among these reasons were the shortage of land, the practice of dry sowing which prevents them from taking care of the catchment structures during the rainy season and concern about a possible excess of water where land is close to the natural catchment areas of the foothills. The rest did not provide a specific reason.

To achieve wheat self-sufficiency it would be necessary to triple/quadruple the five/three ha already under traditional wheat cultivation. If the capital and labor were available to triple or quadruple the area under water-harvesting using the 1:1 treatment, farmers' needs for wheat would be satisfied, with net benefits 22% above those of traditional agriculture and with a 22% reduction in economic risk. ***Abelardo Rodriguez, with AZRI collaborators: N.A. Shah, M. Afzal, U. Mustafa and I. Ali***

References

AZRI (Arid Zone Research Institute)/ICARDA (International Center for Agricultural Research in the Dry Areas), 1992. High elevation research in Pakistan, the MART/AZR project annual report 1991. ICARDA, Quetta, 66 pp.

Farid-Sabir, G., M. Afzal, N.A. Shah, J.G. Nagy, J.D.H. Keatinge and A. Rodríguez, 1991. Camel survey results in highland Balochistan. MART/AZR Research Report. No. 66, ICARDA, Quetta.

ICARDA (International Center for Agricultural Research in the Dry Areas), 1989. High-elevation research in Pakistan: the MART/AZR Project annual report for 1988. ICARDA, Aleppo, Syria. ICARDA 138-En., p. 38.

Kidd, C.H.R, D.J, Rees, J.D.H. Keatinge, F. Rehman, A. Samiullah, and S.H. Raza, 1988. Meteorological data analysis of Balochistan. MART/AZR Research Report No. 19, ICARDA, Quetta.

Masood, M. A., M. Afzal, J.G. Nagy and S.M. Khan, 1987. Agricultural and related statistics of upland Balochistan. MART/AZR Research Report No. 20, ICARDA, Quetta.

Nagy, J.G. and G. Farid-Sabir, 1987. Household agricultural production systems survey results. MART/AZR Research Report No. 7, ICARDA, Quetta.

Rees, D.J., J.G. Nagy, S.H. Raza, K. Mahmood, B.A. Chowdry, and J.D.H. Keatinge, 1987. The dryland arable farming system of upland Balochistan: a case study. MART/AZR Research Report No. 5, ICARDA Quetta, 21 pp.

Rees, D.J., Samiullah, A., Islam, M., Qureshi, Z., and Raza, S.H. 1989a. Rainfed crop production systems of upland Balochistan. 1. Wheat (Triticum aestivum). MART/AZR Project Research Report no. 51, ICARDA Quetta, 23 pp.

Rees, D.J., Islam, M., Rehman, F., Samiullah, A., and Raza, S.H. 1989b. Rainfed crop production systems of upland Balochistan. 2. Barley (Hordeum vulgare). MART/AZR Project Research Report no. 52. ICARDA Quetta, 24 pp.

Rees, D.J., Qureshi, Z., Mehmood, S., and Raza, H.S. 1991. Catchment basin water-harvesting as a means of improving the productivity of rainfed land in upland Balochistan. J. Agric. Sci., 116:95-103.

Rodríguez, A., N.A. Shah, M. Afzal, U. Mustafa and I. Ali, 1993. Economics of water-harvesting trials with cereal crops in highland Balochistan. MART/AZR Project Research Report No. 78, ICARDA, Quetta, 39 pp.

4.2 Livestock Marketing in Balochistan

As the AZRI Agricultural Economics Section approaches the end of the two-year study on perceptions of livestock prices in the Quetta market (see AZRI/ICARDA 1992 and Khan et al. 1992), the scientists involved have noticed tiredness on the part of the producers and other market agents from whom marketing information is gathered. These cooperators claim that retail prices have increased from 50 to 60 Rs/kg, while the prices received by them in the livestock market have not increased accordingly.

Data from the last 22 months were used to regress price per unit weight with Julian (calendar) days on which the data were gathered; 365 days were added to the Julian days of the second year. Results (Table 4.2.1) are grouped by market agents. Sheep and goats were calculated separately but combined are referred to as mutton (in Pakistan, both meats are given the same name). All coefficients were statistically highly significant with the exception of the slope of goats in the "others" group. The intercepts (January 1, 1991) ranged from 23.6 to 26.3 Rs/kg, and the significant slope coefficients ranged from 0.0054 to 0.0099 Rs/kg per Julian day. From January 1991 to October 1992, the estimated increase in the price per unit weight of live sheep was Rs 6.63 for others and Rs 5.29 for producers, 28% and 20%, respectively. In both instances, the increase was above the official retail price increase of 10% (ALPMG, Agricultural and Livestock Products Marketing and Grading Department, GOP, Quetta). Informal interviews with consumers have revealed that the ongoing price of mutton is 60 Rs/kg, which represents a 20% increase over the price in January 1991.

Contrary to the views of our cooperators in the livestock market, prices of live animals reflect an increase in meat prices paid by consumers. However, the increases have not been simultaneous. According to the ALPMG, it was not till January 1992 that retail prices of mutton started to increase, from 51 Rs/kg to 55 Rs/kg in

October 1992. It would be desirable to have market information flowing among the livestock producers and other market agents in such a way that price changes and trends are familiar to those involved in marketing transactions.

Table 4.2.1. Price per unit weight of small ruminants in the Quetta livestock market regressed with calendar day. All the coefficients except one were highly significant (P<0.001)

	Intercept	Slope	r	n
All market agents				
Mutton	24.98	0.0077	0.136	4400
Goats	24.40	0.0080	0.142	2200
Sheep	25.56	0.0074	0.130	2200
Producers				
Mutton	25.87	0.0098	0.149	2053
Goats	25.13	0.1194	0.180	969
Sheep	26.30	0.0079	0.124	1084
Others†				
Mutton	24.58	0.0054	0.102	2347
Goats	25.26	0.0015^{NS}	0.030	1231
Sheep	23.56	0.0099	0.180	1116

***NS** Non significant at P<0.10*
† Butchers, wholesalers and traders

It was discussed earlier (AZRI/ICARDA 1992) that the prices perceived by different market agents should be interpreted as those prices expected at the beginning of the one-to-one bargaining process. The goat price perceived by producers was 29.4 Rs/kg while that perceived by others was 25.3 Rs/kg (Table 4.2.2). Likewise, the producer-perceived sheep price was 29.1 Rs/kg, while that of other agents was 27.1 Rs/kg. These differences (16% for goats and 7% for sheep) reflect the nature of the market agents and their role in the marketing chain. Even though the differences appear to be small, they represent the potential gains that producers could take from the market if their knowledge of supply and demand were rationalized and if they acted to market particular types of animals at the appropriate time.

Table 4.2.2. Liveweight, price per head and price per unit weight of small ruminants in the Quetta livestock market by market agent and sex

Animal	Market agent	Sex of animal	Liveweight (kg/hd)	Price (Rs/hd)	Price (Rs/kg)	n
Goats:	Producers	Female	28.3 (9.1)	671.0 (216.6)	25.3 (9.5)	92
		Male	29.4 (12.5)	841.9 (463.2)	29.8 (11.8)	877
		All	29.3 (12.2)	825.7 (448.4)	29.4 (11.7)	969
	Others	Female	30.7 (10.6)	698.5 (331.6)	23.4 (8.4)	231
		Male	28.4 (10.6)	706.6 (412.7)	25.7 (10.1)	1000
		All	28.9 (9.8)	705.1 (398.6)	25.3 (10.6)	1231
Sheep:	Producers	Female	34.4 (10.4)	828.4 (249.0)	24.8 (6.5)	73
		Male	30.5 (12.9)	848.7 (441.3)	29.4 (12.6)	1011
		All	30.7 (12.8)	847.3 (431.0)	29.1 (12.3)	1084
	Others	Female	29.7 (10.8)	751.6 (315.5)	26.5 (8.4)	203
		Male	31.1 (13.0)	816.4 (406.5)	27.2 (9.6)	913
		All	30.8 (12.6)	804.6 (392.2)	27.1 (9.4)	1116

Correlating some of the variables collected up to October 1992 showed that, in general, the price per unit weight is related to liveweight, month, sex and body condition (Table 4.2.3). Liveweight is correlated with seasonality (month) and body condition. There is also a correlation between sex and class of animal (either one year old male, two year old male or older, castrate and lactating or dry ewe/doe). These, among others (e.g. breed, number of cattle also on sale, camels and rainfall), are key variables to be quantified by animal type and type of market agent.

Table 4.2.3. Correlation matrix of some variables collected in the Quetta livestock market up to October 1992

	WPRICE (Rs/kg)	PRICE (Rs/hd)	LWT (kg/hd)	MONTH	SEX	CLASS	BCOND
WPRICE	1.0000						
PRICE	.4508**	1.0000					
LWT	-.2541**	.6669**	1.0000				
MONTH	-.1220**	-.0003	.1095**	1.0000			
SEX	.0962**	.0603	-.0177	.0205	1.0000		
CLASS	-.0329	.0056	.0474	.0262	-.2220**	1.0000	
BCOND	.1719**	-.3765**	-.5902**	-.1554**	.0106	-.0417	1.0000

*N of classes: 4400; 1. tailed signif: ** = .001*

An understanding of the price formation mechanisms for live animals should be useful to the extension services in assigning value to expected returns for producers' output. It would also provide quantitative measures to aid the design of pricing policies by which good quality animals, the result of good grazing management practices, would be encouraged and low quality animals, from inappropriate grazing management, discouraged. ***A. Rodriguez, and I. Ali, M. Afzal and N.A. Shah (AZRI)***.

References

AZRI (Arid Zone Research Institute)/ICARDA (International Center for Agricultural Research in the Dry Areas), 1992. High elevation research in Pakistan, the MART/AZR project annual report 1991. ICARDA, Quetta, 66 pp.

Khan, B.R., Thomson, E.F. and A. Rodríguez, 1992. MART/AZR Project Research Report No. 77, ICARDA, Quetta, 47 pp.

4.3 The Marketing of Skins in Balochistan

After cotton, exports of leather and leather products are Pakistan's next largest source of foreign exchange (GOP 1991a), and their value has increased from US$ 269 millions in 1985 to US$ 483 millions in 1990. This rapid growth has been successfully based on indigenous supplies of skins and hides. Considerable research and training has been done by the Leather Research Center of the Pakistan Council of Scientific and Industrial Research (PCSIR) and the Leather Products Development Organization in the processing and handling of skins and hides. However, little or no attention has been paid to the social and economic factors that affect their supply (Rodríguez et al. 1992).

As long as skins are perceived as meat by-products, their supply will continue to be inelastic, responding to meat rather than to leather prices. The tanning industry has the capacity to absorb more than the total domestic supply of 37.6 million skins (GOP 1991b). Imports of raw skins have increased in recent years (GOP 1991b) to satisfy its demand, and Pakistan has evolved from being a net exporter of raw skins to a net importer of raw skins and a net exporter of leather and leather products (GOP 1991b). While this is a desirable trend in economic development, additional savings could be achieved if the domestic supply of skins were sufficient to satisfy the tanners' demand (Rodríguez et al. 1992).

The supply of skins is a function not only of the biological aspects that determine production but also of marketing aspects. If there were market efficiency, the preferences of tanners would be passed back through the marketing chain to the producers, who would then respond to the price signals, producing skins as a function of prices and costs. Efficient marketing systems provide goods and services over time and space and in the form consumers want at the lowest possible cost. The inefficiencies of the skin market in Pakistan were identified three decades ago (Siddiqi 1962), and they are still present (Mahmood and Walters 1990, and Shuja-Uddin-Siddiqi 1992).

There are a few questions to be answered: What can be done to benefit both producers and users of raw skins? Can livestock producers increase their income by paying attention to factors that affect skin quality? Is there research that the Pakistan Agricultural Research Council (PARC) can do to help remove constraints to a steady supply of skins?

A proposal was sent to the private and public sectors involved in the leather industry aimed at reinforcing the competitive advantage of the Pakistani leather industry (Rodríguez and Ali 1992). It proposed that scientists from PARC and PCSIR would provide expertise on livestock production, economics and leather processing, and members of the Pakistan Tanners Association would provide financial support and information about the market for raw skins, leather and leather products in the national and international markets. *A. Rodríguez, I. Ali, M. Afzal, N.A. Shah.*

References

GOP (Government of Pakistan), 1991a. Economic survey 1990-91. Finance Division, Government of Pakistan, Finance Division, Economic Advisor's Wing, Islamabad, 248 pp.

GOP (Government of Pakistan), 1991b. Economic survey 1990-91: statistical supplement. Government of Pakistan, Finance Division, Economic Advisor's Wing, Islamabad, 250 pp.

Mahmood, A. and F. Walters, 1990. Pakistan Agriculture. Directorate of Agricultural Policy and Chemonics International Consulting Division, Economic Analysis Network Project. Government of Pakistan and the United States Agency for International Development. 183 pp.

Rodríguez, A., and I. Ali. 1992. The socio-economics of the skin market: a neglected issue in the leather industry. Pakistan Leather Trade Journal Quarterly 19 (Jul/Sept): 51-56.

Rodríguez, A., I. Ali, M. Afzal, and N.A. Shah, 1992. Marketing of goat and sheep skins in highland Balochistan, Pakistan. MART/AZR Project Research Report No. 76, ICARDA, Quetta, 17 pp.

Shuja-Uddin-Siddiqi, 1992. Prospects of quantitative and qualitative improvement of hides and skins through and integrated approach to meat processing industry. Pakistan Leather Trade Journal, Vol. 19, No. 1 (Jan-Mar):51-62.

Siddiqi, K.A, 1962. Marketing of hides & skins in Pakistan. In: Pakistan Society of Leather Technologists. *Pakistan Leather Year Book 1962*. Karachi, Pakistan. pp. 47-50.

4.4 Women and Technological Change in Tunisia: The Case of New Food-Legume Technology

Recent literature suggests that some technologies, especially those associated with the "Green Revolution" may unfavorably affect rural women by replacing some of their traditional income-generating activities in agriculture, and by aggravating their already limited access and control over resources such as income and land (Whitehead 1985; Agarwal 1985). This literature contradicts an earlier held view that high-yielding varieties, which are the main driving force behind this "Revolution", are relatively gender- and scale-neutral.

Winter-sown chickpea merits close attention within this debate because it is a newly developed technology that consistently and considerably outyields the traditional spring-sown varieties. The technology was first developed in 1982 by the Food Legume Improvement Program at ICARDA. By breeding chickpeas for cold temperature and disease resistance, scientists were able to plant the crop earlier in the season. The significantly higher yields obtained are attributed mainly to moisture regimes more favorable than those that face spring-sown chickpeas. In Tunisia, experiments on winter-sown chickpeas have produced a 160 to 243% increase in yield over traditional varieties (Halila et al. 1990).

To ensure the higher productivity of winter-sown chickpeas however, an extra weeding operation is required in early spring. In Tunisia, weeding is usually done by hand by women; and the question of whether this new technology will benefit women in terms of added income or adversely affect them by increasing their workload without necessarily producing any added benefit, was the main focus of this study.

Since winter-sown chickpeas have not yet been widely adopted by

Tunisian farmers, a rapid appraisal study and a survey of fifty farmers in northern Tunisia were conducted (1) to establish the extent to which women are involved in food legume production, (2) to identify constraints to the adoption of winter-sown chickpeas, and (3) to determine the potential impact of this technology on women's labor.

The rapid appraisal study provided an overview of the social construct within which rural women in Tunisia perform their work. It consisted of examining the existing literature and holding discussions and interviews with key national and local government officials, extension officers, influential elders and farmers, and researchers and scientists specialized in the field.

A set of consistent patterns emerged from the information collected. First, women play a major role in agricultural production in Tunisia, as both family and hired labor, although that role is not well documented in the literature or in national statistics. Secondly, an unequal division exists between men and women with respect to workload and to access and control over income, land, credit and other resources. Thirdly, national and international research and development projects have, more often than not, ignored the central role of rural women. In the few projects where it has been acknowledged, the women's component in the design has not been aimed at their full integration in the development process.

These results were augmented with data collected through a short formal questionnaire and a series of informal discussions held with fifty farmers growing food legumes in the region of Mateur in the northern province of Bizerte, a principal cereal and food legume producing area.

The data collected shed light on the food legume production practices and the role of women in these systems. They show that food legume production is extremely labor intensive compared with other crops, with women contributing a large proportion of the labor needed. It was established that women plant, fertilize, weed, harvest, thresh, clean and bag all food legumes. Compared with men, women spend longer hours and undertake more tedious work in the production of these crops. It was further established that weeding, followed by harvesting, required the greatest labor input from women. On large farms, women were hired to perform these tasks, while on small farms most of the weeding and harvesting was done by the female members of the household. The majority of the farmers agreed that the major constraints to increasing food legume production were labor costs and the availability of labor at weeding and harvest times.

An ex-ante economic feasibility analysis showed winter-sown chickpea technology to be an economically attractive enterprise that poses no additional risk in most cases. However, the results also indicated that adoption will differ between small and large farms. It was found that large farmers will be the most likely to adopt winter-sown chickpeas, as they can afford to hire women to perform the additional weeding and harvesting tasks. Small farmers, however, are unlikely to adopt because of limited funds to hire labor, with the possible exception of farmers with "underutilized family labor" or those with no cash problems. Both exceptions are likely to be rare in the study region.

Since large farmers will be the most likely adopters of winter-sown chickpeas, it is expected that this adoption will create additional job opportunities for local women. This increased demand for hired labor might be met by either landless women or women from smaller holdings. It is possible that these women will then bring additional income into the poorer rural households. However, it must be pointed out that, although more jobs for women may be created, the type of work involved is both tedious and tiresome.

It is not expected that there will be any significant impact from winter-sown chickpea technology on women members of large farm households, since they were found to play a minimal role in chickpea production. The opposite effect, however, is expected on any small family holdings where winter chickpea is adopted. Although small farmers are unlikely to adopt winter-sown chickpeas, where they do the impact on the female members of the farm will be negative. Since it is unlikely that labor will be hired, the additional uncompensated work required for winter chickpea will become the responsibility of the women, who are already overburdened with their daily household and fieldwork chores.

In the final analysis, whether or not the adoption of winter-sown chickpea varieties is beneficial to women depends on a whole complex of interrelated factors, such as local and regional conditions, farm size, farming system and spending decisions. Results from the rapid appraisal indicated that rural women in Tunisia are usually excluded from income-spending decisions, and that the additional income received by the household from their labor is spent by men according to their own priorities. It is possible to argue, however, that even if women are excluded from decision making, their negotiating power within the family might be enhanced as a result of the additional direct or indirect non-cash benefits they bring in.

It is recommended that more descriptive and analytical data be collected to help gain a better understanding of how women spend their time and, if given the choice, what alternative ways they would prefer to allocate their time and effort. Further analysis of how decisions are made in the household regarding income-spending and technology adoption is also suggested. ***Lamia El-Fattal.***

References

Agarwal, B., 1985. "Women and Technological Change in Agriculture: The Asian and African Experience." In Technology and Rural Women: Conceptual and Empirical Issue, ed. Iftikhar Ahmed, pp. 67-114, Allen and Unwin.

Halila, M.H., Dahmane, A.B.K. and Seklani, H., 1990. "The Role of Legumes in the Farming Systems of Tunisia." In The Role of Food Legumes in the Farming Systems of the Mediterranean Areas, (eds) A.E. Osman, M.H. Ibrahim and M.A. Jones, pp. 115-129. Kluwer

Academic Publishers for ICARDA, The Netherlands.

Whitehead, A., 1985. "Effects of Technological Change on Rural Women: A Review of Analysis and Concepts." In Technology and Rural Women: Conceptual and Empirical Issues, ed. Iftikhar Ahmed, pp. 27-64, Allen and Unwin.

4.5 Triticale Production and Utilization by Tunisian Farmers: Preliminary Results of a Farm Survey

The Tunisian Ministry of Agriculture started promoting triticale production in the early 1980s with the aim of reducing maize imports for the rapidly expanding poultry industry. Triticale areas rapidly increased from 4,000 ha in 1984 to 16,500 ha in 1991. Triticale's yield advantage and its good resistance to major cereal diseases and to lodging has made its cultivation very attractive, particularly in the favorable zones of the North where barley harvests are unreliable due to diseases and lodging risk. However, the reluctance of the poultry industry to incorporate triticale in poultry diets did not allow triticale utilization to expand, leading to the present situation in which production has largely exceeded demand, resulting in chronic surplus stocks. This situation has lead some officials to question the rationale of current government policy of supporting triticale production and, over the past two years, there were persistent rumors that the State was about to abandon this support policy.

The main objectives of this study were to identify how Tunisian farmers have integrated triticale in their farming systems, the extent of triticale's on-farm utilization and the agronomic and socioeconomic constraints to triticale adoption and diffusion. The findings could provide policy-makers and researchers with additional farm-level information to assist them in their efforts to re-evaluate the current triticale situation and to develop new strategies to deal with it. The study was based on a survey of 52 triticale growers in the sub-humid district of Mateur and the semi-arid districts of Medjez-el-Bab and Goubellat.

The survey showed that triticale is a crop grown predominately by large farmers (with 50 ha or more) who accounted for 95% of total triticale production in 1991. Small and medium farmers have only recently started growing triticale and, in 1992, they represented about one third of all triticale growers. The survey farmers consistently praised triticale's resistance to diseases and lodging and its tolerance to drought. Moreover, triticale demonstrated a clear yield advantage over barley (an average of 22% higher grain yield). Triticale's yield advantage over wheat was very modest in normal years (5-6%) but was more apparent in dry years, when it outyielded durum wheat by an average of 39% and bread wheat by 10%.

The survey results also indicated that on-farm utilization of triticale is still relatively limited, with about 15% of total grain output fed to on-farm sheep and cattle. More than half of livestock owners used some triticale to feed their animals, but only 10% of the survey farmers used more than 50% of their triticale output in animal feeding. These farmers were generally very satisfied with the results, especially in feeding milking cows and ewes. Given that a relatively large number of triticale growers seem to be still experimenting with small quantities of triticale grain in animal feeding, the positive results obtained by more experienced farmers suggest that the prospects for a much higher on-farm consumption are promising.

So we have, on the one hand, survey results that clearly show that triticale is highly adapted to the sub-humid and semi-arid areas of Northern Tunisia, that farmers there are obtaining reasonably high yields and that it is becoming increasingly utilized in the livestock production activities; but, on the other hand, as a result of widespread rumors about the State's intention to abandon its support to triticale production, we find that triticale areas declined sharply in the 1991/92 season to a level approximately 45%

below that of 1990/91. Such sharp declines in production will likely solve the short-term problem of excess stocks. However, in the absence of official statements clarifying the State's position as to the future of triticale cultivation, the uncertainty could push the majority of farmers to abandon triticale cultivation permanently.

Should the government opt to remove its support, the lack of a private triticale market and the still limited on-farm consumption could very well lead to the virtual disappearance of a crop that has shown great adaptability and productivity under Tunisian conditions. The positive results obtained by some of the survey farmers in feeding triticale to sheep and cattle suggest that policy makers may want to explore alternative triticale strategies based on promoting triticale for livestock as well as for poultry feeding. The current reluctance of the poultry industry to use triticale will likely diminish gradually, particularly if triticale prices remain as competitive as they currently are compared to other feed ingredients. In addition to this cost-saving incentive, the poultry industry would probably require a reasonably large and stable supply of triticale before it could be incorporated in poultry diets.

An alternative strategy to promote triticale as a livestock feed should expand the demand. This would not only solve the problem of excess production and but might ultimately induce farmers to expand their triticale areas. Thus, by the time the poultry industry decides to start incorporating triticale in poultry diets, production might well have reached levels sufficiently large to guarantee a stable supply for poultry feed manufacturing. However, the elaboration of such an alternative strategy would require more research to estimate current and future demand for triticale by the livestock feed manufacturing industry and by livestock producers. Such research should attempt to determine possible triticale producer and sales prices that would minimize both the need for government subsidies and for prolonged storage of excess production. ***Maurice Saade.***

4.6 Migration and Livestock Feeding Patterns of Semi-Nomadic Bedouin in Northern Syria

4.6.1 Introduction and study methods

This project* studied the social organization of the semi-nomadic agropastoral society -- as well as sheep flock management systems and migration patterns -- in northern Syria, in order to improve understanding of the area's current production systems. The specific objectives were:

1. To analyze the social and economic organization of production to identify factors determining the management of flocks and land resources.
2. To analyze the sustainability of production based on resources derived from the steppe society (land, labor and capital), and also to study the impact of "modernization" and recent economic change on the "sustainability" of production in the steppe.

Research concentrated on an in-depth study of three villages in the Aleppo and Raqqa provinces of northern Syria. As these villages had been the focus of a three-year study between 1979 and 1981 (see Thomson and Bahhady 1983; Thomson 1987; and Thomson et al. 1989) it was possible to look at changes which have taken place during the intervening 10 years.

Field work was undertaken from October 1991 to December 1992, when 11 families were visited on average once every three weeks. The families were studied both through a series of questionnaires and through semi-structured interviewing. The questionnaires covered all aspects of production, including cropping and animal husbandry. Certain questions, such as stock sales and feeding practices, were asked systematically, while others, for example milk

---

* A collaborative study between the University Institute of Development Studies (IUED) in Geneva and ICARDA.

production or harvest yields, were treated in a questionnaire at the time of year when the event took place. Semi-structured interviewing was used to learn more about social organization and the history of the region. The results of this project will be written up as a thesis for an IUED research diploma. This report covers only a part of those results, namely migration and feeding patterns.

4.6.2 <u>**Migration patterns**</u>

It is difficult with a small sample to generalize about the migration patterns for particular tribes, but the eleven families studied fell into four different groups during the year: the three Mouhaseneh families in one group, the four from Bir Amaleh in a second group, and the four from Hazm Alsurr dividing into two groups, with three families in group three and one in group four.

It appears that tribal groups do, in general, move to the same areas: members of other tribes are not usually present. Bedouin living on the Mediterranean coast in the summer all seem to be Haddiddiin from Hazm Alsurr, and those on irrigated land east of Deir Hafer in autumn seem to be mostly Wahab (Shammar) from Bir Amaleh or near Bir Amaleh. We will consider in turn the migration patterns of the four groups studied.

Group one: In the past 10 years, the three families in this group have become sedentary. All three flocks are small, the largest comprising 123 sheep. Mouhaseneh is near the government farm of Mounshat Al Assad, and two of the three flocks graze there part of the year on rented cereal stubble, fallow and medic. People from Mouhaseneh are also able to obtain seasonal work on the farm, providing extra off-farm income.

Although 10 years ago these flocks, in good years, still moved to the steppe to graze rangeland, the spread of cultivation in the steppe as well as the reduction in feed available from the rangeland, has stopped this movement. Now, the sheep are hand-fed in winter and spring and graze standing barley or stubble during the rest of the year.

Group two: The migration patterns of the Bir Amaleh group have changed over the past 10 years. As a result of the extension of irrigated land in the Euphrates project, the flocks now graze irrigated crop residues from September until December. Rangeland degradation in Bir Amaleh has also contributed to these changes. In the early 1980's, the flocks generally spent up to six months during winter and spring at Bir Amaleh grazing rangeland and, in the winter, were fed supplements. At that time, these feeds were truly only supplementary to the diet, whereas now they contribute the whole diet during the winter months, and rangeland grazing is limited to the spring. In 1992, none of the farmers relied totally on rangeland grazing at any time; while the sheep were on the rangeland, supplements were still being fed. In late spring and summer the flocks grazed standing barley and stubble. One typical migration pattern for this group is shown in Fig. 4.6.1.

Group three: The major movement of this group now is towards the Mediterranean coast. Ten years ago, these flocks were kept at Hazm Alsurr over the winter, grazing local rangeland and being fed supplements. In May or June the flocks would be taken to the Breda-Bueda area to graze cereal stubble, then later moved either to the coast, on to irrigated land in Aleppo Province, or back to rangeland in Hazm Alsurr. Movement to the coast began in 1973 with just a few farmers. Numbers have greatly escalated since 1988. Now, the flocks are handfed in Hazm Alsurr or in the Breda-Bueda area during the winter. There is some rangeland grazing in the spring but supported by supplements. In late spring, after grazing standing barley and cereal stubble, the sheep are moved westwards, often stopping in the mountains on the way to Lattakia to graze

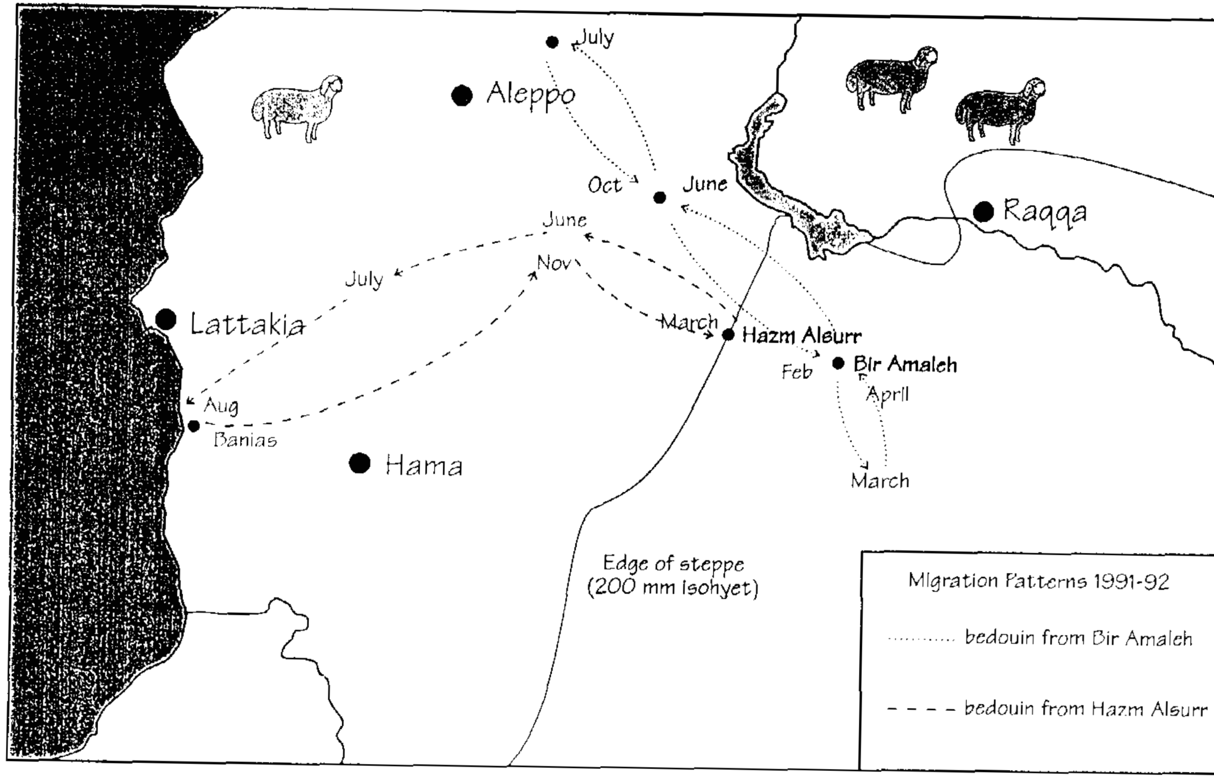


Figure 4.6.1 Migration patterns

rented mountain pasture before arriving at the coast for the summer and autumn period. *Here, the sheep graze irrigated residues from* vegetables, tobacco and peanuts.

Group four: In 1992, farmers in Hazm Alsurr estimated that five percent of the total population remained in Hazm Alsurr the whole year. One sample family was among this five percent. Most of the time the sheep were fed supplements, but also grazed rangeland or, from May to August, standing barley. During later August and early September the sheep grazed government fallow land, before beginning the pattern of rangeland grazing and supplementary feeding again.

4.6.3 Feeding patterns

While the annual pattern of sheep feeding showed some differences between individual farmers (arising partly from different migration patterns), nevertheless a fairly general pattern could be distinguished, and this is sketched in Fig. 4.6.2.

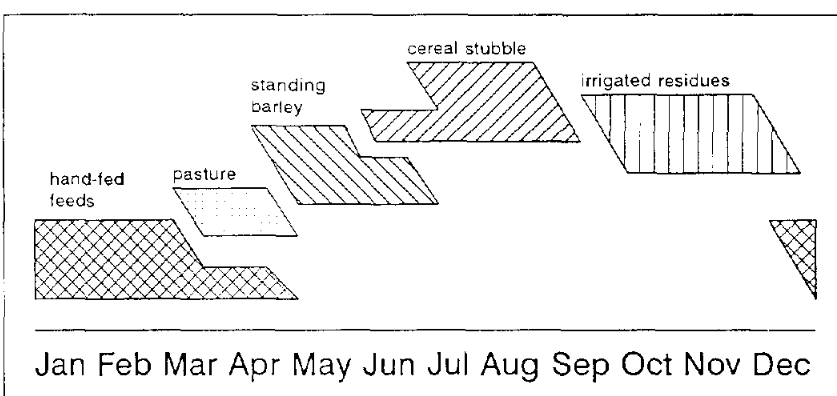


Figure 4.6.2 Annual feed cycle

Winter feeding practices. There have been many changes in winter feeding practices in the past 10 years in the three villages studied, both in the timing and duration of the winter feeding period and in the feeds offered. As already mentioned, rangeland grazing during the winter is now practically non-existent, whereas 10 years ago the Bir Amaleh and Hazm Alsurr flocks were, except in a dry year, kept in the steppe and both grazed and fed supplements. During the winter of 1991/92, despite average to above-average rainfall, seven of the 11 sampled flocks did not graze at all, and three grazed cultivated land. As the past four years have not been climatically favorable for grass growth, it is difficult to say whether rangeland grazing might not return if there were several "wet" years in a row.

The study by Thomson et al. (1989) showed that rangeland grazing 10 years ago was still an important part of the sheep's diet. This was reflected in the differences in the amount of feed offered in Bir Amaleh and Hazm Alsurr compared to Mouhaseneh, where even 10 years ago the sheep did not graze the steppe in winter (Table 4.6.1). Feed offered at Mouhaseneh was double that at the other two locations, except in 1979/80, an exceptionally wet year, which possibly provided additional grazing in Mouhaseneh on fallow land.

Table 4.6.1. Daily feed offered (kg per head)

	78/79	79/80	80/81	Mean 78-81	91/92
Feed (kg, air dry basis)					
- Mouhaseneh	2.1	1.0	2.0	1.6	1.5
- Bir Amaleh	0.6	0.8	0.8	0.8	1.4
- Hazm Alsurr	-	0.9	0.8	0.9	1.7
Mean	**1.3**	**0.9**	**1.2**	**1.1**	**1.6**

Source: Thomson, Bahhady and Martin, 1989, page 45, for the figures 1978-81

In the 1991/92 winter, there was little difference between the three locations in the average amounts of feed offered. However, the figures shown do not mean that the ewes were fed exactly 1.6 kg of feed per day throughout the period of supplementary feeding. In fact, in January 1992, the sheep were receiving on average 1.98 kg per day, almost double that of 10 years ago. Later, when rangeland grazing began, towards the end of March, supplements continued to be offered but in smaller quantities.

Another difference from 10 years ago is the change in the timing of the winter feeding period, due to the increasing amount of irrigated crop (mainly cotton) residues available. Thomson et al. (1989) reported that in the "dry" year of 1978/79 winter feeding started in September and continued for nearly 200 days until June or July (due to poor steppe grazing). In the following two years, 1979/80 and 1980/81, feeding started in October or November and continued for about 150 days until late February or early March.

In the winter of 1991/92, though following a dry year (when it might be expected that winter supplementation would begin earlier), hand-feeding started in December. However, the grass growth in the late winter and early spring of 1992 was disappointing and winter feeding extended into May. So, the number of feeding days remained around 150.

Changes in types of feed offered. Finally, there was a change in the type of feeds offered, due to the escalating prices of supplements. This could have a detrimental effect on sheep nutrition, as farmers try to find ways of feeding their sheep with cheaper materials. The changes over the 10-year period are shown in Table 4.6.2. In 1991/92, on average, four commodities covered three-quarters of the feed offered, straw, wheat bran, sugar beet pulp and dry bread. This is in marked contrast to the situation 10 years previously, when barley grain was the most important feed commodity after straw.

Table 4.6.2. Total winter consumption of different supplemental feeds in 1978-81 (mean) and 1991/92

Components	kg/head winter		Percentages	
	1978-81	1991/92	1978-81	1991/92
Barley grain	42	6	25.1	2.4
Cereal straw	70	91	41.9	36.3
Cottonseed cake	10	4	6.0	1.7
Cottonseed hulls	8	10	4.8	3.9
Cotton seed	5	4	3.0	1.7
Wheat bran	6	59	3.6	23.5
Sugarbeet pulp	18	32	10.8	12.7
Other feed total	8	44	4.8	17.8
Bread *		(26)		(10.6)
Other		(18)		(7.2)
Total consumption	**167**	**250**		

** For the period 1978-81, "other feed" means compounds, wheat grain, bread flour, sorghum grain, lentil straw and bread. 1992 figures have been divided into bread, and other feeds (vetch straw, weeds/grasses and "lundel", a mixture of rubbish from cotton seeds.*
(Source: Thomson et al. 1989, page 88, for 1978-81 figures)

The largest change was the huge reduction in barley grain, from one quarter of the feed offered in 1978-81 to only 2.4% in 1991/92. As 1991 was a dry year, not all farmers harvested their barley but left their sheep to graze the crop in situ. As a result, they had no grain stock for winter feed. This problem occurred during each of the three years, 1989 to 1991, all of which were drier than "normal"; so barley grain has probably not constituted a large part of the sheep's winter diets since 1988. Barley grain, at around 10 SL per kg, was considered too expensive to buy, as other feeds were cheaper.

Nevertheless, the total amount of crude protein and metabolizable energy fed has not actually changed much in the 10-year period (Table 4.6.3). The calculations were based on a total of 250 kg of feed per sheep (the average of what was fed during 1991/92) and the amounts and quality of each commodity, for the periods 1978-81 and 1991/92. Decreases in the amounts of barley grain and cottonseed cake have been compensated by corresponding increases in the use of wheat bran and bread.

Table 4.6.3. Metabolizable energy and crude protein of supplementary feeds offered, and total amount in the feeds offered in 1978-81 and 1991/92

	ME*	CP**	M.E. in total feeds offered		C.P. in total feeds offered	
			1978-81	1991/92	1978-81	1991/92
Barley grain	11.5	110	722	69	6903	660
Cereal straw	5.8	33	608	528	3457	3003
C.S. cake	11.0	380	165	44	5700	1520
C.S. hulls	7.0	50	84	70	600	500
Cotton seed	15.0	230	113	60	1725	920
Wheat bran	10.0	150	90	590	1350	8850
S.B. pulp	10.0	100	270	320	2700	3200
Other ***	(7.8)	(76)	94	440	912	3905
Bread wheat	12.6	120	-	(340)	-	(3240)
Grasses	7.1	100	-	(9)	-	(125)
Vetch straw	4.9	45	-	(7)	-	(68)
Lundel	6.6	37	-	(84)	-	(472)
Total			2146	2121	23347	22558

* *Metabolizable Energy (MJ per kg as fed)*
** *Crude Protein (g per kg as fed)*
*** *The "other feeds" for 1991/92 were individually calculated, while the figures for 1978-81 were calculated using average ME and CP rates for the four feeds in the 1991/92 calculations. It is not known what proportions of other feeds made up the 1978-81 figures.*
Source: 1, Thomson et al. 1989, page 89
2, Arab and Middle East Tables of Feed Composition, 1979

Bread now seems much more important: during the 1991/92 winter it comprised nearly 11% of the feed offered (seven of the 11 farmers fed bread to their sheep), whereas 10 years earlier it has been, at most, 5%. Through government subsidies, bread in towns is priced artificially low and is therefore a relatively cheap source of feed (around five SL/kg).

The proportion of straw fed did not change much, from 42% to 36%, while that from cotton by-products (cottonseed, cottonseed cake and cottonseed hulls) seems to have decreased from 14% in 1978-81 to just over 7% in 1991/92. However, lundel is also a by-product of cotton and formed 5% of the total feed offered in 1991/92. It is a cheap feed, costing only 2.75 SL/kg. In fact, the amount of metabolizable energy coming from cotton by-products in many Aleppo and Raqqa Province-based flocks has markedly increased in recent years, due to the increasing use of irrigated cotton crop residues for autumn grazing.

While the winter feeds offered to sheep in 1991/92 did not differ much in their contents of metabolizable energy and crude protein from those of 1978-81, the reduction in natural grazing that has occurred could be having a detrimental effect on the vitamin and mineral content of the sheeps' diet.

Cost of supplementary feeding. The cost of supplementary feeding increased by around 1000% between 1978-81 and 1991/92, from around 130 SL to 1350 SL* for 250 kg of similar feed. However, using the average prices paid by the studied farmers for each commodity during the 1991/92 winter season, and calculating the cost on a proportionate basis for each commodity fed in 1978-81 and 1991/92, it would appear that farmers are spending nearly 350 SL less per sheep than the 1350 SL calculated. They are feeding their sheep as cheaply as possible. The average amount spent per sheep over the 1991/92 winter was 6.3 SL (SD 1.7) per day. The minimum was 4.2 and the maximum 10.4 SL/day. The total over the winter averaged 1007 SL per sheep, with a minimum cost of 657 SL per sheep.

Barley grazing. In May, the farmers start to anticipate their harvest yields. If expectations are low, they may decide to graze

---

* Calculated from figures given in Thomson <u>et al.</u> (1989), pp. 88 and 91.

the barley in situ. Other factors are taken into consideration besides the anticipated harvest; it also depends on how much the farmers have invested in cultivation -- some have sharecropping arrangements, by which their partners finance the cultivation. Once the sheep began grazing barley in May 1992, milk production increased markedly; this factor also has a bearing on the grazing decision. Only one of the sampled farmers harvested all his barley in 1992. The other 10 each grazed at least part of their crop. In two cases no crop was harvested at all, and the whole planted area was grazed. The average percentage of land harvested was 42.2%, leaving an average of 29.5 ha (or 57.8%) to be grazed in situ (Table 4.6.4).

Table 4.6.4. Barley yields 1992

	Land planted (in ha)	Land harvested (in ha)	Percentage harvested	Yield (kg/ha)	
				Grain	Straw
Mean	45.7	16.2	42.2	251	223

The number of sheep grazing the standing barley differed from sample to sample, as did the number of grazing days. Of the nine farmers using their barley for grazing, plus three other observations of land rented by three of those farmers, the average stocking rate was 237 sheep-days/ha (SD 74.8)*. However, rates ranged from 110 to 360 sheep-days/ha.

For the farmer who rents standing barley, there are obvious economic advantages: with an average stocking rate of 237 sheep-days/ha and an average rent of 514 SL/ha, it costs 2.17 SL/day to feed each sheep. However, the rent charged for unharvested barley

---

* Calculated as follows: $\frac{\text{no. of sheep x no. of days land grazed}}{\text{no. of hectares}}$

does not cover the costs of cultivation, which averaged, for the 11 farmers in the sample, 1265 SL/ha (i.e. cost of seed and cultivation). Even with the highest rent paid, 1000 SL/ha, there was still a monetary loss. Farmers grazing their own land had paid the cost of cultivation, so their "cost" of grazing was higher -- for the average cultivation cost and the average stocking rate, it was 5.3 SL/day.

Irrigated crop residues. Two main types of irrigated crop residues are used by the farmers studied: cotton, wheat and maize crops in Aleppo and Raqqa Provinces, and vegetable and other crop residues on the Mediterranean Coast. The grazing of irrigated crop residues on a large scale has started only in the last six years, as the amount of grazing in the drier areas has decreased and the amount of land under irrigation has increased.* During 1991-92, eight of the 11 farmers used irrigated land for part of the year.

Cotton, wheat and maize. *In October and November* 1991, and part of December, all four farmers from Bir Amaleh were renting irrigated land in Aleppo and Raqqa Provinces. Two were grazing cotton residues at a cost of 6000 SL/ha, and two maize residues at 2500 SL/ha.

Although the cost of grazing cotton residues appears high, it represents between five to six SL/day/sheep, a price which contrasts favorably with that of handfeeding; and no transport of water is necessary. The farmers maintain that cotton residues, grazed during the final stages of gestation, are better for the sheep than the supplements previously handfed at this time.

Mediterranean coast. All the flocks in group two grazed similar types of land at the coast. The land here is parcelled in small

---

* The Syrian Government is working on an irrigation project using water from the Euphrates River, which is planned eventually to develop 320,000 ha in the region around Aleppo.

blocks of one and two donums, and the farmers moving to the coast must negotiate for each donum of grazing land. The cost varied between 50 and 250 SL/donum (500 and 2500 SL/ha), and the principal residues were from tomatoes, peppers, eggplant and squash. Tobacco residues were also rented, and in October 1992 peanut crop residues were collected to be fed to the sheep. The farmers did not pay for the peanut residues, but the women harvested the crop for the land owner in return for the use of the residues.

A donum of vegetable residues feeds 100 to 200 sheep for one day, although all three farmers in the present sample supplemented their flocks' diets with small amounts (0.25-0.50 kg/sheep) of handfed feed, usually bread and bran, each day as well.

4.6.4 Discussion and conclusions

The eleven farmers in the survey fall into two basic categories: those who have become more sedentary, and those who have become more nomadic. Farmers in groups one and four are more sedentary than in the past, although group four may revert to a more nomadic existence in the future in order to survive. The more sedentary farmers are generally those with smaller herds of sheep and who live in villages further from the present area of rangéland (i.e. Mouhaseneh in this sample: all three farmers are now sedentary).

Other farmers have become more nomadic, from the necessity of finding cheaper feed for their flocks. Handfed feeds comprise the largest portion of annual costs, and so, to minimize their use, farmers seek alternative grazing. There is little rangeland available: none of the farmers in the sample relied totally on rangeland grazing at any time during the 1991/92 season, and all the farmers expressed concern at the reduction of vegetative cover. Natural rangeland grazing now contributes very little to the annual metabolizable energy and protein requirements of flocks.

Alternative forms of feed are becoming more common: irrigated crop residues and bread and potatoes, which are cheaper than traditional materials. Irrigated land is now being used for grazing for two or three or even up to six months per year in some cases. Grazing irrigated crop residues coincides with the later stages of pregnancy, which could have a bearing on birth rates, growth rates in lambs and in lactation levels.

The very small contribution from rangeland grazing towards flock requirements makes it difficult to maintain that these flocks are "steppe-based", particularly as they spend so little time at their home bases. Farmers in group three (Hazm Alsurr) have, over the past four years, remained out of the steppe area during the winter months. All four farmers from group two (Bir Amaleh) remained out of their village during the first part of winter. There was little to graze near their villages except unharvested barley or stubble. In fact, during the past four years they have returned to Bir Amaleh only because that is where they plant their crops.

All the farmers studied wish to continue planting barley. They maintain that it is the only way they can be sure of having something for their sheep to graze. Certainly the situation in spring 1992 gave some support to their view: cultivated fields stood green next to fallow or rangeland, which had little or no growth at all, even where it had not been grazed.

The farmers are receptive to new ideas and want to improve the land's capacity for growth. However, they are convinced that barley is the best crop for them and would not welcome any schemes that would prevent them planting it. Grain yields in the 1988 season of up to 2 t/ha prove to them that their decision to plant is correct.

But there are other possibilities; for example, research at ICARDA is examining the possible benefits of cropping <u>Atriplex</u> spp. in association with barley (Jones 1992). The atriplex bushes would act as wind breaks for the land devoted to barley, as well as providing fodder for sheep (and small amounts of firewood). Reaction amongst the sampled farmers to this proposal was mixed. At Hazm Alsurr they were receptive and might be willing to adopt it, if they were shown (perhaps by visiting trial sites) that it was feasible. At Bir Amaleh the reaction was negative, as farmers there maintained that their soil was not suitable for atriplex. These two reactions show the necessity of working directly with farmers when designing any improvements to their production cycles.

This report was not intended to cover social organization, but a brief mention is relevant here. Since Syria's agrarian reform in 1958, a number of government attempts have been made to cut up and redistribute steppe land to pre-determined groups, for example in cooperatives. The use of a "hema" system was advocated, whereby land would be put aside and protected for use in dry years. But these measures interrupted the bedouin's own system of land distribution, which appears to have taken place in 1955. The farmers from both Hazm Alsurr and Bir Amaleh say that the land was divided among the steppe-based tribes in 1954/55, and the land within each tribe was then allocated to sub-divisions and house groups. In Hazm Alsurr, land was divided at half-way points between private wells, while in Bir Amaleh long strips of equal width were parcelled out (some strips being shorter than others). The farmers still consider these divisions as valid; and while steppe rangeland is, in theory (according to the government), open access, the bedouin maintain that tribal rights still exist and are adhered to. Nothing can be achieved in the steppe unless these tribal land laws are taken into consideration. *Marina Leybourne, with technical assistance from Jihad Shehadeh.*

References

Bahhady, F.A. 1981. "Recent changes in Bedouin systems of livestock production in the Syrian steppe", The Future of Pastoral Peoples, Proceedings of Nairobi Conference, Kenya, IDRC-175e, pp.258-66.

Chatty, D. 1974. From Camel to Truck: A study of the pastoral economy of the Al-Fadl and the Al-Hassanna in the Bekaa Valley of Lebanon, Doctoral dissertation, University of

California.

Jaubert, R. and Oglah, M. 1985. Farming Systems Management in the Bueda/Breda Subarea, FSP ICARDA.

Jaubert, R. 1991. "Transformations et extension des systemes de cultures au detriment des steppes: la destruction des steppes syriennes", paper presented at the conference "Devenir des Steppes d'Arabie et du Bilad Ach-Cham", held at the Arab World Institute, Paris, 10-13 April.

Jaubert, R. and Oglah, M. 1987. "Supplementary Feeding of Awassi Ewes in the Barley Zone of North-West Syria", International conference on animal production in arid zones (ICARDA), Proceedings of a conference held at Damascus, Syria, 7-12 September 1985, Damascus, pp. 736-747.

Jones, M.J. 1991. "Agronomic research and strategies for the improvement of the cultivated zone", Colloque international, "Devenir des Steppes d'Arabie et du Bilad Ach-Cham", held at the Arab World Institute, Paris, 10-13 April.

Jones, M.J. 1992. "Potential of Atriplex hedges for wind erosion control", Farm Resource Management Program Annual Report for 1991, ICARDA, pp.57-60.

Keaal, L.C., Farid, M.F.A., Harris, L.E., Warden, M.F. and Lloyd, H. 1979. Arab and Middle East Tables of Feed Composition, International Feedstuffs Institute, Utah State University, and ACSAD.

Lewis, N. 1987. Nomads and Settlers in Syria and Jordan 1800-1980, Cambridge University Press.

Masri, A. 1991. The tradition of Hema as a land tenure institution in arid land management, the Syrian Arab Republic, FAO, Rome.

Thomson, E.F. 1987. Feeding Systems and Sheep Husbandry in the Barley Belt of Syria, ICARDA.

Thomson, E.F., Bahhady, F. and Martin, A. 1989. Sheep Husbandry at the Cultivated Margin of the North-West Syrian Steppe, ICARDA.

Thomson, E.F. and Bahhady, F. 1983. Aspects of Sheep Husbandry Systems in Aleppo Province of Northwest Syria, FSP ICARDA.

Treacher, T. 1991. "Linkages between steppe and cultivated areas through livestock systems - implications for research and development to establish more productive and stable systems"

Colloque international, "Devenir des Steppes d'Arabie et du Bilad Ach-Cham", held at the Arab World Institute, Paris, 10-13 April.

4.7 Wheat Production Systems in Lebanon: A Rapid Appraisal

4.7.1 Introduction

Following recent improvements in the socio-political and security conditions in Lebanon, an urgent need to enhance agricultural development has been expressed by national (governmental and private) institutions and by regional and international organizations. Two development objectives of particular importance are: (1) to improve the production of basic food commodities of cereals and legumes (which currently contribute 13% and 48% of the total domestic needs, respectively); and (2) to develop an economically sound alternative to replace illicit crops, the area of which expanded during the civil war period.

Collaborative activities to enhance research and technology transfer for cereal and legume improvement have been initiated recently by the Faculty of Agriculture and Food Science (FAFS) of the American University of Beirut (AUB), the Agricultural Research Institute (ARI) of Lebanon, and ICARDA. However, it was realized that according to the farming systems approach, before setting out plans for improvement, diagnostic research is required to (i) characterize current wheat production systems (legumes can be included later on) and identify major technical, biological and socio-economic constraints to improved production; (ii) give guidance to the design and implementation of experimental research and technology transfer activities; and (iii) predict the potential for improvement. The diagnostic research has two complementary components: rapid appraisal and farm survey. This report presents and discusses some basic findings of the rapid appraisal of wheat production systems conducted around the end of 1992.

4.7.2 Methodology

Rapid appraisal is a useful approach for (i) obtaining insights into the farming system, (ii) identifying, in a preliminary way, major constraints, especially those of a physical, biological and institutional nature, (iii) providing an initial assessment of the potential for improvement, and (iv) guiding the planning, design, and implementation of any subsequent farm survey required for more quantification and in-depth analysis.

Such an appraisal is usually conducted by a multi-disciplinary research team. Techniques and activities used are (i) secondary data collection and analysis, (ii) visual observations through field tours, and (iii) informal (reconnaissance, or cursory) interviews of groups (or individuals) of farmers, researchers, government officials, agricultural commodity dealers.

Secondary data sources used in the present appraisal are listed in the references. Hamze (1992) was an extremely helpful source of background information on Lebanese agriculture; and good insights into aspects of wheat production systems were gained from the manager and technical staff of the ICARDA research station at Terbol and from Dr M. Abi Antoun (ARI, Tel Amara). Field tours and farmer interviews in the cursory survey were conducted at different locations in the Bekaa valley, where 80% of Lebanon's wheat is produced.

4.7.3 Cereals in the Lebanese agriculture

The importance of cereals in Lebanon's agriculture has declined drastically during the last few decades (Table 4.7.1). It was declining even before the civil war, from an area of 91,700 ha in 1964 to 60,030 in 1973, then down to 41,000 ha in 1990 (63% wheat, 27% barley, 5% maize, 5% others). The area lost to cereals (51,700 ha) has gone mainly to vegetable production (24,000 ha increase, of which 10,000 ha were allotted to potatoes alone). Fruit trees increased by about 10,000 ha, legumes by 1,400 ha, and 17,000 ha were used for illicit crops and (or) went out of production.

Table 4.7.1. Changes in crop areas in Lebanon since 1964

	1964		1973		1990	
Crop category	ha	%	ha	%	ha	%
Cereals	91700	39.7	60036	27.1	41000	19.7
Legumes	12680	5.5	14007	6.3	14000	6.7
Industrial crops	11800	5.1	20150	9.1	11000	5.3
Vegetables	28815	12.5	30564	13.7	46000	22.2
Tree crops	86179	37.2	96888	43.8	96000	46.1
Total	231174	100.0	221645	100.0	208000	100.0

Source: compiled from LSA (1973) and FAO (1990)

Lebanon's total output of cereal crops, previously around 83,000 t, decreased to 76,000 t in 1990, whereas the output of other agricultural products has increased. However, it should be noted that the decline in cereal area has been compensated for, to a great extent, by yield improvement. Wheat yield, for example, has increased from 0.9 t/ha in 1964 to 1.1 t/ha in 1973 and to about 2.0 t/ha in 1990. Corresponding figures for barley are 1.0, 0.9, and 1.65 t/ha, respectively. And further improvements in yields are still possible.

In spite of the reduction in area, cereal production is still considered, by many farming communities of Lebanon, as one of the major components of the cropping system. It is also expected that cereals (and legumes, representing now only 7% of total area in crop production) will assume greater importance in the near future. Farmers are facing marketing problems with vegetable and fruit exports, and many are considering a reallocation of crop land. The increased power of the central government, and the consequent improvement in security conditions, means that illicit crop production has been (and will be) diminished considerably. In addition, there is much fallow land (about 175,000 ha, according to LSA 1973). Fallowing can be eliminated or reduced to a minimum, providing for a much increased area in annual crop production. Furthermore, there is the potential for 300,000-400,000 ha (Hamze 1992) of currently unused land to be reclaimed for crop production.

4.7.4 Wheat in the farming systems

Wheat is still important in the cropping systems of many areas (rainfall: 250-550 mm) especially in the Bekaa valley where 80% of Lebanon's wheat is produced. In drier areas where horticulture is not (or barely) practised, the contribution of wheat to total farm income may be 40-90%. This could not be precisely assessed by the rapid appraisal; the ongoing farm survey will provide the necessary data.

Bread wheat is the single crop that can be marketed through governmental agencies. Despite the government intention to protect the producers through price subsidy policies, the pricing mechanism does not respond adequately to the very rapid devaluation of the local currency. Therefore, wheat producers, in Lebanon, face unfavorable prices compared with most developing countries. The support price for 1991, for example, was one-third less than the price of imported wheat, US$ 110 and 175/ton, respectively. Poor national agricultural policies during the last fifteen years seems to be one of the major factors behind wheat production stagnation.

Wheat is normally sown around mid-November after removing the residues of the preceding crop (most usually potatoes). Wheat plots are given two or three ploughings in late October-mid November. These ploughings are mostly done with a five-bladed moldboard plough, although on some soils rotovators may be used for the first cultivation, and chisel or ducksfoot cultivators for the second. Around mid-November, seeds are broadcast at a rate of 150-200 kg/ha, but this can be reduced to 120-140 kg on soils of good quality. Most sowing is done with mechanical spinners (broadcasters), but hand broadcasting is practised on hilly and/or stony soils. After sowing, seeds are covered using the chisel or ducksfoot cultivator. Improved (white and brown) Mexican varieties are common, but local varieties (Haurani, Salamouni, and Aersali) are also grown. Varieties released by ICARDA, such as the Chams and Sibou, have been introduced and adopted in the last few years; but the scope and extent of adoption could not be evaluated by this rapid appraisal. It will be assessed by the survey.

At sowing, farmers may apply single superphosphate (18% P_2O_5) at a rate of about 500 kg/ha (i.e. 90 kg/ha P_2O_5). In most cases, no nitrogen is given at sowing time; but at tillering, ammonium nitrate (33% N) is topdressed at a rate of 150 kg/ha (50 kg/ha of N) for rainfed plots, and 500 kg/ha (165 kg/ha N) for supplementally irrigated wheat.

Hand weeding is limited to small areas of severe weed incidence. However, farmers may give one application of herbicide (mostly 2,4-D) in early spring (mid February-mid March).

Where water for supplemental irrigation is available, farmers may give one heavy, or two light, irrigations, mostly late in the season (April-May). Sprinkler systems are common, although many farmers believe that surface, or gravity, irrigation is more appropriate for wheat as sprinkler irrigation may cause lodging and smut disease problems. Both surface and groundwater resources are available for irrigation, but the latter is the main source for irrigating wheat. Rough estimates indicate that in Bekaa groundwater is used on about 80% of the supplemental irrigation areas. Groundwater conditions are generally good in terms of quality and quantity, with no indications of salinization or lowering and depletion of aquifers. Groundwater can be available even for farmers who do not have wells by purchase from neighbours. Such a purchase, when needed, is economically sound. While it may cost about US$ 150-200, grain and straw yield might be doubled as a result, creating an extra revenue of about US$ 950.

Suni bug (Eurigaster integriseps) is the one insect that may cause serious crop damage in some areas in some years (according to the few farmers met in the cursory survey). No control measures are practised because individual control measures are not effective, and collective control of all fields is required.

Smut and rust are wheat diseases of economic importance in Lebanon. Al Rahaob or the covered bunt smut (Tilletia foatida) is considered, by farmers, as the most serious of wheat diseases. In some wheat producing regions, it is considered the major constraint to yield improvement. Loose smut (Ustilago tritici) and -- to a lesser extent -- flag smut (Urocystis agropyri) are smut species reported in Lebanon (Mamlouk, Pers. Comm.). Some farmers control these diseases by copper sulphate seed-dressing. Leaf rust (Puccinia recondita), stem rust (Puccinia graminis) and strip rust (Puccinia striiformis) are also observed. Wheat diseases of minor importance are powdery mildew, foot rot, leaf spot, leaf blotch, and node blotch (Khatib et al. 1970; Saad and Niehaus 1969).

Major crop rotations practised in wheat producing regions of Lebanon are:

- Potatoes/wheat
- Potatoes/wheat/other crop (legumes or industrial)
- Potatoes and(or) other vegetables/wheat/fallow
- Legumes/wheat/fallow or wheat/legume/fallow
- Wheat/fallow; and wheat/wheat

Wheat is harvested from mid June to mid July, mostly mechanically; and no problems concerning machine availability were reported. However, on small and/or hilly plots, hand harvesting of wheat may be common. Mechanical harvesting cost, in 1992, was about 50,000 LL/ha (25$/ha) which can be recovered from leasing crop residues for grazing. Manual harvesting is much more expensive (200,000 LL or 100$/ha), but straw sales compensate for the extra cost.

In areas with about 400 mm rainfall, rainfed wheat yield is 1.2-2.5 t/ha of grain with equal amounts of straw. In areas of higher rainfall, yield rises to 2.5-3.5 t/ha of both grain and straw. However, in years of good rainfall distribution, the upper limits of those yield ranges may be increased by about 1.0 t/ha. Average yields of wheat with supplemental irrigation are normally about 5.0 t/ha for both grain and straw, with a range of 3.0-6.0 t/ha. Economically, straw is as important as grain in terms of prices and revenues. In 1992, the price of straw was almost equal to that of grain.

Most of the output (both grain and straw) from medium to large sized landholdings is sold, preferably, in the case of grain, to government agencies because of the price subsidy. On such farms, a small proportion of the grain output might be kept for next season's sowing and for home consumption. However, on small farms the total output of grain and straw may be used on-farm. There are no difficulties in marketing wheat products and by-products. The only marketing problem faced by farmers now is that related to inflation. The government price of grain announced early in, or in the middle of, the season does not respond adequately to the extremely rapid changes in the exchange rate of the local currency.

4.7.5 Economics of crop production

Rough estimates of crop production economics showed that wheat production is a good farming enterprise but not the best. In 1991, returns from wheat were 400,000 LL/ha (exchange rate was about 1 US$ = 1000 LL) compared with 1,500,000 LL/ha for citrus crops, 2,000,000 LL/ha for potatoes, 5,000,000 LL/ha for banana, and only 100,000 LL/ha for tobacco. These huge differences in returns have rearranged farmers' crop priorities. More areas have been allotted to potatoes and fruit trees at the expense of other crops, especially wheat. Market forces have pushed many farmers to change their cropping systems even though the changes, in many cases, might not fit the potential of the soil and the experience of the farmer. However, due to recent marketing difficulties (export and prices), the trend is now expected to reverse, with perhaps more emphasis given to cereals (particularly wheat) and to legumes (particularly lentils and chickpeas).

4.7.6 Conclusions

In spite of the importance of wheat as the basic food staple, the crop area has declined by more than 60% over the last two or three decades. Although the decline in total output was much slower, due to yield improvements, Lebanon still has to import over 80% of its wheat requirements.

The relatively low position of wheat in the list of profitable crops, exacerbated by the collapse of governmental and private institutions concerned with agricultural research, technology transfer and development during the civil war, has been the major factor behind the stagnation of wheat production. Erratic rainfall, a poor supply of good quality seed, diseases and pests, timely applications of nitrogen, pricing mechanisms, absence of easily accessed credits, and small land holdings are other yield constraints so far identified.

However, a good potential for wheat production improvement has been identified as well. This is based on (i) the importance of wheat in Lebanon's rainfed agricultural systems, especially in the 250-500 mm rainfall zone; (ii) the recent trend of improving economic conditions for wheat production relative to other crops; (iii) the predicted shift of land out of fruit and vegetable production because of increasing marketing difficulties; (iv) the elimination of illicit crops; (v) a reduction in fallowing; (vi) the ploughing of new lands; (vii) a government intention to increase the country's self-sufficiency ratio of wheat; and (viii) the intention recently expressed, and efforts exerted by national (governmental and private), regional and international institutions, to reactivate and enhance agricultural research and technology transfer endeavors. *Abdul Bari Salkini and Haytham Zaiter (AUB).*

References

FAO, 1989. Production Year Book, FAO, Rome, Italy.

FAO, 1990. Production Year Book, FAO, Rome, Italy.

Hamze, M. 1992. Agriculture in Lebanon: Present situation and Future Horizons. FAO/Lebanese University Training Course on "Agricultural Extension in Lebanon: Present and Future Horizons", 1-5 June 1992 (in Arabic).

Khatib, H., Davet, P. and Sardy, G. 1970. List des Maladies des Plants au Liban. Inst. Rec. Agron. Lab. de Phytopathologie, Fanar, Lebanon, 41 pp.

LSA, 1973. The Lebanese Statistical Abstract. Directorate of Central Statistics, Ministry of Public Design, Beirut, Lebanon.

Mamlouk (Pers. Comm.). Personal communications with Dr Omar Mamlouk, Cereals Pathologist, ICARDA.

Saad, A.T. and F. Neihans, 1969. Plant Diseases in Lebanon. Journal No. 271, Faculty of Agricultural Sciences, American University of Beirut.

5. TRAINING AND AGROTECHNOLOGY TRANSFER

During 1991/92 season, FRMP conducted several training activities which could be summarized as follows:

5.1 Headquarters Training Courses

5.1.1 Short-term group training

Computer Application in Agricultural Research: Ten participants from different organizations in Syria attended this course which was conducted in collaboration with CBSU of ICARDA during the period 13 - 30 January 1992.

Supplemental Irrigation Technology: The course was attended by eight participants from the Agricultural Extension Directorate (AED) and the Directorate of Irrigation and Water Use (DIWU) in Syria. It was conducted during the period 17 May to 4 June 1992.

5.1.2. Individual non-degree training

Participant	Country	Subject	Duration
Seoud Al Habsi	Oman	Soil and plant analysis	3 weeks
Abdul Rahman Gharkan	Syria	Neutron probe usage	2 weeks
Ghiath Khalil Tibi	Syria	Economic analysis for cultivation and rotation trials	2 weeks
Mazen Fouad H. Naji	Syria	Economic analysis for cultivation and rotation trials	2 weeks
Gergos Al Baho	Syria	Harvesting methods	2 weeks
Salman Antar	Syria	Harvesting methods	2 weeks
Mohamed Rahmoun	Syria	Economic analysis for on-farm trials	3 weeks
M. Fawaz Al-Mourabet	Syria	Economic analysis for on-farm trials	3 weeks
Safa Al Masri (Ms)	Syria	Soil and plant analysis	2 weeks
Sawsan Homsi (Ms)	Syria	Soil and plant analysis	2 weeks
Zahra Dowaje (Ms)	Syria	Mineral N determination and evaluation	1 week
Fayez Al-Sawaf	Syria	Data entry and analysis of farm surveys	2 months
Jihad Abderrazak	Syria	Data entry and analysis of farm surveys	2 months
Ahmet Ahmet Bayanar	Turkey	Data entry and statistical statistical analysis	2 weeks

5.1.3. Individual degree training

Name	Country	Degr.	University	Topic
Mehiar Ali Shahin	Syria	MSc	Aleppo	Organic matter in soils (Crop rotations)
Ahmed H. Yousef	Jordan	MSc	Amman	Water balance of crop rotations under different tillage/residue practices
Mohamed M. Khalaf	Jordan	MSc	Amman	Nitrogen fertilizer management of crop rotations under different tillage/residue practices
Amer S. Jabarin	Jordan	PhD	Jordan	Impact of technology on the production of selected field crops
M. Leybourne (Ms)	Canada	PhD	Geneva	Socio-economics/Bedouin
Theo Mahner	Germany	MSc	Gottingen	Soil evaporation
Zouheir Masri	Syria	PhD	Dokuchaev/ Russia	Soil physical status of rotations

5.2 Sub-Regional and In-Country Training Courses

Winter Chickpea Technology Transfer: This was a sub-regional course conducted jointly by LP and FRMP in cooperation with ITGC, Algeria. It was held in Sidi Bel Abbes, Algeria, during the period 17 - 20 May 1992, and attended by 23 participants from Algeria (14), Libya (3), Morocco (3), and Tunisia (3).

Techniques for Technology Transfer: ICARDA office in Amman, with major FRMP input, conducted this course as part of the Mashreq project. It was held in Amman, Jordan, during the period 24 May to 4 June 1992, and attended by 12 participants from Iraq (4), Jordan (4), and Syria (4). The course was jointly sponsored by UNDP, AFESD, and ICARDA.

Lentil and Chickpea Production Technology: This was an in-country course conducted jointly by LP and FRMP in cooperation with CRIFC, Turkey. It was held in Ankara, Turkey, during the period 29 June to 1 July 1992, and attended by 18 participants from different organizations in Turkey.

Water Harvesting Concepts and Techniques for the Arid and Semi-arid Regions: This was a sub-regional course conducted in collaboration with the University of Jordan. It was held in Amman, Jordan, during the period 16 - 27 August 1992, and attended by 12 participants from Jordan (5), Iraq (3), Oman (1), and Syria (3).

Regionalization of Climatic Data for Applications in Agroclimatology: This was the second in a series of in-country training courses held in Morocco in collaboration with INRA and DMN, Morocco, and with financial support from IDRC, Canada. It was held in Settat from 9 to 13 November 1992, and attended by 12 participants from various organizations in Morocco.

5.3 Miscellaneous Activities

As in previous seasons, FRMP scientists contributed to other programs' training courses through lectures and practicals on approaches to resource management research. A number of researchers and students visited the program for varying periods of time to work on collaborative research projects or to get themselves acquainted with the program's activities.

LIST OF STAFF

Michael Jones	Program Leader, Barley based systems agronomist
Hazel Harris	Soil water conservation scientist
Abdallah Matar[1]	Consultant - Soil chemist
Mustafa Pala	Wheat based systems agronomist
Richard Tutwiler	Anthropologist
John Ryan[3]	Soil fertility specialist
Peter Smith[3]	Visiting senior economist
Graham Walker	Agroclimatologist
Theib Oweis	Water management specialist
Abelardo Rodriguez[3]	Agricultural economist
Wolfgang Goebel	Post Doc Fellow/Agroclimatologist
Karel Bernhard Timmerman	Post Doc Fellow/Wind erosion
Elizabeth Bailey[2]	Visiting Scientist/Agricultural Economist
Akhtar Beg[3]	Visiting Oilcrops Agronomist
Ahmed Mazid	Agricultural economist
Abdul Bari Salkini	Agricultural economist
Maurice Saade[4]	Rockefeller Post-doc/Agricultural Economist
Sobhi Dozom	Research Associate I
Mahmoud Oglah	Research Associate I
Afif Dakermanji	Training Assistant
Sonia Garabet	Research Assistant II
Rafik Makboul	Research Assistant II
Layth el Mahdi	Research Assistant II
Zuhair Arous	Research Assistant II
Atef Haddad	Research Assistant II
Haitham Halimeh	Research Assistant II
Nerses Chapanian	Research Assistant II
Mohamed Salem	Research Assistant II
Ghalia Martini	Research Assistant II
HAssan Jokhadar	Research Assistant II
Mohamed Samir Masri	Research Assistant II
Shahba Morali	Research Assistant II
Hisham Salahieh	Research Assistant II
Mohamed Tahhan[1]	Research Assistant II
Pierre Hayek	Research Assistant I
Sabih el Dehni	Research Assistant I
Malika Abdul Ali	Research Assistant I
Mohamed Aziz Kassem	Senior Research Technician
Samir Barbar	Senior Research Technician
Ahmed Nael Hamwieh	Research Technician II
Mohamed Lababidi	Research Technician II
Issam Halimeh	Research Technician II
Dolly Mousalli	Research Technician II
Mohamed Zeki	Research Technician II
George Estephan	Research Technician II
Nabil Musattat	Research Technician II
Shereen Baddour	Research Technician II
Ghassan Kanjo	Research Technician I
Ralla el Naeb	Research Technician I

Elianor Nasseh	Research Technician I
Ali Haj Dibo	Research Technician I
Ghazi Yassin	Research Technician I
Jihad Abdullah	Assistant Research Technician
Abdul Baset Khatib	Assistant Research Technician
Hayel el Shaker	Assistant Research Technician
Mohamed Elewi Karram	Assistant Research Technician
Marica Boyagi	Senior secretary
Zuka Istanbouli	Secretary II

---

1. Left in 1992
2. Moved as a Staff Member of the International Cooperation
3. *Joined in* 1992
4. Joined end of 1991, Tunis Office

المركز الدولي للبحوث الزراعية في المناطق الجافة
إيكاردا
ص. ب. 5466 حلب ، سورية

INTERNATIONAL CENTER FOR AGRICULTURAL RESEARCH IN THE DRY AREAS
Box 5466, Aleppo, Syria

ICARDA-058/1000/Aug 1993