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FARMING SYSTEMS PROGRAM

Annual Report for 1986

ICARDA

FARMING SYSTEMS PROGRAM

ANNUAL REPORT 1986

The International Center for Agricultural
Research in the Dry Areas

Aleppo, Syria

FARMING SYSTEMS PROGRAM
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TABLE OF CONTENTS

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1. INTRODUCTION

1.1 FSP AFTER 10 YEARS AND THE FUTURE

During the ten years since ICARDA's inception, the Farming Systems Program has both developed and matured. We have endeavoured to establish a solid reputation as a program which is focussed on issues of direct relevance to the farming systems of West Asia and North Africa, and we are encouraged in this belief by our increasing links with National Programs and Institutes outside our region.

Over the years, a large proportion of our core research activity has focused on the farming systems in northern Syria, a natural and necessary step which allowed the program to gain experience and develop a methodology of farming systems research applicable to the environment in which we work. Soil, water and plant nutrients are vital, but highly variable resources in the region, and in this respect we have attached high priority to research associated with soil management and improving the water and nutrient use efficiency of crop production. In addition, we have paid proper attention to the important role of livestock in the farming systems and its interaction with crop production (Cooper, Gregory, Tully and Harris 1986). Throughout, we have conducted farm and village surveys to help guide ICARDA's research direction, and on-farm testing of potential improvements has kept our program's research focussed on farmers problems and needs. Much of this work in N. Syria has been of an applied nature, and its success is evident through the strong cooperative programs of research which we have developed with the Syrian Ministry of Agriculture and Agrarian Reform.

During the last year, the program, recognizing its success in our host country, has been developing a framework of operation which will allow a logical expansion of our work to other countries and guide the direction of our core research activities into the future. Such a framework must, of course, retain some flexibility, but is based on the following philosophy. The program will seek to develop, upon request and in collaboration with National Programs, special projects working in defined farming systems of the region.

As the network of these specially funded projects develops, the level of applied farming systems research conducted by the core program itself will decrease, and greater emphasis will be placed on research of an upstream nature and interaction with the regional projects. The interaction between core staff and staff working in the regional projects will help ensure two things: firstly, the relevance of such upstream research to applied problems will be maintained, and secondly that its findings are rapidly transmitted and utilized within the region.

Within the last year we have begun putting this philosophy into practice, and in the first instance have focussed on the establishment of special projects in the barley/livestock systems (BLS) of the region. In summary, BLS are those in which livestock (principally sheep) are the main source of income for farmers, and barley is the predominant crop grown and is almost entirely utilized as animal feed. We have chosen these systems for several reasons:

a) BLS are widespread, but occur in the driest and harshest environments and in resource terms contain some of the region's poorest farmers. Generation of rural income in such areas is a high priority.

b) The systems are fragile and show evidence of a degraded and declining resource base.

c) Increased urbanization has led to greater demand for livestock products and sheep feed resources are often chronically deficient. Nevertheless, both the problems and potential of these systems are poorly understood, and they do not always receive high priority in the allocation of research and development funds by National Programs.

d) ICARDA has the CGIAR global mandate for barley and over the last ten years, FSP and ICARDA as a whole, has attached high priority to these systems and has developed considerable experience and expertise of direct relevance.

To date, we have developed the following projects.

1) The Barley/Livestock Systems of N. Syria

Our cooperative work with the Soils Directorate is now largely funded by the Near East Foundation with three staff (one postdoctoral scientist and two research assistants) assigned full time to the maintenance and further development of this cooperative research. The funding also allows the purchase of vehicles and equipment specifically for this work.

2) The Barley/Livestock Systems of NW Egypt

At the request of the Egyptian Government, and with special funding from Ford Foundation, we are initiating survey work in the project area to describe current farming practices and identify research goals and objectives for future project activities. This survey work will be done by two Egyptian Postdoctoral staff (one economist and one agronomist). If, as a result of this survey work, we are successful in formulating a project, we have already succeeded in identifying a potential donor agency which is keen to fund any subsequent project.

3) The Barley/Livestock Systems of SE Turkey

During 1985 and 1986, we have been cooperating with the University of Cukurova, with special funding from Ford Foundation, in conducting survey work in the project area.

This is currently being analysed and in the coming year we will try to establish additional cooperative links with the South East Anatolian Research Institute to implement cooperative research in the project area based on previous research in the project area and the findings of the survey.

In the coming year we hope to expand this network of BLS projects to other countries in collaboration with other ICARDA programs.

In the higher rainfall areas however, we recognize contrasting farming systems where wheat is the dominant crop, and is grown in rotation with food legumes and summer crops. Trees and, to a lesser extent, livestock are also important components of these systems. We refer to them as Wheat Based Systems (WBS). Potential crop production is greater in these areas, and farmers are financially more secure. National Programs have allocated most of their research and development resources to the higher potential areas and have in many cases been successful in developing improved recommendations and agricultural policies which have allowed their rapid adoption by farmers. In these systems, and in contrast to our research on BLS, we have focussed more on specific components of the system, namely cereal and food legume production, rather than the system as a whole. Much of this work is done in cooperation with other ICARDA programs. During the coming years we will seek to develop special projects in collaboration with National Programs. We expect that many of these projects will have a specific component focus, depending on the requirements of the National Program, and will be oriented towards technology optimization rather than generation. In subsequent paragraphs of this overview of our future direction, we present research areas in which we feel our experience and expertise should continue to develop within our core program. In the formulation of cooperative research projects in the Wheat Based Systems, we will utilize this expertise to enhance and complement on-going research programs in the region. In the development of such projects, as with those developed for BLS, close collaboration with other ICARDA programs is essential.

Core program staff will clearly have to allocate considerable time to the formulation and subsequent support of these projects, but they will also continue to develop their own specialized fields of research. Within the program there is a wide range of such expertise which encompases the fields of:

- The design, execution and analysis of field surveys for the development of research priorities and objectives.
- Research on crop water use and increased water use efficiency through improved fertilizer strategies, soil tillage and stubble management, and crop management factors.
- The stabilization and increase of production through supplementary irrigation of rainfed winter sown crops.
- The integration of such components of research into the development and testing of improved farming systems through on-station and on-farm rotation trials, evaluation of

crop/livestock interactions and economic analysis of whole farm production.

- The development of methodologies which enable the integration of climatic, environmental and socio-economic variability into the evaluation of improved production practices and systems across both time (sustainability) and space (stability across and within recommendation domains).
- The development of methodologies for targetting research results to the region through agro-ecological characterization, classification and mapping.
- The assessment of adoption and impact of new production technologies on rural labor and social welfare.

None of these fields of research are unique to ICARDA and all are basic to any well balanced agricultural research and development program. Nevertheless, the cultural and environmental characteristics of West Asia and North Africa combine to place ICARDA in a unique position in the development and application of these areas of research within the region we serve.

Our overall goal is to assist National Programs to stabilize, increase and sustain the productivity of the rainfed farming systems of the region through the improved management and maintenance of their natural resource base. With this goal in mind, we will seek to develop these areas of expertise within our core program so that we may continue to support National Programs and act as catylists of innovative research for the future.

1.2 STAFF CHANGES

During the year, the program has been joined by several new staff members. In January we welcomed Drs. Michael Jones and Mustafa Pala to fill the positions of barley/livestock systems agronomist and wheat based systems agronomist respectively. Both are senior and experienced scientists who are already making substantial contributions to ICARDA's research. Dr. Dennis Tully, who had joined the Program for 2 years in 1984 as a Rockefeller Foundation postdoctoral student, has stayed with the Program, and is now coordinating our Agricultural Labor and Technological Change project. Messrs. Marz, Yousif and Dahroug also joined the program as postgraduate students. Mr. U. Marz is a PhD student from Germany who is studying the economics of the intensification of sheep and crop production in Syria. Mr. F.S. Yousif, an MSc student from Sudan, is analysing factors associated with faba bean marketing in Sudan. Dr. Tom Nordblom is acting as local supervisor to both these students. Mr. H.M. Dahroug joined us from S. Yemen to do an MSc in wheat agronomy, and Dr. Mustafa Pala is acting as his local supervisor. We were pleased to hear that during 1986 five previous postgraduate students, Mohamed A.S. Abdel Moneim (Egyptian), Noureddin Mona (Syrian), Yousef Sabet (Syrian), Ammar Wehbe (Syrian) and Eglal Rashed (Canadian) were awarded their Doctorate of Philosophy; we extend our sincere congratulations to them all.

Dr. Peter Cooper also rejoined the program after a successful and enjoyable sabbatical leave at Reading University, U.K., and Dr. Kutlu Somel (our only departure during 1986) who had acted as program leader in Dr. Cooper's absence, has joined FAO, Rome, for a year for a well earned sabbatical leave.

With this influx of new staff, and no permanent departures, the program is in a strong position, and this is reflected in an excellent year's research in which progress has been made in many areas. In this context we acknowledge, with very genuine appreciation, the substantial and vital role played by our regional staff members who continue to form the solid core of the program. A full list of program staff is given in this report on page 183.

1.3 THE SEASON'S WEATHER

The 1985/86 growing period started in the second week of November at Jindiress, the wettest of the Farming Systems Program's research sites. At all other sites, the season did not get underway until the second half of December. Approximately 40 mm of rain, which had fallen before that time, were ineffective and their contribution to crop moisture supply was negligible. Until mid-February a moist period followed with rainfall clearly above the long-term average (cf. Table 1) which created favourable conditions for the establishment of the crops and their early growth. A pronounced dry spell lasted from mid-February into the second half of March and coincided with the stem elongation phase of cereals and the pre-flowering phase of legumes. The occurrence of such a dry spell, which undoubtedly had some negative effect on yield, during this development stage of the crops has to be expected about once every six to ten years. Rainfall remained below average until the end of the season, when at Tel Hadya and Ghrerife some showers interfered with harvest, but without causing any serious problems.

Table 1 Monthly precipitation during the 1985/86 season as percentage of the long-term average

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	Season	Long-term Average (mm)
Tel Hadya	116	32	98	114	151	65	66	165	96	330
Jindiress	94	111	56	107	132	40	63	101	87	472
Breda	125	14	64	118	148	55	43	63	78	283
Khanasser	433	58	113	113	95	54	78	75	95	224

The worst frost of the 1985/86 season came in December (cf. Table 2), before crops were established, and therefore did not cause any damage. Another spell of frost in January caused some minor damage only. During the remainder of the season, the weather was rather mild and the number of days with frost fell considerably short of the average at all sites.

On the whole, 1985/86 was quite a normal season, and this was reflected in crop performance and yields. We should emphasize that some meteorological event or another with a probability of occurrence of around 1 year in 10 (positive ones like mild temperatures or negative ones like dry spells), has to be expected every season in climates as variable as that of northern Syria. Indeed, a season with

Table 2 *Frost events (1985/86 cropping season)*

	OCT	NOV	DEC	JAN	FEB	MAR	Total	Long-term average No. of frost days
KHANASSER								
Number of frost days	(1)	-	(9)	11	4	2	(27)	51
Absolute Minimum	(0.0)		(-5.5)	-4.1	-1.3	-4.0	(-5.5)	
BREDA								
Number of frost days	(-)	(-)	15	12	4	3	(34)	43
Absolute Minimum			-8.0	-6.2	-1.0	-1.4	(-8.0)	
GHRERIFE								
Number of frost days	(-)	-	14	(5)	-	(-)	(19)	(-)
Absolute Minimum			-9.0	(-3.2)			(-9.0)	
BUEDEIR								
Number of frost days	(4)	(4)	16	(-)	3	4	(31)	(-)
Absolute Minimum	(-3.4)	(-1.0)	-6.0		-0.9	-2.2	(-6.0)	
TEL HADYA								
Number of frost days	-	-	7	7	1	2	17	37
Absolute Minimum			-6.4	-4.0	0.0	-1.1	-6.4	
JINDIRESS								
Number of frost days	-	5	5	-	-	-	10	33
Absolute Minimum		-5.0	-5.0				-5.0	

() = incomplete

overall average values of all climate variables would be a very rare event.

1.4 RESEARCH AND TRAINING HIGHLIGHTS

Following our established format of reporting, we will present our annual report under the following headings: Project 1: Barley/Livestock Systems Research; Project 2: Wheat Based Systems Research; Project 3: Intersystems Research and Training and Agrotechnology Transfer.

During the 1985/86 season, the following research highlights are notable. In our Barley/Livestock Systems research, FSP scientists:

- In collaboration with the Syrian Soils Directorate expanded our on-farm fertilizer trials on barley to 22 locations. Economic responses to P and N were found at all locations, but the magnitude of responses were affected by rainfall, soil fertility, crop rotation and soil depth (see section 2.2).

- Successfully demonstrated, through analyses of on-station long-term rotation trials, on-farm grazing trials (with PFLP) and on-farm rotation trials, that annual sown forage legumes (vetch and lathyrus) can economically replace fallow or break continuous barley cultivation. Profitability of doing so is substantially increased when phosphate fertilizer is used in the rotation, and the economic return is greatest when the forage is grazed in spring or harvested as a mature crop. Hay making is the least profitable option (see sections 2.3, 2.4).

- Initiated, in collaboration with the Institute of Water Research, Michigan State University, the development of a CERES-N Barley crop growth model.

In our Wheat Based Systems Research, our research showed:

- That farmers growing wheat in NW Syria in 1984/85 achieved very variable profits, and many lost money. Factors such as level of inputs, crop rotation, rainfall and soil quality appear to have significant effects on the profit margin achieved (see section 3.2).

- Confirmed aspects of the above analyses through on-farm trials in 1985/86 which showed that crop rotation had a significant effect on the economics of nitrogen and herbicide use on wheat (see section 3.3).

- In collaboration with FLIP, demonstrated in on-farm trials that early sowing of lentils with herbicide and sitona weevil control gave substantial and consistent increases in net revenue compared with the traditional late planted crop (see section 3.6).

- In collaboration with FLIP, demonstrated, in on-farm trials, great potential for winter sown chickpea with pre-emergence herbicide, but illustrated the large variability of profit associated with this practice (see section 3.6).

- Showed that nitrogen losses through volatilization of ammonia from urea applied to wheat grown on calcareous soils at Tel Hadya were not a severe problem. Smaller losses than expected appeared to be due to cool soil temperatures at the time of application, and the large cation exchange capacity of the soil (see section 3.5).

In our Intersystems Research, we showed that:

- Supplemental irrigation (1/3 water balance) increased wheat grain and straw yields (averaged across nitrogen fertilizer levels) at Tel Hadya from 3.0 and 3.8 t/ha to 5.8 and 5.7 t/ha. In an on-farm trial at Breda, grain yields were increased from 2.6 to 5.6 t/ha. Economic survey work indicated that net income of farmers using supplementary irrigation was between 3-5 times greater in NE Syria and 6-10 times greater in NW Syria than comparable rainfed farmers (see section 4.6).

- Mechanization of farm operations reduces female agricultural activities and that off-farm employment and migration continue to reduce the male agricultural labor force in NW Syria. A special project has been initiated to study the regional implications of technology change on labor requirements (see sections 4.3, 4.4).

- Simple models, incorporating soil test calibration, can be used to predict the effect of soil fertility, rainfall and level of phosphate fertilizer application on the economics of barley production (see section 4.5).

In our Training and Agrotechnology Transfer project we:

- Held our first 6-week residential training course (attended by 19 participants from 12 countries).

- Held two short courses on "Soil and Plant Analyses", in Aleppo, and "Economics in Agricultural Research", in Turkey, (attended by 26 participants).

- Held three workshops (attended by 122 participants) namely:

  1) The Regional Farming Systems Workshop, in Islamabad
  2) Inter-Center Workshop on "Agroecological Characterization, Classification and Mapping", in Rome
  3) Regional Soil Test Calibration Workshop, in Aleppo

- Jointly supervised 10 postgraduate students (4 PhD and 6 MSc) and provided individual non-degree training to a further 10 scientists (see Section 5).

During the season, FSP staff travelled to many countries of our region to discuss and foster cooperative research projects with National Programs. Countries visited include Jordan, Egypt, Pakistan, India, Tunisia, Morocco, Iran, Ethiopia, N. Yemen, Turkey and Kenya. In addition to these visits, we continued to develop our contacts with Institutes in Europe and the United States of America.

In summary, the program enjoyed a successful year in which our manning power was substantially increased and good results were achieved in our research and training programs. It is not possible to report fully or even to summarize all our research each year. Thus, as in previous years, this annual report can only represent a part of our total program. Those readers who wish for a more complete picture of our research activities are referred to previous annual reports, or are welcome to write for more details on specific topics of research.

2. BARLEY/LIVESTOCK FARMING SYSTEMS RESEARCH

2.1 INTRODUCTION

Our on-going research in these systems has been presented in previous Annual Reports [ICARDA, 1985 (p 8-44), 1986 (p 8-42)], and the socio-economic and environmental conditions of the Barley/Livestock Systems of N. Syria has been described in detail elsewhere and recently summarized by Cooper et al. (1986). The research has the following long-term goals and objectives.

Overall Objectives

To enhance productivity, yield stability and rural income of farmers practising integrated barley/livestock farming systems in areas receiving less than 350 mm of rainfall through improved crop management, alternative crop rotations, improved integration of crop/livestock activities and a more efficient use and maintenance of the natural resource base.

Long-Term Goals

a) To evaluate, in collaboration with National Programs, the potential for improved yields, water use efficiency and greater economic return of barley production through the use of improved husbandry and phosphate and nitrogen fertilizer.

b) To assist National Programs, through on-farm research and testing of fertilizer application in formulating policies to encourage the economic adoption of fertilizer use in dry areas.

c) To evaluate in cooperation with PFLP the potential role of forage legumes in dry areas, either to replace fallow land or to break continuous barley production, through long-term rotation trials, forage agronomy research and on-farm forage legume/livestock trials.

d) To assist National Programs, through on-farm research and testing of alternative crop rotations, in formulating policies to encourage the increased adoption of improved cropping rotations which will result in a more stable agricultural system.

This year we present a summary of our cooperative research with the Syrian Soils Directorate on the economics of fertilizer use on barley in dry areas. This work is progressing well, and during 1986 has gained great momentum, not only because of a very successful season's research, but also due to the special funding we have received from the Near East Foundation to support this effort.

The principal focus of this year's report, however, is on our research into the introduction of forage legumes into those farming systems which are currently dominated by fallow-barley and continuous barley cropping sequences. The work is presented in two sections. The first section (2.3) gives an up to date biological and economic analysis of our long-term on-station crop rotation trials at Tel Hadya and Breda. These trials are complex and investigate the interaction between fertilizer use and many possible 2-course rotations involving barley, fallow and forage legumes. We also present the analyses of simpler and shorter duration on-farm rotation trials in which forage legumes were assessed, in cooperation with farmers, as a source of spring grazing and as a mature crop harvested for both grain and straw (section 2.4).

2.2 SOILS DIRECTORATE/ICARDA BARLEY TRIALS IN NORTH SYRIA

The results of this on-going collaborative research have been reported in great detail elsewhere (Soils Directorate/ICARDA, 1986), and the results from 1984/85 were fully presented in last year's Annual Report (ICARDA, 1986, p 9-18). This cooperative research with the Syrian Soils Directorate has two specific objectives. Firstly, it will allow the Syrian Government to formulate fertilizer recommendations and policies for a major barley producing area, and the potential impact for Syria alone is very substantial indeed. Secondly, and in keeping with our plans for the future (section 1.1) it allows us to generate a methodology for the prediction of fertilizer needs for similar dry barley producing areas in other countries.

This year we present a summary of the highlights of this year's research, together with some results of the associated socio-economy survey work conducted in 1984/85 which forms an integral part of this study.

2.2.1 1985/86 Research Highlights

Continuing the collaborative project between FSP and the SMAAR Soils Directorate initiated in 1984/85, twenty-two 2-replicate 4 x 4 factorial fertilizer trials on Arabic Aswad barley were successfully carried out on farmers' fields across Hama, Aleppo, Raqqa and Al Hassakeh provinces during the 1985/86 season.

Grain and straw production was significantly increased by phosphate fertilizer at twenty-one sites and by nitrogen fertilizer at eleven sites. Mean increases over no-fertilizer control were 0.54 t grain/ha and 0.80 t straw/ha from the highest rate of phosphate (90 kg P_2O_5/ha), and 0.19 t grain/ha and 0.41 t straw/ha from the highest rate of nitrogen (60 kg N/ha) (Fig. 1). Positive responses to nitrogen fertilizer and the relative magnitude of those to phosphate fertilizer reflected the availability at planting-time of native soil mineral-N and Olsen available phosphate (Fig. 2). The relationship between soil analyses for N and P, and crop responses to fertilizer are discussed in more detail in section 4.5.3 of this report.

In paired comparisons of six trials on land cropped to barley the previous year with six trials, each on an adjacent field previously fallowed, the barley-barley sequence produced a smaller unfertilized crop yield but also a much stronger response to nitrogen fertilizer (Fig. 3). This stronger response did not appear to be simply the result of a less available native soil-N at planting time.

The yields of straw and grain, within each agricultural zone, were used to estimate the economic returns of fertilizer application.

The principal assumptions used in the analysis were:

Figure 1. Mean yield responses of barley to phosphate and nitrogen fertilizer in twenty-two on-farm trials

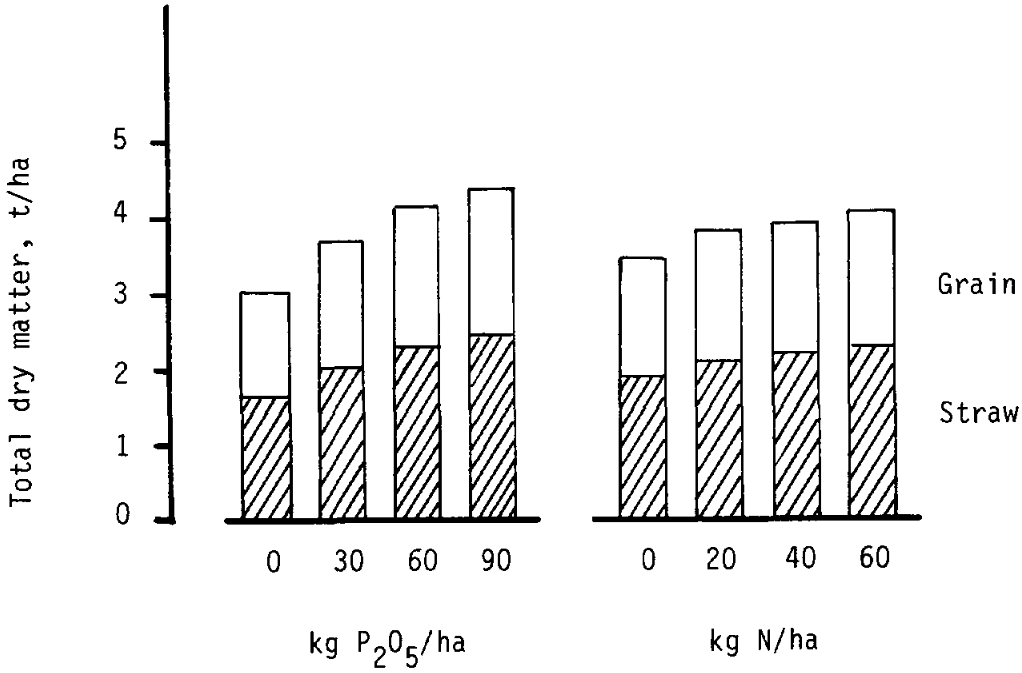


Figure 2. Percentage increase in dry matter production from three levels of phosphate fertilizer (30, 60 and 90 kg P_2O_5/ha) in relation to initial level of Olsen available-P in the soil

Equations are:

30 P_2O_5: $y(\%) = 49.75 - 17.48 \ln(\text{Olsen P}) - 0.632$
60 P_2O_5: $y(\%) = 84.62 - 30.14 \ln(\text{Olsen P}) - 0.662$
90 P_2O_5: $y(\%) = 105.61 - 38.39 \ln(\text{Olsen P}) - 0.537$

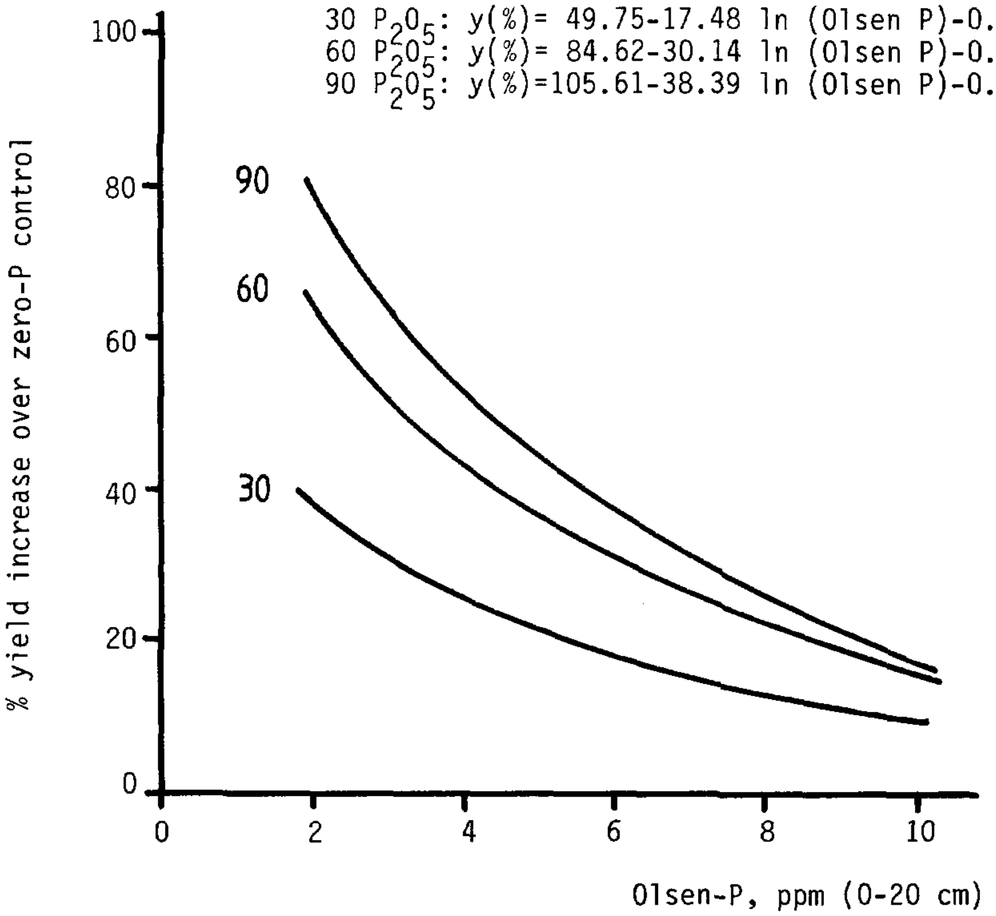
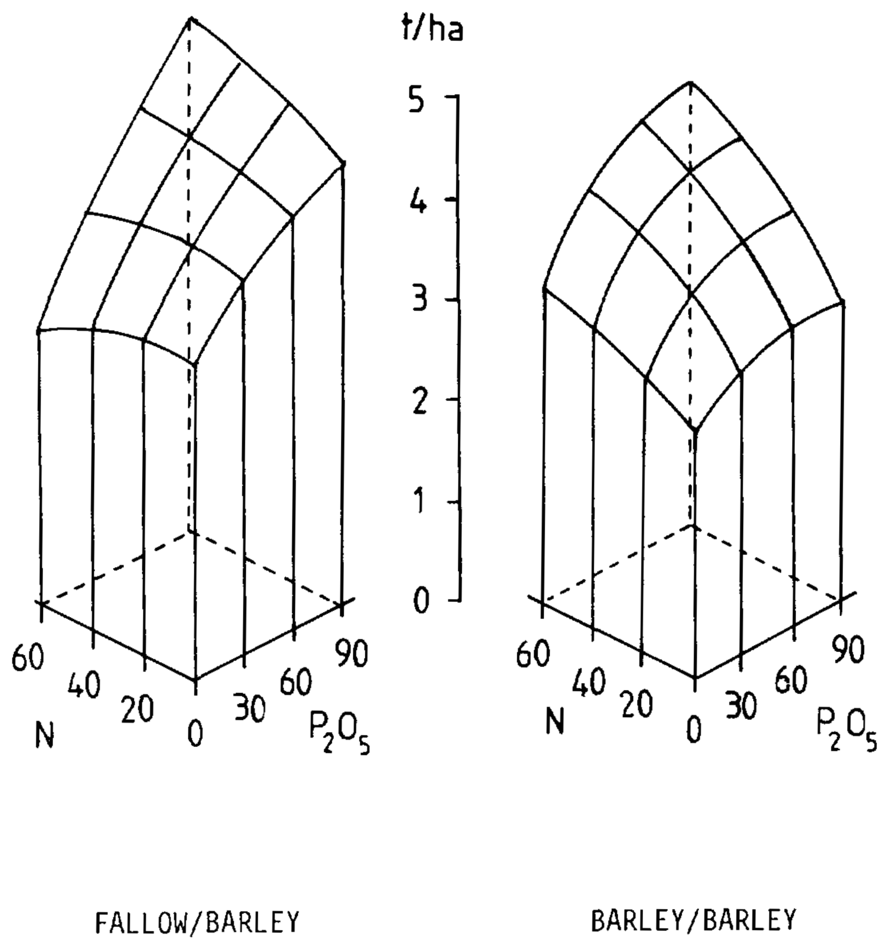


Figure 3. Comparison of six paired trials: fitted surfaces representing mean dry matter responses of barley following fallow (B/F) and barley following barley (B/B) to N and P fertilizers



Government barley grain price	1295 SL/ton
Barley straw price	450 SL/ton
Triple superphosphate (46% P_2O_5) price	1300 SL/ton*
Ammonium nitrate (30% N) price	1150 SL/ton*
Fertilizer application cost	20 SL/application
Harvesting costs	10% of gross revenue

Economic analysis showed little or no net revenue from the use of nitrogen in the absence of phosphate in either agricultural stability zone 2 or 3 (Table 3). Phosphate alone was moderately profitable, but the best results in both zones came from using the two fertilizers together.

Table 3 Calculated values of net revenues and marginal net benefit: cost ratios for agricultural stability zones 2 and 3.

		Net revenue, SL/ha				Net benefit:cost ratios			
	P_2O_5 rate:	0	30	60	90	0	30	60	90
	N rate								
Zone 2 (9 trials)	0	-	329	456	638	-	2.15	1.74	1.70
	20	-38	573	844	701	< 0	1.99	2.04	1.43
	40	-35	471	626	711	< 0	1.30	1.32	1.23
	60	-269	279	700	835	< 0	0.66	1.23	1.24
Zone 3 (13 trials)	0	-	217	309	432	-	1.54	1.26	0.55
	20	72	378	587	541	0.34	1.42	1.53	1.14
	40	60	333	603	639	0.21	0.96	1.28	1.12
	60	-72	386	609	874	< 0	0.88	1.09	1.29

* Figures for fertilizers are farmgate prices including transport.

The derived net benefit/cost ratios imply that marginal profit rates of over 100% can be achieved through fertilizer use. The large increases in net revenue per hectare (max. 844 SL/ha at N20P60 in zone 2 and max. 874 SL/ha at N60P90 in zone 3) can accommodate many overlooked costs. However, any suggestion that there was a real zonal difference here would be unjustified. It will be necessary to wait until another year has brought more data.

Six of the sites used for trials in 1984/85 were retained in 1985/86 for an investigation of fertilizer residual effects, using a mixed barley+vetch test crop. Of the four sites successfully harvested, two (strongly) and one (marginally) showed vetch hay responses to residual phosphate. Barley, harvested as hay, responded significantly at only one of those sites. Any residual effect from nitrogen fertilizer was limited to a slight redistribution of hay production between its barley and vetch components.

2.2.2 Social and Economic Research Component, 1984/85 Season

The objectives of this component are to conduct social and economic studies at the farm level in order to :

1. Follow farmers' reaction, understanding and evaluation of the trials through the season and to find problems related to fertilizer acquisition and application.

2. To understand farmers' practices, costs and resources in order to study social and economic feasibility of fertilizer use.

3. To obtain through farm level prices information on inputs, services, wages, transportation, costs and product in order to conduct economic analysis on feasibility and profitability of fertilizer use.

Thirty seven farmers were monitored through 1984/85 season with two visits:

1. The first visit was conducted during December 1984 and January 1985 after planting. In this visit, preliminary questions on practices, crops, resources and inputs were asked.

2. The second visit was in November 1985 after production disposal and emphasized information on yields, production prices, utilization and marketing.

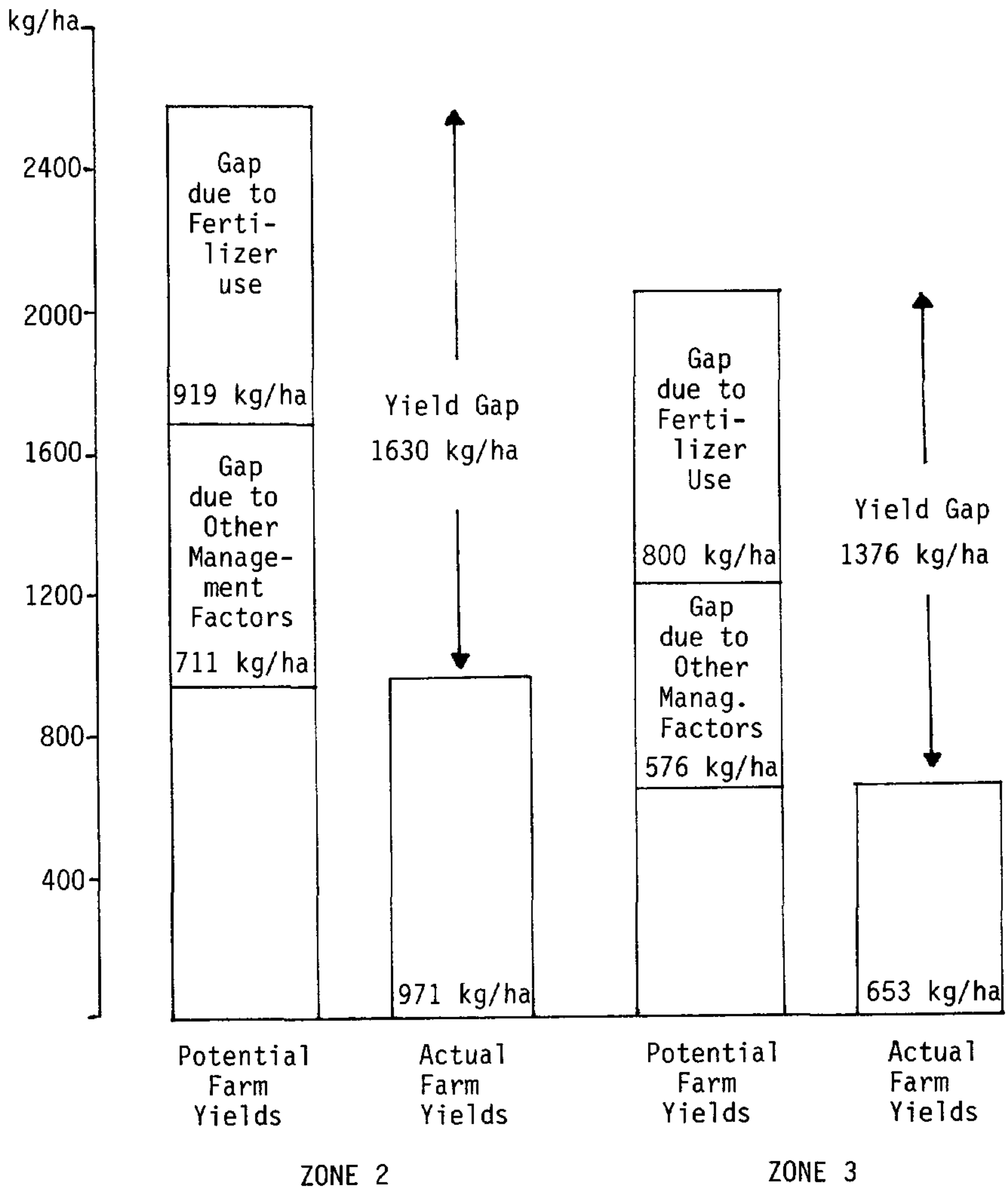
These visits were directed to three groups of farmers at each site: (a) farmers collaborating with the project, (b) other farmers from the same village, and (c) farmers from neighbouring villages. At each farm visited, the largest barley plot was selected for obtaining technical information. Even though this may impart certain biases to the analysis, experience indicates that it will ensure more accurate technical data.

The values for total dry matter and grain yields obtained from an analysis of covariance of the pooled data were used to evaluate the economic feasibility of fertilizer application and derive the potential yield for each zone. Farm gate prices were used for grain, straw and fertilizer. Under these assumptions fertilizer application consistently gave increased gross revenues higher than the increased costs. These results were fully reported in last year's annual report, and in this report we focus on two aspects, namely the yield gap between our on-farm trials and current farmers' yields, and the impact of our first year's trials on farmers attitude towards fertilizer use.

Analysis of the yield gap (de Datta et al., 1978) identified two components: (1) that between experiment station yields and potential yields on farmers' fields (on-farm trials); this is unrecoverable, since it is due to non-transferrable technology and environmental differences; and (2) that between potential and actual farm yields. Discussion here focuses on this latter component which, as it is due to biological and/or socio-economic constraints, is recoverable. Biological constraints include variety, weed, pests and diseases, water, soils, etc., while socio-economic constraints involve tradition and attitudes, knowledge, costs and returns, credit, input availability and institutions.

It is clear from Fig. 4 that there are substantial yield gaps, both in zone 2 and 3 between farmers and the on-farm trial yields. In terms of the economically optimal yields, it appears that farmers' yields can be increased by 1630 kg/ha (168%) in zone 2 and 1376 kg/ha

Figure 4. Yield Gaps in barley grain yields, SD/FSP trials, 1984/85, N. Syria



(211%) in zone 3. Of this potential increase 919 kg/ha in zone 2 and 800 kg/ha in zone 3 is directly attributable to fertilizer use. The other potential increase is due to other management factors. In on-farm trials, at every site, the initial cultivation was done by the farmer, but the final seedbed was prepared with a spiked-tooth harrow immediately prior to sowing. Barley seed, treated with vitavax, was sown at the rate of 100 kg/ha using an Oyjord planter. The phosphorus fertilizer and half of the nitrogen was drilled with the seed, the remaining nitrogen was top-dressed at the tillering stage. Weeds were controlled by a single application of *Brominal Plus* at the time of top-dressing. Table 4 summarized farmers' practices in their fields.

Table 4 Farmers' practices (% of farmers)

	Zone		Region		
	2	3	North-west	North-east	Total
1. Cultivation before autumn	20.0	17.6	16.0	25.0	18.9
2. Cultivation during autumn	30.0	17.6	28.0	16.7	24.3
3. Two cultivations (1+2)	40.0	58.8	44.0	58.3	48.6
4. No pre-sowing tillage	10.0	5.9	12.0	0.0	8.1
5. Use of treated seed	10.0	11.8	12.0	8.3	10.8
6. Varieties:					
Arabic Aswad	70.0	58.8	48.0	100.0	64.9
Arabic Abiad	30.0	41.2	52.0	0.0	35.1
7. Average seed rate (kg/ha)	129	102	121	107	116
SD	(30)	(12)	(27)	(24)	(27)
8. Manual broadcasting of seed	50.0	52.9	72.0	8.3	51.4
9. Mechanical broadcasting of seed	30.0	41.2	20.0	66.7	35.1
10. Drilling of seed	20.0	5.9	8.0	25.0	13.5
11. Weeding	15.0	11.8	20.0	0.0	13.5
12. Grazing all over barley field at green stage	20.0	11.8	16.0	16.7	16.2

The farmers main reaction to the trials is manifested, after just one year of trials, in changes in fertilizer use. It must be emphasized that these trials were not demonstrations nor part of an extension effort. They were on-farm trials which are an integral part of research with a farming systems perspective. All the farmers reported that the trials were beneficial, successful and interesting. Among the monitored farmers, fertilizer use increased from 11% to 35% within a year. Another 35% would like to use fertilizer but face various problems. The actual use or interest in fertilizer use was considerably higher among those who were able to observe the trials.

About 54 percent reported problems that prevent them using fertilizer, the most important being shortage of funds or credit and fertilizer unavailability. Most farmers are present in the village at fertilizer application time, but farmers who have sharecroppers or landlords have to consult the other partner before using fertilizer.

Finally, these results are from the first season of the project. The project will continue for several years. The socio-economic research component will also continue. More conclusive results are expected after several seasons of trials.

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2.3 ON-STATION ROTATION TRIALS WITH BARLEY AND FORAGE LEGUMES

2.3.1 Introduction

Sheep rearing is the dominant activity of the 200-300 mm rainfall zone of northern Syria. Most flocks have some access to grazing on marginal hill land or in the adjacent lower-rainfall steppe zone, but the major feed source almost everywhere is barley, grain and straw. Large areas in the zone are therefore cropped to rainfed barley, grown in rotation with bare fallow, monocropped, or (much more rarely) rotated with forage legumes. Yields vary greatly with rainfall but are generally rather poor. It is reported that yields have fallen severely over the last thirty years (Jaubert and Oglah, 1985) and that farmers currently expect an average of only 600-700 kg grain/ha. The introduction of tractors has enabled farmers to cultivate a larger proportion of their land every year, and the consequent increase in the frequency of cropping to low-input continuous barley has probably brought about a decline in soil fertility.

Over the last 8 years, ICARDA scientists have been seeking ways to reverse the fall in yields and make more efficient use of the land for sheep rearing. In particular, the replacement of fallows with annually sown forage legumes is seen as having great potential. In order to understand better the biological, technical and economic factors involved, three rotational trials were established some years ago, and the present report summarizes their biological and economic productivity to date. The trials are:

	Site	Year of establishment
New Rotation	Tel Hadya	1982/83
New Rotation	Breda	1982/83
Old Rotation	Breda	1980/81

2.3.2 New Rotation Trials. Experimental

At both sites, the design is an incomplete factorial combination of six two-year rotations and six fertilizer treatments (Table 5). Each treatment can be considered to consist of two one-year phases, and three replicates of each phase are planted each year as fully randomized complete blocks.

Table 5 New Rotation trials: definition of treatments

Fertilizer Regime No.	$N:P_2O_5$ in Ph 1	$N:P_2O_5$ in Ph 2	Rotation: A Phase 1: Barley Phase 2: Peas	B Barley P+B	C Barley Vetch	D Barley V+B	E Barley Fallow	F Barley Barley
I	20:60	20:60						19
II	0:0	20:60						22
III	20:60	0:0	1	2	3	4	18	20
IV	20:30	0:30	5	6	7	8		
V	20:0	0:60	9	10	11	12		
VI	0:0	0:0	13	14	15	16	17	21

Numbers in the main body of the table are those ascribed to particular treatment combinations of rotation and fertilizer regimes. Fertilizer materials are ammonium nitrate and triple superphosphate. The rate of N fertilizer indicated, 20 kg N/ha, applied to Breda only; at Tel Hadya the rate was 40 kg N/ha.

P+B = Peas/barley mixture; V+B = Vetch/barley mixture

Crops, all local landraces, are drilled at 17.5 cm row-spacing into moist soil in 6.5 x 12.5 m plots in November or December at seed rates (kg/ha): barley (var. Arabic Aswad), 90; peas, 200; vetch, 150; peas + barley mixture, 185 + 15; and vetch/barley mixture, 135 + 15. All legumes are previously inoculated with appropriate rhizobia. Fertilizers are drilled with the seed, but at Tel Hadya half the nitrogen is held back and top-dressed at the start of stem extension. Weeds are controlled with herbicides or, in mixed crops and bare fallows, by hand. Following farmer practice, fallows are cultivated in early April.

The legumes (and mixtures) are harvested at the hay stage (early pod set) and the barley as a mature crop. Hay, grain and straw yields are assessed from six 1 m row lengths randomly selected in each plot. All remaining plant material is then hand pulled and removed to leave the land as bare fallow for the rest of the summer, again following farmer practice. In late October all plots are tilled with a duck's foot cultivator and then harrowed with a spiked-tooth harrow immediately before seeding.

The results presented here include:

1. A summary of biological yield over the first four years of each trial: hay from the legume plots and total dry matter from the barley. (Grain and straw separately show very similar trends.)

2. Economic calculations based on contemporary costs and prices of inputs, services and products.

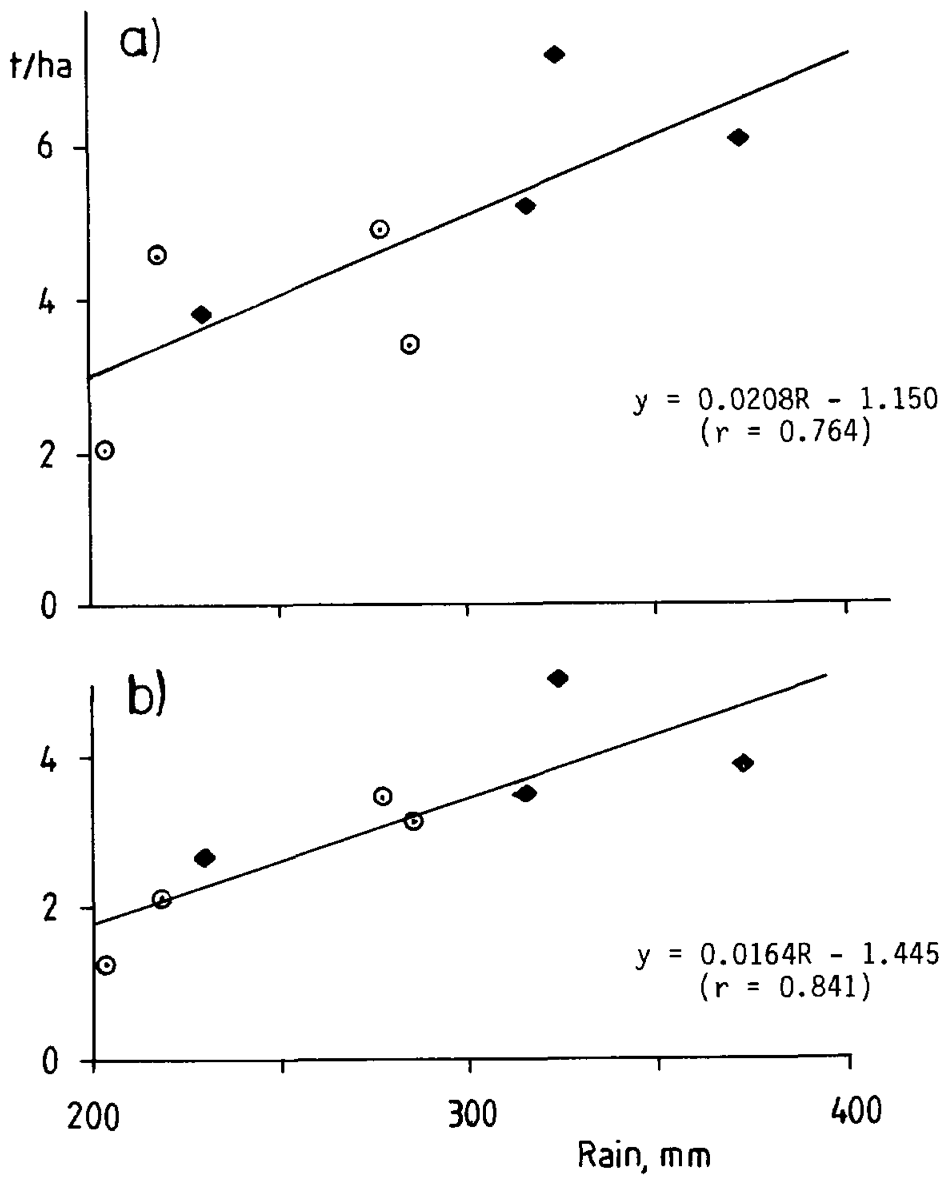
2.3.3 Biological Yield

Yields were a function of three factors: weather, fertilizer regime and crop rotation. Considering weather first, two factors were of obvious importance, rainfall and frost. Mean dry matter production increased in an approximately linear fashion with increasing total seasonal rainfall (Fig. 5). Despite soil differences, values from the two sites apparently shared the same relationships, with increases of roughly 21 kg barley dry matter and 16 kg legume hay per hectare per mm increase in rainfall. There was only one significant effect from frost; in 1984/85, peas at both sites were killed by late spring frosts, and productivity was effectively zero.

The main difference due to fertilizer lay between "with" and "without", i.e., regimes I-V v. VI (Table 6). At Tel Hadya, fertilizer increased mean dry matter yields over those of the zero-fertilizer control by 34, 35 and 50% in the barley/legume, barley/fallow and barley/barley rotations, respectively. Corresponding figures for Breda were 72, 59 and 56%.

Differences due to the timing of the phosphate component were small (compare regimes III, IV and V in the barley/legume rotations) but sometimes significant. Consistently, both barley and legume crops yielded more when phosphate had been applied in the current rather than

Figure 5. Relationship between mean annual dry matter production and seasonal rainfall in New Rotation Trials at Tel Hadya (●) and Breda (⊙): a) barley; b) legume hay



the alternate year of the rotation, with the split treatment (regime IV) intermediate; but only for legumes at Breda did the mean difference over four years exceed 10%.

Table 6 New Rotation trials: mean 4-year fertilizer effects on crop dry matter production (t/ha)

	Fertilizer regime						
		$N:P_2O_5$ to phase		Barley dry matter		Legume hay	
Rotation	No.	Barley	Leg/Fal	Tel Hadya	Breda	Tel Hadya	Breda
Barley/legume	III	20:60	0:0	5.67	4.76	3.68	2.32
	IV	20:30	0:30	5.66	4.46	3.87	2.79
	V	20:0	0:60	5.34	4.37	3.93	3.05
	VI	0:0	0:0	4.15	2.63	3.55	1.75
Barley/fallow	III	20:60	0:0	7.16	4.81	--	--
	VI	0:0	0:0	5.31	3.02	--	--
Barley/barley	I	20:60	20:60	5.82	3.75	--	--
	II	0:0	20:60	3.86	2.85	--	--
	III	20:60	0:0	4.69	3.13	--	--
	VI	0:0	0:0	3.20	2.08	--	--

Comparisons of regimes II and III in the barley/barley rotations show, not surprisingly, that barley yielded more on currently applied than on residual fertilizer. In fact, the difference was quite small: mean, 22% at Tel Hadya, 10% at Breda. The greater response at Tel Hadya, the wetter site, perhaps implies that it is the nitrogen that is the more important component to have applied in the current year.

Comparison of the three types of rotation, barley/legume, barley/fallow and barley/barley can be made for only three years (omitting 1982/83, the establishment year) and across only two fertilizer regimes (III, N and P applied, once per two years, to the barley; and VI, no fertilizer). Such a comparison is necessarily limited to barley. The main feature is the immense variation in rotation effect from one year to the next, evident even after only three years and apparently related to rainfall (Fig. 6). In 1984/85, a relatively wet year, barley productivity was little influenced by the nature of the rotation, particularly if fertilizer was applied; but in 1983/84 and 1985/86, both relatively dry years, yields of barley following fallow and, to a lesser extent, barley following legume were greatly superior to those of barley following barley. However, results of additional treatments in regimes I and II show that the inferiority of the barley/barley rotation was mitigated by the residual effects of fertilizer applied in the alternate year: (compare treatments 19 with 20, and 22 with 21). Perhaps the most remarkable feature throughout was the close correspondence in these various effects between sites and, where treatments are comparable, with those in the Old Rotation trial (see later in this section).

Differences between individual barley/legume rotations were generally small. Figure 7 shows the sequence of dry matter yields (meaned over four fertilizer regimes) in each of the two phases of the four rotations. The failure of peas in 1984/85 stands out; but over the other three seasons, any advantage was usually with peas. In the three-year means, peas and peas + barley outyielded vetch and vetch + barley very significantly at Tel Hadya (p=0.001; 33% increase)

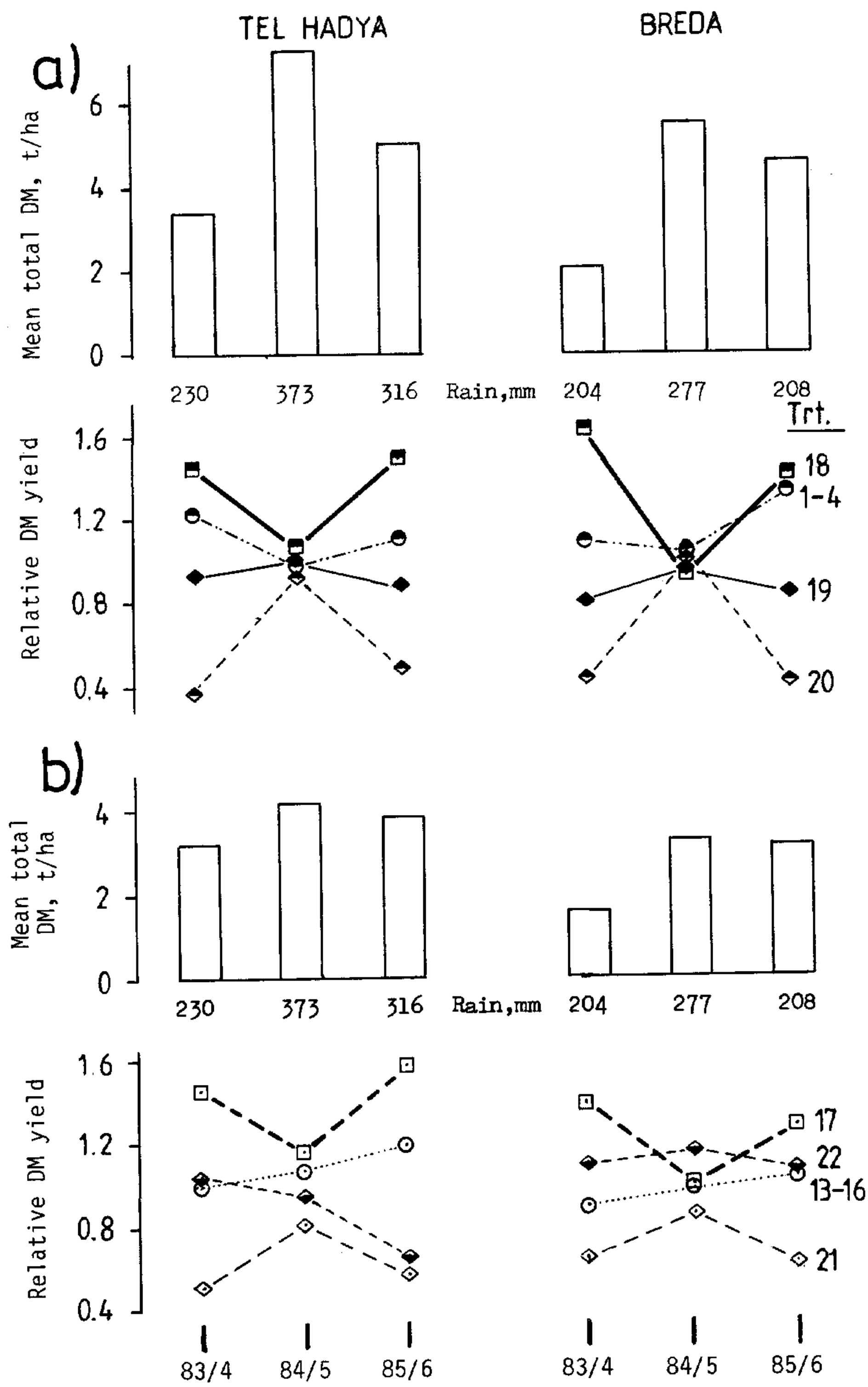
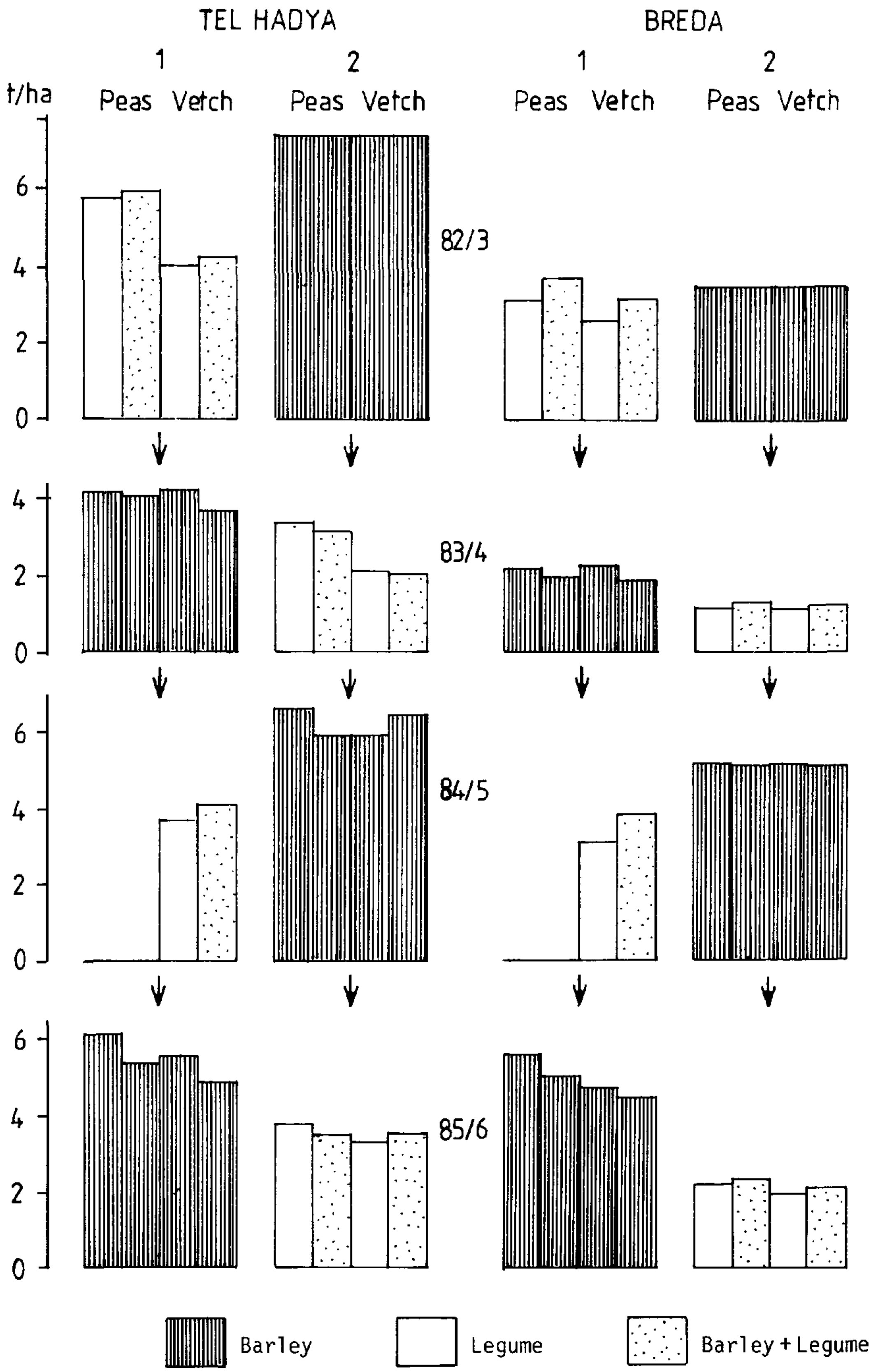


Figure 6. New rotation trials, barley dry matter yields, 1983-86: means of four rotations and individual rotation values in relation to those means (=1); a) fertilized rotation, regime III; b) unfertilized rotation, regime VI (to identify treatments, see Table 5)

Figure 7. New rotation trials: sequence of mean dry matter yields in the four barley/legume rotations; two phases per site



and marginally at Breda ($p=0.10$; 13%) (Table 7). Differences in barley crops following the four legume treatments were smaller but in the same direction. Taking both sites together, barley following peas or peas + barley yielded 5.5% more than barley following vetch or vetch + barley (4.76 v. 4.50 t/ha; $p=0.05$).

Table 7 Barley/legume rotations in New Rotation trials: effect of the nature of the legume phase on production of hay and of barley dry matter in the subsequent season (3-year means, t/ha)

	Legume hay			Barley dry matter		
Legume phase	Tel Hadya	Breda	Mean	Tel Hadya	Breda	Mean
	***	+	***	NS	NS	**
Peas	4.35	2.15	3.25	5.59	4.31	4.95
Peas + barley	4.18	2.42	3.30	5.07	4.06	4.56
Vetch	3.15	1.88	2.51	5.20	4.05	4.63
Vetch + barley	3.30	2.16	2.73	4.96	3.80	4.38
SE (±)	0.130	0.133	0.060	0.194	0.157	0.114

Here and subsequently: ***, **, *, + and NS indicate significance at $p=0.001$, 0.01, 0.05 and 0.10 and non-significance, respectively.

At Breda, mixing barley with the legume increased hay production by about 14% (2.30 v. 2.01 t/ha, $p=0.05$), but at Tel Hadya, this effect was seen only with vetch and was in any case much smaller. However, mixed forage crops generally had an adverse effect on the following barley crop. Over three years at two sites, the mean reduction in barley dry matter was about 7% (4.47 v. 4.79 t/ha; p=0.05).

2.3.4 Economics

In complex rotation trials, biological data alone are rarely sufficient to demonstrate the superiority of one treatment or rotation over another. Yields expressed in terms of kilogrammes per hectare of grain or hay or dry matter take no account of differences in cash or utilization value nor of differences in cost of production. For valid comparison it is necessary to assess all treatments on a cash basis. To this end, using the money values given in Table 8, two economic indices have been calculated:

1. Net value: revenue from theoretical sale of crops minus the calculated cost of production.

2. Rate of return: ratio of net value to total production cost.

Net value was increased by fertilizer use in all rotations at both sites. Its mean was 28% and 78% higher at Tel Hadya and Breda, respectively, in fertilizer regime III compared with regime VI, the zero-fertilizer control (Table 9). However, increases in rate of return were limited to Breda, where they were moderately large and significant in all four rotations involving legumes but smaller and non-significant in barley/barley and, particularly, barley/fallow rotations.

Table 8 New Rotation trials: costs and prices assumed in calculating net values and rates of return

	1982/83	1983/84	1984/85	1985/86
<u>Costs</u>				
Cultivation, SL/ha	85	100	100	150
Fertilizer: SL/kg N	1.875	1.875	3.70	3.83
SL/kg P_2O_5	2.72	2.72	2.85	2.85
Seed: SL/kg barley	0.95	1.00	1.84	1.55
SL/kg vetch	2.00	2.25	2.15	2.50
SL/peas	2.00	2.25	2.15	2.50
Harvest: barley, SL/t grain	232.5	267	307.5	353.5
legume hay, cutting and baling, SL/ha	575	661	760	875
<u>Prices of harvested product, SL/t</u>				
Barley grain	920	1500	1800	1180
Barley straw	330	700	650	450
Legume hay	540	850	930	1000

Table 9 New Rotation trials: the effects of crop rotation and fertilizer application on net value and rate of return, shown as means over four seasons.

Fertilizer regime	Sig.	Barley peas	Barley P+B	Barley vetch	Barley V+B	Barley fallow	Barley barley	S.D. (±)	Mean
				TEL HADYA					
Net value, SL/ha:									***
III	NS	3469	3180	3184	3463	2935	3791	90.2	3337
VI	NS	2841	2632	2772	2578	2218	2608	86.0	2608
Mean	*	3155	2906	2978	3020	2576	3199	96.9	
Rate of return:									
III		2.37	2.26	2.20	2.41	3.32	3.37	0.125	2.65
VI		2.39	2.27	2.28	2.22	3.57	3.31	0.141	2.67
Mean		2.38	2.26	2.24	2.32	3.45	3.34	0.063	
				BREDA					
Net value, SL/ha:									***
III	***	1779	1844	2016	2083	1760	2424	60.5	1984
VI	***	846	977	1008	1198	1123	1552	59.6	1117
Mean	***	1312	1411	1512	1614	1442	1988	35.2	
Rate of return:									
III		1.38	1.45	1.55	1.63	2.59	2.96	0.149	1.93
VI		0.83	0.96	0.97	1.15	2.56	2.67	0.190	1.52
Mean		1.11	1.20	1.26	1.39	2.58	2.82	0.024	

Rotation effects were significant at both sites, but largest differences tended to be between one or both barley-only rotations and the four barley/legume rotations. The barley/barley and barley/legume and rate of return at both sites barley/barley was markedly superior. The difference was particularly great at Breda, where in both fertilized and unfertilized situations the rate of return from the barley/barley was double that from the barley/legume rotation.

Because of the alternate bare-fallow years, mean annual dry matter production in the barley/fallow was generally lower than that in other rotations; but at Breda (though not Tel Hadya) its net value approached those of the barley/legume rotations in the presence of fertilizer and equalled or exceeded them in the absence of fertilizer. At both sites, rates of return were close to those achieved by the barley/barley and greater than any of those achieved by the barley/legume rotations.

Within the barley/legume rotations, the timing of fertilizer application had no significant effect at either site (compare regimes III, IV and V in Table 10b). However, at Breda but not Tel Hadya, there was a small but consistent trend, both in the presence and the absence of fertilizer, according to the nature of the legume component:

$$B/P < B/P+B < B/V < B/V+B$$

Net value and rate of return were higher when the legume phase included vetch rather than peas and when it comprised a mixture with barley.

Table 10 New Rotation trials: the main effects of barley/legume rotation and the timing of phosphate fertilizer on net value (SL/ha/yr) and rate of return, as means over four seasons, 1982-86

		Tel Hadya		Breda	
		Net value	Rate of return	Net value	Rate of return
a) Rotation effects:					
Rotation	Treatments	NS		***	
A B/P	1, 5, 9, 13	3268	2.37	1592	1.29
C B/V	3, 7, 11, 15	3199	2.29	1837	1.47
B B/P+B	2, 6, 10, 14	3068	2.27	1629	1.35
D B/V+P	4, 8, 12, 16	3251	2.37	1949	1.61
	SE (±)	106.2	0.059	21.1	0.014
b) Fertilizer effects:					
Regime	Treatments	***		***	
III	1, 2, 3, 4	3324	2.31	1931	1.50
IV	5, 6, 7, 8	3441	2.38	2380	1.61
V	9, 10, 11, 12	3315	2.34	2031	1.62
VI	13, 14, 15, 16	2706	2.29	1007	0.98
	SE (±)	106.2	0.059	21.1	0.014

Differences between the extremes, B/P v B/V+B, were statistically significant in all cases. Nevertheless, it should be remembered that these figures include one year in which peas failed. If that year were omitted from the calculations, peas would probably emerge as superior to vetch at both sites.

2.3.5 Discussion

The value of fertilizer, already demonstrated in many annual trials, was further confirmed by these rotation trials. Nitrogen and phosphate fertilizers in combination substantially increased the productivity and profitability of all crop rotations under test. Rates of return on the higher investment involved were at least as good as, if not better than, those on the lower investment of traditional practice.

The rotation question is more problematic. Of the two barley-only rotations, continuous barley was clearly the more productive and profitable option in the short period under test, but it is uncertain how long this could continue. Local experience is that yields of continuous cereals decline over time. It seems that the decline can be moderated by using fertilizers, though probably not completely nor indefinitely. The cause often suggested is a build-up of plant pathogens, but as yet this remains unproven. Now the observation of a large seasonal variation in the effects of rotation on barley performance apparently adds another factor.

The reported decline in monocropped barley yields was, of course, the main reason for testing rotations with forage legumes in the first place. In terms of dry matter yield, such rotations have proved to be highly productive, but they have not so far matched the profitability or rate of return of continuous barley. Part of the reason for this lies in the experimental procedure so far employed. Harvesting legumes green as hay involves substantial hand harvesting and baling costs. It also necessitates annual seed purchase, and seed costs of vetch and peas are presently double those of barley. More economical options are to use the legumes as pastures to graze lambs in the spring or as standing hay later in the summer. The latter allows enough seed to be harvested for the next season's planting. In future, forage legumes in these trials will be harvested at maturity and will be costed for partial seed harvest and subsequent grazing in situ.

The decision as to which forage legume, vetch or peas, is the more suitable has been temporarily resolved in favour of vetch. Overriding the small differences observed in productivity are two other factors affecting peas: evidence of grazing unpalatability (ICARDA, 1984, p 51-57), and susceptibility to frost. Perhaps in the long term it might be wiser to seek more palatable varieties than to abandon the species completely, for a potential for high productivity has been demonstrated. Moreover, the meteorological records indicate that frost as severe as that which killed peas in 1985 may be a very rare event. Recent research (see ICARDA 1986 p. 26-42) has indicated that lathyrus is well adapted to dryland conditions in terms of both seed and total dry matter production, and has no palatability problems. Hence, for the immediate future in these trials lathyrus will be substituted for peas.

The effect of mixing in a small percentage of barley with the legume was generally small. A small increase in dry matter production may be expected but at the expense of a slightly reduced barley yield in the following year. On present evidence, this is rather a minor issue.

2.3.6 Old Rotation. Experimental

This trial, like the New Rotation trials, compares three types of two-year rotation, barley/legume, barley/fallow and barley/barley. In this case, the legumes include lentils and chickpeas as well as vetch and peas, but the degree of combination with different fertilizer regimes is much more limited (Table 11). Again, there are three replicates, and each replicate carries two plots of every treatment, one for each phase (year) of the rotation. Management is generally similar to that described for the other trials. All fertilizer is drilled with the seed; and seed rates are (kg/ha): barley (var. Beecher), 90; vetch and lentils, 150; and peas and chickpeas, 200.

We present here a summary of rotation and fertilizer effects on yields, 1981-86, and their relation to water utilization, and an economic analysis for the years 1984-86.

Table 11 Old Rotation trial: definition of treatments

Fertilizer ($N:P_2O_5$)			Rotations					
Phase 1	Phase 2	Phase 1: Phase 2:	Barley Vetch	Barley Peas	Barley Lentil	Barley Chickpeas	Barley Fallow	Barley Barley
20:60	20:60							2
20:60	0:60		6					
20:60	0:0		8		9	10	4	
0:0	0:60		7					
0:0	0:0		5	11			3	1

Treatment 3 is duplicated throughout. Full data for treatments 9, 10 and 11 are not available for all years of the trial and these treatments are therefore omitted in the five-year summary below.

2.3.7 Five-Year Yield Pattern and Water Utilization

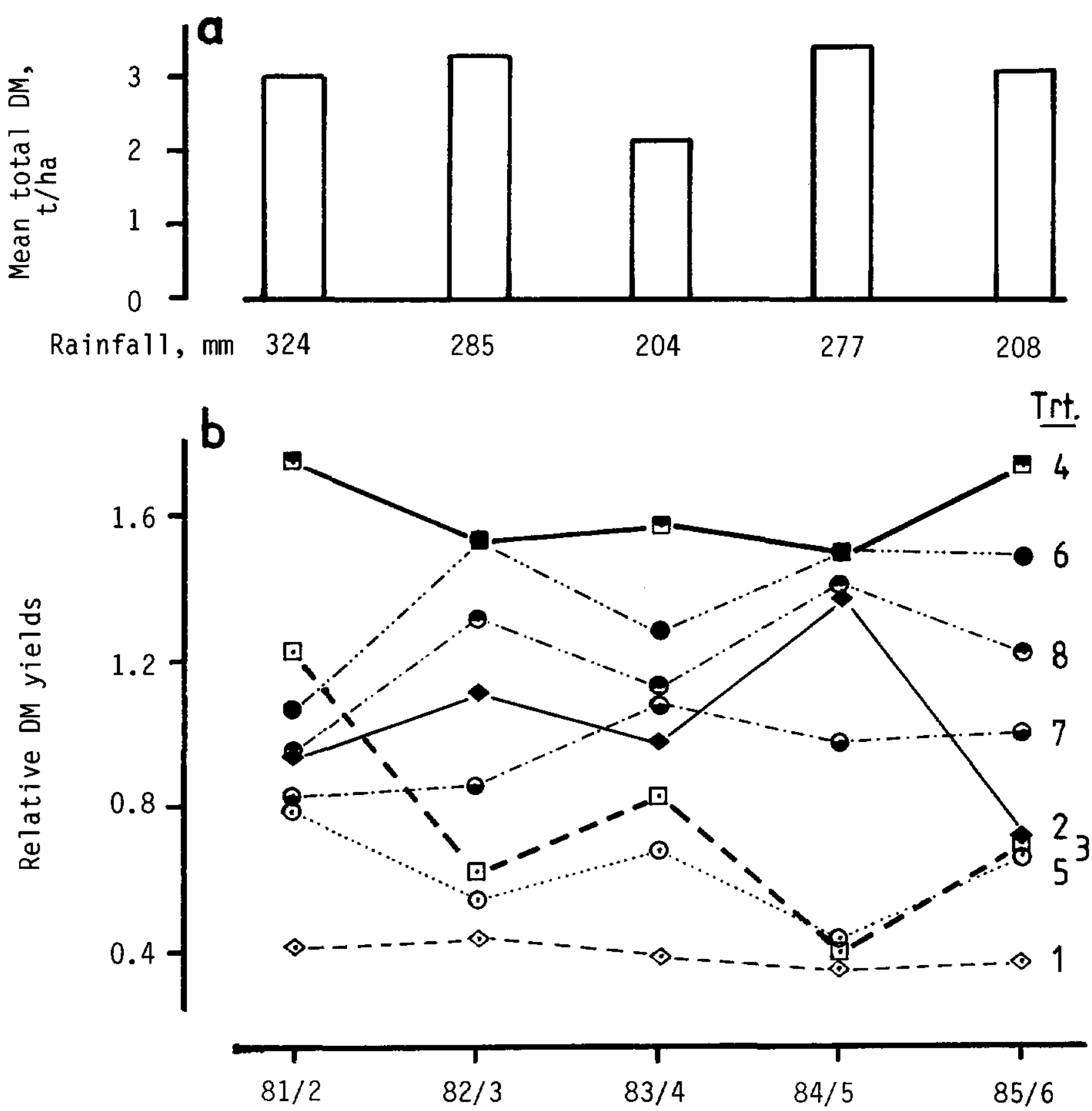
Barley production each year broadly reflected seasonal rainfall (Fig. 8a). That for 1983/84, a dry year, was particularly poor. The higher value for 1985/86, which was almost equally dry, is attributable to a better rainfall distribution. Over 70% fell during the three months, December-February, when it could be most effective, whereas nearly 40% of the 1983/84 rain fell in March and April after a very dry period, December-February.

Treatment yield means (1981-86) differed by up to a factor of four, according to rotation and fertilizer:

	Treatment		Grain t/ha	Straw t/ha	Total t/ha
1)	Barley/barley	0:0/0:0	0.48	0.72	1.20
2)		20:60/20:60	1.31	1.82	3.13
3)	Barley/fallow	0:0/0:0	0.94	1.30	2.24
4)		20:60/0:0	2.00	2.87	4.87
5)	Barley/vetch	0:0/0:0	0.76	1.11	1.86
6)		20:60/0:60	1.75	2.44	4.18
7)		0:0/0:60	1.29	1.55	2.85
8)		20:60/0:0	1.59	2.11	3.69

But there were interactions between treatment and year. Some treatments showed a much greater yield fluctuation, both in absolute and relative terms, than did others (Fig. 8b). Thus treatment 1 (unfertilized continuous barley) consistently yielded around 40% of the eight-treatment mean, whereas treatment 2 (fertilized continuous barley) fluctuated widely around 100%.

Figure 8 Old rotation trial, barley dry matter yields, 1981/86: a) means of eight rotations in relation to seasonal rainfall; b) individual rotation values in relation to those means (=1) (to identify treatments, see Table 11)



Such fluctuations, in this and other treatments, were apparently related to the rainfall. For example, where fertilized barley followed vetch rather than fallow there was a relatively greater reduction in yield if the year was dry (compare treatments 6 and 8 with treatment 4 in Fig. 8b). Similarly, where fertilized barley followed fertilized barley, the yield approached that achieved by fertilized barley following fallow only if the year was wet (treatments 2 and 4, in 1984/85).

Results from water balance studies help to explain these patterns of yield. Although much of the water accumulated in the soil under fallow during the winter is lost by evaporation during the summer, after a wet year, some still remains for use by the following crop. After a dry year such as 1983/84, however, little remains (Fig. 9A). Where barley is grown continuously, there is no carry-over of water to the next crop even after a wet year (Fig. 9B). The relative stability of the yields of fertilized barley following fallow so far experienced can therefore be attributed to the buffering effect of fallow-stored water.

Vetch, managed as a hay crop, uses less water than barley and acts more like a fallow. After a wet year under vetch, the soil retains some available water for a succeeding barley crop (Fig. 10). So, although the substitution of fallow with vetch hay crops causes increased seasonal variability in barley yields, some damping of the yield fluctuations relative to continuous fertilized barley is evident (Fig. 8b). However, if vetch were to be allowed to grow to maturity

Figure 9 Old Rotation: Soil water profiles at four times during the crop cycle in a wet year following a dry yaer (left) and a dry year following a a wet year (right) for: (A) Barley following fallow; (B) Continuous barley.

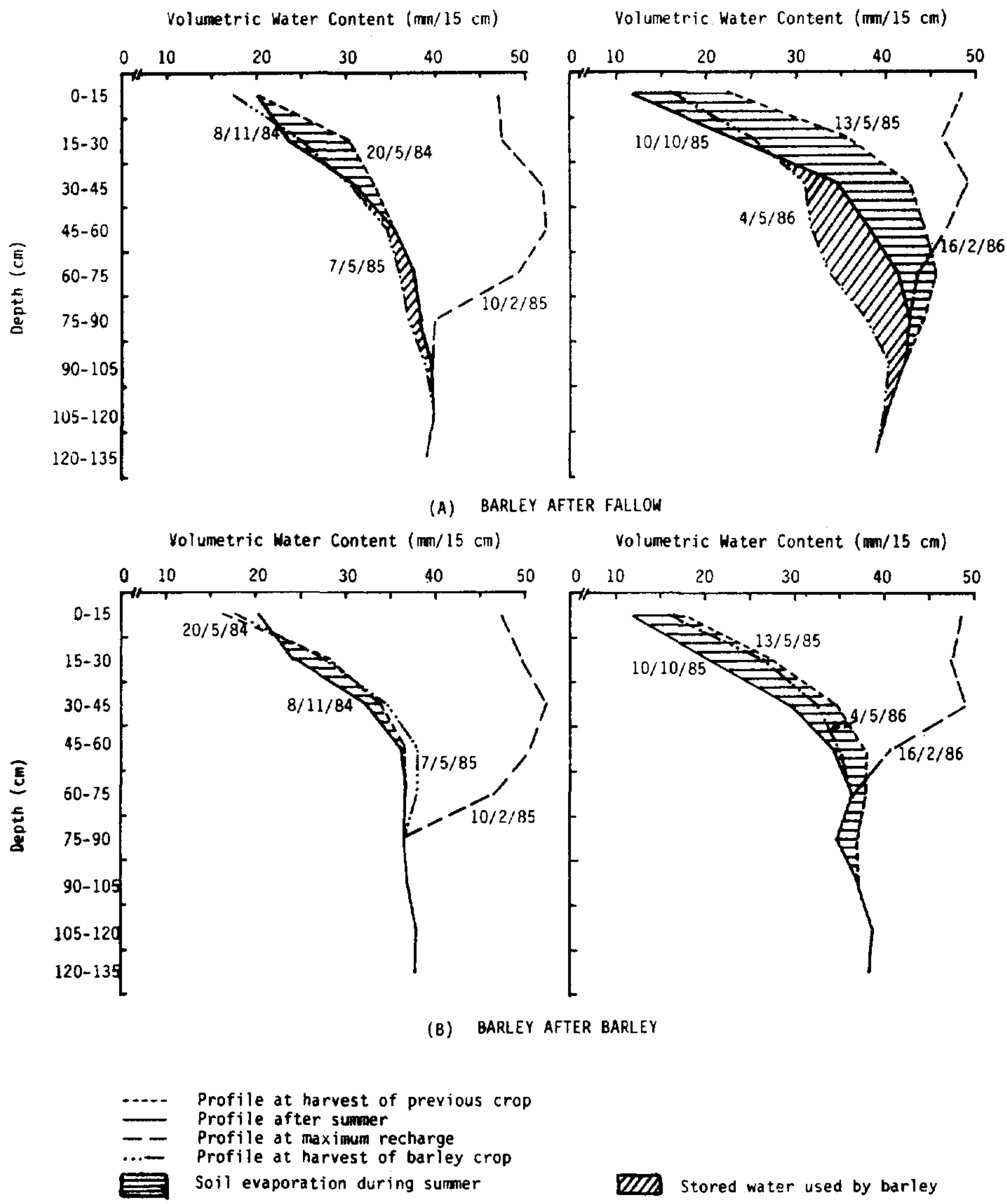
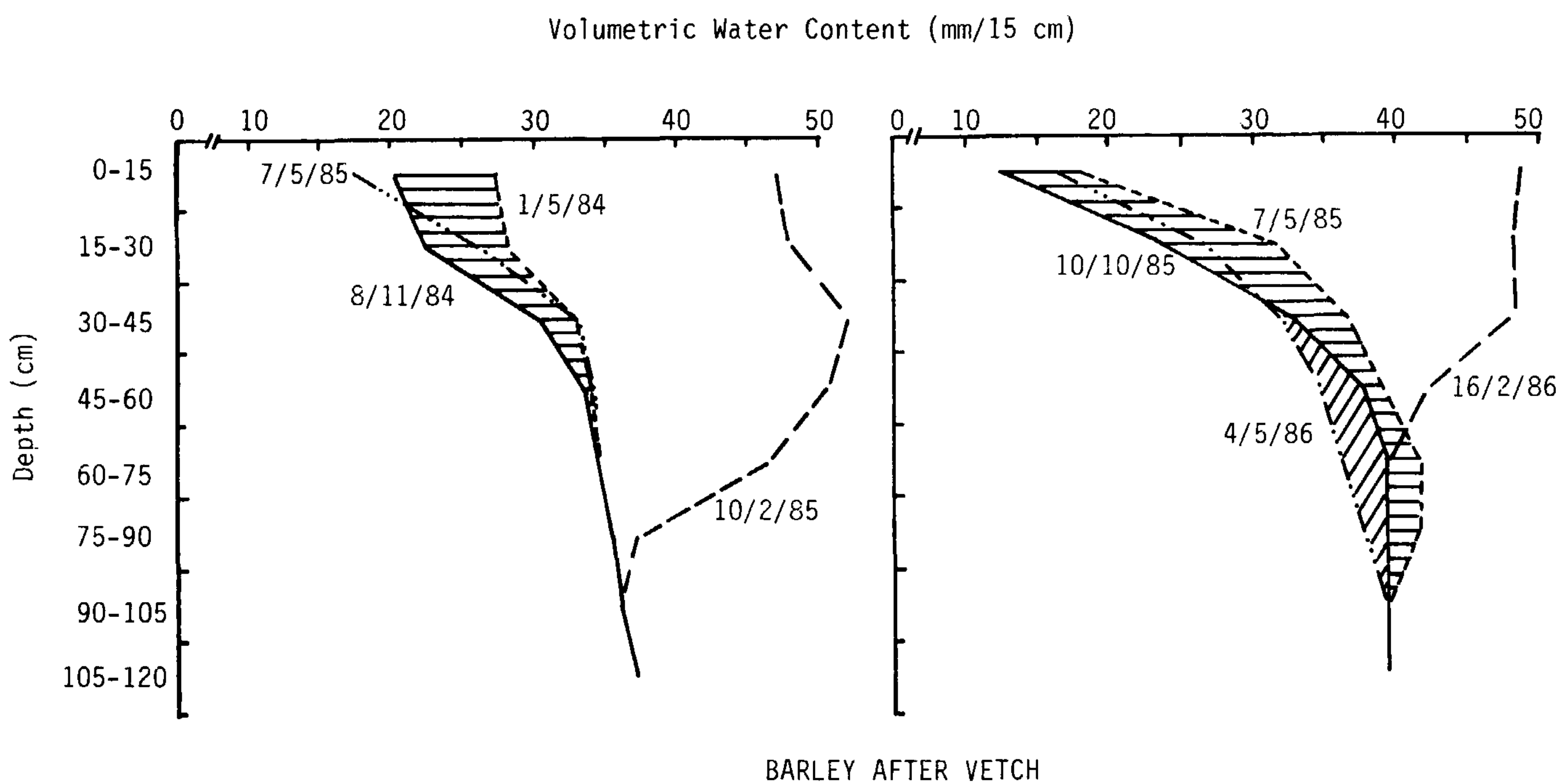


Figure 10 Old Rotation: Soil water profiles at four times during the crop cycle in a wet year following a dry year (left) and a dry year following a wet year (right) for barley following a vetch hay crop.



(For legend see Figure 9)

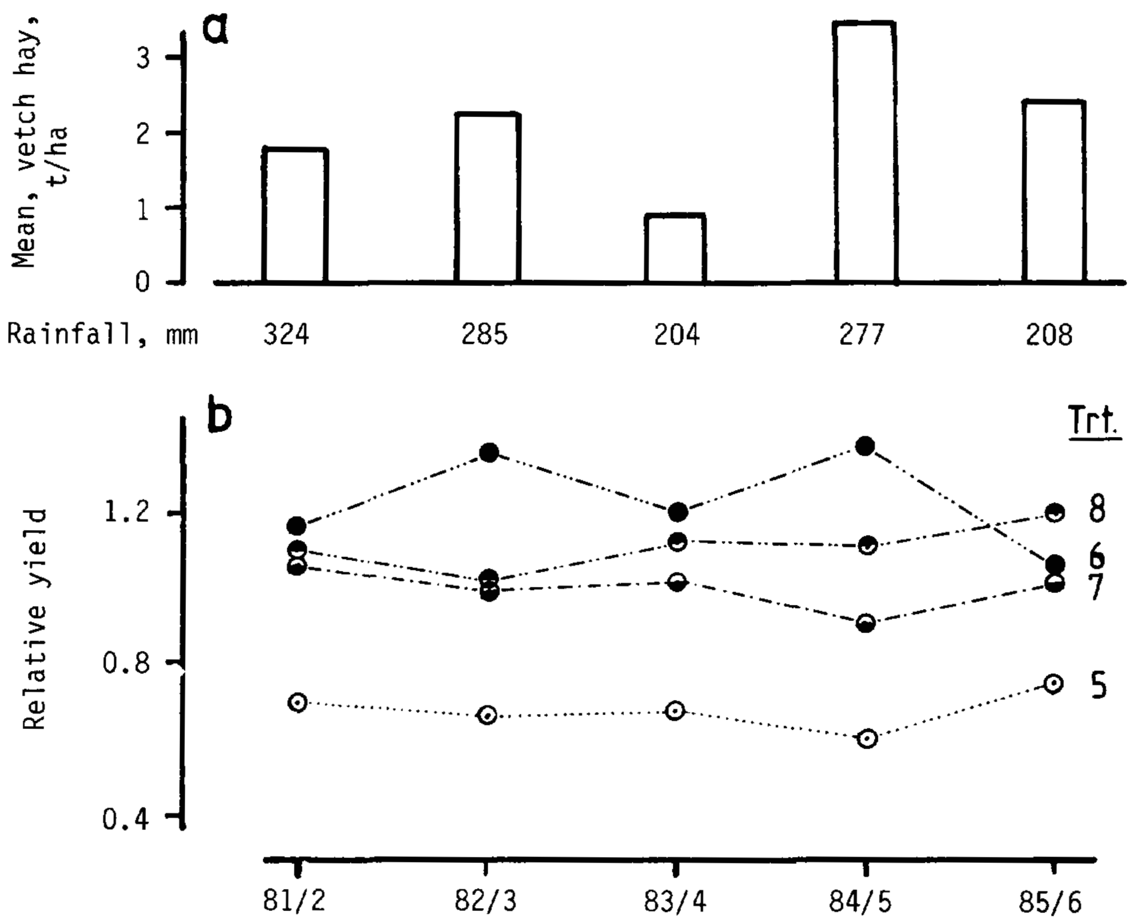
for seed harvest and in situ grazing, as is proposed in future for the New Rotation trials, it is unlikely that this relative stability of barley production in vetch/barley rotations would be maintained.

Given the background fluctuations, five years is too short a period to show any general upward or downward trend in the barley yield of any particular rotation. We may note (Fig. 8b) that treatment 3 (unfertilized barley following fallow) has declined seriously from its high initial position in 1981/82; and that treatment 7 (unfertilized barley following fertilized vetch) appears to be improving gradually; but at least several more years are required to establish whether these are real effects.

Comparison of the two treatments (6 and 8) in which fertilized barley follows vetch demonstrates the large requirement for phosphate in these rotations. Both have the same yield pattern in respect of annual rainfall, but where phosphate was applied to vetch as well as to barley (treatment 6) dry matter production averages 0.5 t/ha higher.

Like barley, yields of vetch hay reflected variations in annual rainfall -- but with a built-in upward trend (Fig. 11a). At similar rainfalls, 1984/85 markedly outyielded 1982/83, and 1985/86 outyielded 1983/84. These may be no more than the effects of rainfall distribution; but, alternatively, the increase may be genuine, resulting perhaps from an accumulation of available phosphate in the soil. This needs to be verified.

Figure 11 Old rotation trial, vetch hay yields, 1981:86: a) 4-treatment mean in relation to seasonal rainfall; b) patterns of annual treatment yields relative to 4-treatment mean

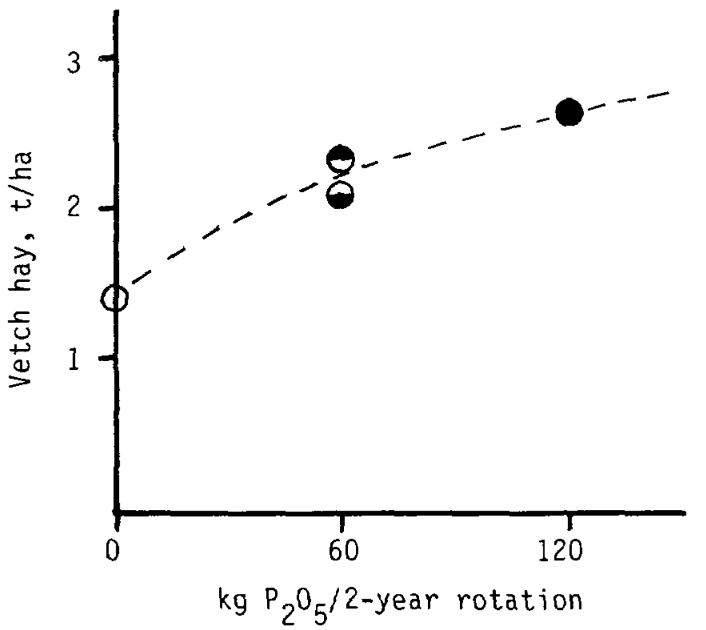


Individual treatment fluctuations around the general mean were much smaller than for barley and were restricted mainly to treatment 6 (Fig. 11b). Its higher phosphate status resulted in greater production when rainfall was sufficient. The considerable importance of phosphate fertilizer is shown by Fig. 12. A single biannual dressing of 60 kg P_2O_5/ha, even when applied to the barley phase of the rotation, greatly increased hay production; but the apparent shape of the response curve implies that even 60 kg applied annually is not sufficient to maximize that production. It may be that so far we have been underfertilizing vetch.

2.3.8 Economics

A simple budget for treatments 1-8 for the years 1982/83 and 1983/84 was given in ICARDA (1985, p 24-28). Table 12 presents the results of similar calculations for 1984/85 and 1985/86 but this time covering eleven treatments. Mean net value (2301 SL/ha) and rate of return (2.18) in 1984/85 were much larger than in the two previous years or in the following year. This was because both the rainfall and the price for barley grain in that year were high (Table 8). Rates of return exceeded 1.0 in all treatments except those involving peas or chickpeas, both crops that were killed by late spring frosts. In 1985/86, mean net value and rate of return were 1208 SL/ha and 1.07, the smaller values reflecting both poorer yields in a drier year and a lower price for barley. In both years, the largest net value and rate of return were achieved by the barley/lentil rotation. This was the result of good yields of both components and good prices for lentil grain and straw.

Figure 12 Old rotation trial: relation between mean vetch hay yields and 2-year phosphate application to the rotation (5-year mean)



Considering eight treatments involving barley/fallow, barley/barley and barley/vetch rotations over four years, we find that annual variability in the rate of return -- an indicator of risk -- was much smaller in barley/fallow than in either barley/barley or barley/vetch rotations (Table 13). This is attributable partly, if not fully, to the conservation of soil moisture under fallow, described above. This moisture assisted barley growth and permitted moderately good rates of return in the two dry years, 1983/84 and 1985/86, thereby moderating year to year variability.

Table 12 Old Rotation trial: economic analysis, 1984/85 and 1985/86

Treatment:	1	2	3	4	5	6	7	8	9	10	11
1984/85											
Gross revenue	1565	5392	890	3122	1884	5279	3906	4384	6560	2856	883
Total costs	511	1230	319	714	883	1358	1133	1253	1375	1717	920
Net value	1054	4162	571	2408	1001	3921	2773	3131	5185	1139	-37
Rate of return	2.06	3.38	1.79	3.37	1.13	2.89	2.45	2.50	3.77	0.66	--
1985/86											
Gross revenue	1045	1810	871	2112	1709	3101	2719	2760	3759	3724	1802
Total costs	551	967	449	818	1060	1478	1256	1348	1341	1723	1152
Net value	494	843	442	1294	649	1623	1463	1412	2418	2001	650
Rate of return	0.90	0.87	0.99	1.58	0.61	1.10	1.16	1.05	1.80	1.16	0.56

Gross revenue, total costs and net value, all in SL/ha.
Rate of return = net value/total costs.
Calculations based on data in Table 8 plus the following:

	1984/85		1985/86	
	Lentils	Chickpeas	Lentils	Chickpeas
Seed, SL/kg	5.0	7.0	5.0	7.0
Harvest+transport costs, SL/ha	556	620	639	713
Grain price, SL/t	2350	3830	2790	3980
Straw price, SL/t	930	325	1000	225

Table 13 Old Rotation trial: rates of return in eight treatments over four seasons

Rotation:	Barley/barley		Barley/fallow		Barley/vetch				
Treament No.	1	2	3	4	5	6	7	8	Mean
1982/83	0.58	1.05	1.01	1.39	0.18	0.60	0.37	0.59	0.72
1983/84	0.86	1.44	2.08	2.22	0.42	0.68	0.79	0.73	1.15
1984/85	2.06	3.38	1.79	3.37	1.13	2.89	2.45	2.50	2.45
1985/86	0.90	0.87	0.99	1.58	0.61	1.10	1.16	1.05	1.03
Mean	1.10	1.69	1.47	2.14	0.59	1.32	1.19	1.22	
% variation	60	69	38	42	69	81	76	72	

Further analysis of the rate of return values in Table 9 demonstrates two additional points:

a. Mean rates of return were appreciably greater in barley/fallow rotations (treatments 3 and 4) than in barley/barley rotations (1 and 2), 1.81 v. 1.40.

b. Fertilizer greatly increased the rate of return in all three types of rotation:

	Treatments	Means	
Barley/barley	1 v 2	1.10	1.69
Barley/fallow	3 v 4	1.47	2.14
Barley/vetch	5 v 6,7,8	0.59	1.24

A completely unfertilized barley/vetch rotation appears to be a particularly poor investment; and unfertilized continuous barley also, except perhaps in a wet year.

2.3.9 Conclusions

The results of Old and New Rotation trials form a coherent picture. The main features are:

1. Fertilizers proved profitable in all rotations. The timing of phosphate within a rotation was not very important, implying good residual effects at least one year after application.

2. In rotations with fallow, barley was apparently buffered against the effects of a dry year by water stored in the soil from the previous, wetter year. Yields in these treatments showed greatest stability and consistently good rates of return. (However, buffering would be unlikely in a succession of dry years.)

3. Yields of continuous barley, unbuffered by any reserve of soil moisture, fluctuated widely with rainfall; but it appeared that such fluctuations could be moderated by extra fertilizer. In any case, rates of return were quite good.

4. Yields of barley in rotation with fodder legumes were intermediate, in level and degree of fluctuation, between those from barley grown continuously and that grown in

rotation with fallow, but growth of the legume beyond the hay stage will probably reduce the stability of barley yields, by eliminating the possibility of stored soil moisture.

5. In all barley/legume rotations, the main costs lie with the legumes. Of the grain legumes, lentils appear to be a very profitable option, chickpeas less so. Of the fodder legumes, vetch was less troublesome than peas; but with either, profitability depends very much on mode of utilization.

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2.4 ON-FARM ROTATION TRIALS WITH BARLEY AND FORAGE LEGUMES

2.4.1 The Mature Crop Option. Introduction

In the 1984/85 season, a comparison of currently practiced two-year crop rotations and alternatives with legumes was begun on farmers' fields and replicated at Tel Hadya. The main purposes were to compare the productivity and economics of: (1) barley in rotation with various legumes, fallow, or barley, and (2) crop production with several fertilizer treatments. A third goal was to evaluate the extent to which damage to nitrogen-fixing nodules by sitona weevil larvae reduces yields of legumes and of a subsequent barley crop. The treatment design is specified in Table 14.

Table 14 Trial design

Treatments	1983/84	1984/85	1985/86
Rotation	Barley	Lentil	Barley
	Barley	Vetch	Barley
	Barley	Lathyrus	Barley
	Barley	Fallow	Barley
	Barley	Barley	Barley
	Barley	Barley+N	Barley+N
Nitrogen (kg)	0	0	0
	0	60	60
Phosphate (kg)	0	0	0
	0	46	0
	0	0	46
	0	46	46
Carbofuran (kg)	0	0	0
	0	30	0

Rotations as main plots split by Carbofuran; phosphate treatments in strips. The Nitrogen treatment is subsumed within the rotation treatment.

One replicate per farm; two at Tel Hadya; 200 m^2 plots.

In the first year of the rotation, substantial treatment effects were found for both legume and barley crops. The results were fully presented in the previous year's report (Tully, Cooper and Keatinge, 1986) and will not be detailed here. In brief, results were as follows:

- Lathyrus and vetch were substantially more productive than lentils, and lathyrus produced more seed than either vetch or lentils.

- Lathyrus was very resistant to sitona damage.

- Lathyrus fixed more nitrogen (as inferred from acetylene reductase activity) than either vetch or lentils, whether or not sitona was controlled.

- Legume crops were less profitable than barley in all farms, and produced less net revenue than barley except at Tel Hadya.

- On the six lowest yielding farms, neither barley nor legumes could be economically grown after barley, and thus continuous cropping is unlikely to be an attractive alternative to a barley/fallow rotation. However, both barley and legumes could be profitably grown after one year of barley on the better fields.

- Phosphate substantially increased yields and net revenues for all species.

- Nitrogen substantially increased yields and net revenues of continuous barley.

- Carbofuran substantially increased yield, nodule survival, and nitrogen fixation of lentils and vetch, and did so to a lesser extent with lathyrus. However it did not pay for itself except at Tel Hadya.

- Carbofuran substantially increased barley yields as well. The explanation for this must be unrelated to sitona weevil control and requires further study.

2.4.2 Barley Yield after Forages, 1985/86

Species, fertilizer and sitona control might be expected to have residual effects which either add to or detract from their effects in a single year. To compare residual effects, a barley crop was planted after all treatments in the 1985/86 season. Phosphate plots from the previous season were resplit into plus and minus additional phosphate plots. Nitrogen was again added to the barley plot which had nitrogen in the previous year, to represent a continuous barley rotation with nitrogen added yearly. Six farmers' fields were dropped from the trial; these include one field which changed hands and five of the lowest yielding fields, where fallow replacement seems least likely based on first year results.

As shown in Table 15, previous crop, phosphate and Carbofuran all had significant residual effects. The biological effects will be discussed first, and then their economic implications.

Table 15 Main effects on barley yield, 1985/86 (kg/ha)

	Fields			Tel Hadya		
	Grain	Straw	TDM	Grain	Straw	TDM
Rotation	**	**	**	**	*	**
Lentil/barley	1135	1094	2228	1821	1405	3226
Vetch/barley	1142	1065	2207	1757	1386	3143
Lathyrus/barley	1376	1252	2628	2041	1607	3648
Fallow/barley	1232	1123	2355	1579	1218	2797
Barley/barley	965	932	1896	1340	877	2217
Barley+N/barley+N	1172	1220	2392	1934	1512	3445
LSD (5%)	185	154	328	137	410	534
Phosphate	**	**	**	+	+	+
None	1026	965	1991	1583	1158	2741
1985 only	1176	1138	2314	1850	1344	3193
1986 only	1159	1106	2265	1617	1315	2932
Both years	1321	1247	2568	1931	1519	3450
LSD (5%)	108	80	177	325	265	571
Carbofuran in 1985	**	**	**	*	**	**
No	1132	1068	2201	1680	1287	2966
Yes	1208	1160	2368	1810	1381	3192
LSD (5%)	38	42	70	117	63	113

ANOVA levels of significance: ** p<.01; * p<.05; + p<.10

Rotation: On farmers' fields, barley following lathyrus was significantly more productive in grain, straw and TDM than barley after vetch or lentil. This is presumably related to the superior nitrogen fixation exhibited by lathyrus in the previous season. The yields of barley after fallow and continuous barley with nitrogen fell in between and were not significantly less than barley after lathyrus. Barley after barley without nitrogen was the worst performer and its TDM was significantly less than all other rotations except vetch-barley. Results from Tel Hadya were similar; the most important exception was that the relative position of barley after fallow was worse. It yielded significantly less grain and TDM than barley after lathyrus or continuous barley with nitrogen. This is probably a result of more weed growth on the fallow at Tel Hadya than on farmers' fields.

Phosphate: The residual effect of phosphate from the previous season was as great as the effect of phosphate applied in the current season. The result appears to be additive; application of phosphate in both years produced the best yields. In farmers' fields with phosphate applied in either year, grain, straw and TDM were significantly greater than those with no phosphate, and significantly less than those with phosphate in both years. Similar results were found in Tel Hadya although not all contrasts are significant.

Carbofuran: Carbofuran showed a significant positive residual effect on grain, straw and TDM on farmers' fields and at Tel Hadya. This effect was observed following both legumes and barley. For straw and TDM, a rotation-Carbofuran interaction was significant at the 10% level in farmers' fields, but this appears to be related only to an absence of any residual effect following fallow. The yield improvement following legumes treated with Carbofuran could possibly be explained in terms of insect control leading to superior nitrogen fixation by the legume crops, and thus a better nitrogen status of the soil in the subsequent year. However, the positive effect of Carbofuran on barley yields, both in the initial and the subsequent year, remains unexplained. Possible mechanisms underlying this effect are being investigated by PFLP; they may be relevant to both legume-barley and continuous barley rotations.

Other than the rotation-Carbofuran interaction just mentioned, no significant interactions were observed.

2.4.3 Economic Analysis of the Two Years' Results (1984/85, 1985/86)

The revenue and profitability of the various treatments over a two year period will now be compared, using the data from farmers' fields. One farm with a large number of missing values in the first season has not been included in the means. Because there are no significant interactions, economic analysis will largely be restricted to main effects (Table 16). For simplicity, 1985 prices will be used for both planting and harvest values in both years, and no considerations of present value or inflation will be made.

Carbofuran: As previously reported, Carbofuran did not pay for itself in the first year of application. In the second year, the residual effect added to the first year's effect increased the benefits of the treatment; nevertheless over two years the overall result was a decrease in mean net revenue. Although the Carbofuran-rotation interaction was only significant at the 10% level, it is worth mentioning that increased revenues do cover costs of Carbofuran in the continuous barley and vetch/barley rotations, albeit at a low rate of return. Because of the positive effect on yields, cheaper alternatives to this treatment are being studied, including lower rates of Carbofuran application, and alternatively the use of nitrogen fertilizer on legumes. The hypothesis that control of a pathogenic effect by Carbofuran is responsible for the increase in barley productivity is being studied by PFLP.

Table 16 Economics of main effects in farmers' fields (SL/ha)

	Revenue			Net revenue			Percent profit		
	1985	1986	Total	1985	1986	Total	1985	1986	Total
Rotation (1)									
Lentil/barley	1920	2025	3945	853	1379	2231	76	202	127
Vetch/barley	2168	1926	4094	1053	1288	2341	87	190	128
Lathyrus/barley	2435	2326	4761	1202	1637	2839	91	223	144
Fallow/barley (2)	0	2091	2091	-97	1436	1339	-100	206	168
Barley/barley	1939	1722	3661	1340	1112	2452	181	165	177
Barley+N/barley+N	2295	1997	4292	1401	1101	2503	142	119	132
Phosphate (1)									
None	1648	1766	3414	905	1173	2079	82	184	153
1985 only	1938	2040	3978	1013	1416	2429	77	220	153
1986 only	1648	1977	3625	905	1173	2131	82	184	137
Both years	1938	2273	4211	1013	1486	2499	77	181	141
Carbofuran in 1985									
No	1793	2014	3807	959	1325	2284	80	184	146
Yes	2055	2159	4215	780	1453	2234	41	197	106

(1) Means for rotation and phosphate exclude treatments with Carbofuran
(2) Fallow/barley means include applications of phosphate on fallow. This is not considered a likely farmer practice. Excluding these cases, the values would be: revenue: 0, 2034, 2034; net revenue: -30, 1383, 1353, percent profit: -100, 196, 183.

This treatment was included primarily as a diagnostic on the legumes, with applications to barley and fallow for control purposes only. The substantial response of barley to this treatment was not anticipated. Because it is not considered as a possible technology for use by farmers at the present time, Carbofuran treatments will be excluded from the remaining economic analysis.

Rotation: Fallow/barley and continuous unfertilized barley are low input/low output rotations, with low net revenues but high rates of return; thus they are likely to be favored by cash-poor farmers. With more investment, more income per hectare can be obtained, and in terms of combining high net revenue with a high rate of return on investment, two rotations excel: lathyrus /barley and barley/barley with nitrogen. It is encouraging that a legume/barley rotation is able to compete with continuous barley plus nitrogen, because it is expected that the latter rotation will not maintain its productivity over the longer term. Indeed, barley/barley with nitrogen produced no more net revenue than barley/barley without nitrogen in the second year.

Because of its large seed yield and positive residual effect, lathyrus appears to be the legume of choice in these environments. It should be noted, however, that the economic assumptions used include an equal seed and straw price for all legumes. In this year official lentil prices were increased, which would improve the relative standing of that crop; in addition, marketing and seed purchase are much easier for lentils than for vetch and lathyrus. On the other hand, much of the increased net revenue of the lathyrus/barley rotation is achieved in the barley year; thus the economic results are partially insulated from changing legume prices.

Phosphate: As previously reported, phosphate in the 1984/85 season substantially increased net income from legumes and barley; in the current season income was also increased but to a lesser extent. Money spent on phosphate in 1985/86 returned a 61% profit the same year whereas in 1984/85 it returned a 105% profit. By including residual effects, the economic return to phosphate is improved. Money spent on phosphate in 1984/85 increased mean net income over two years by SL 413, which represents a 308% profit.

2.4.4 Conclusion

On-farm trials have confirmed that legume/barley rotations can profitably increase the productivity of farmers' fields which are currently used in a fallow/barley rotation. Lathyrus has been identified as a legume with high yield potential and a positive residual effect on a subsequent barley crop. Phosphate fertilizer can be used to increase income per hectare and is particularly profitable when residual effects are considered. Legume responses to Carbofuran indicate that damage by sitona weevil does decrease legume yields and also has a negative residual effect on a subsequent barley crop; responses by barley also suggest the existence of soil pathogens which need to be identified. The Carbofuran treatment used was expensive for these areas, and gave little profit. Less expensive techniques to improve the availability of nitrogen to legume crops would be more attractive to farmers.

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2.4.5 The Grazing Option. A Stochastic Analysis of Subsequent Barley Yields. Introduction

On-farm forage grazing trials were conducted in 1984/85 near Bueda and Breda villages, southeast of Aleppo, where barley is the principal crop, grown either continuously or alternating with fallow (Thomson et al., 1985).

Vetch and lathyrus with (50 kg/ha P_2O_5) and without fertilizer, separated by a fallow strip, were sown in each site. These trials were grazed by Awassi ewes to measure the milk yield and the liveweight gain (Thomson et al., 1986). In 1985/86, uniform barley was sown to all fields where forages and fallow had been the year before. In order to determine the effects of the replacement of the fallow in the traditional Fallow/Barley (F/B) rotation by fertilized and unfertilized forage crops, the total dry matter yield (TDM), grain yield (GY) and straw yield (SY) of barley were measured.

2.4.6 Results

The barley yields in 1986, across six locations (farms) are examined in stochastic (probabilistic) terms. Data for the rotations fallow/barley (F/B), fertilized vetch/barley (V+/B), unfertilized vetch/barley

(Vo/B), fertilized lathyrus/barley (L+/B) and unfertilized lathyrus/barley (Lo/B) were collected. From each location and for each rotation, ten samples of barley crop yields were taken.

For barley yield comparisons, the ten samples/field were bulked to provide a yield estimate for that field, and standard analysis of variance was done treating locations as replicates. In addition, the sixty samples taken from each rotation across locations were also examined to assess the probability of yield distribution of barley yields within each rotation.

The calculation of probability distributions of the TDM, GY and SY is only applicable when the data follow normal distributions (Weber, 1980, pp 150ff). Thus, the pooled data for each rotation were first tested for normality by a modified form of the Kolmogorov-Smirnov test (Hartung, 1985, pp 187ff; Lilliefors, 1967), outlying observations were detected and discarded according to the Grubbs-test (Grubbs/Beck, 1972). Based on the arithmetic means and respective standard deviations (STD), the probability distributions of the yields of five different rotations were defined. These distributions serve as indicators for the stability of yields between different locations in one year.

The distributions of the GY and the SY for the five rotations are skewed (the coefficient of skewness for an ideal normal distribution is 0) and show pronounced peaks (the coefficient of kurtosis of an ideal normal distribution is 3, Table 17); however, according to the

Kolmogorov-Smirnov test they can be regarded as normal (to accept the hypothesis of normality at p=0.9, the D-value for n=55 must be smaller than 0.108 [Lilliefors, 1967]).

Table 17 Effects of different rotations on the yield distributions of barley (kg/ha) following forage legumes and bare fallow, 1985/86

Rotation	Mean	STD	c.k.*	c.s.**	D-value***	n
Grain Yield (kg/ha)						
F/B	814	352	2.79	0.21	0.077	56
V+/B	1287	284	3.00	0.34	0.048	52
Vo/B	988	363	3.00	0.08	0.081	54
L+/B	1486	373	3.11	0.68	0.100	53
Lo/B	1045	471	3.00	0.49	0.068	56
LSD (0.05): 373 kg/ha						
Straw yield (kg/ha)						
F/B	750	309	2.46	0.08	0.084	56
V+/B	1206	393	2.08	0.26	0.078	52
Vo/B	911	256	2.40	-0.39	0.079	54
L+/B	1273	411	3.16	0.61	0.100	53
Lo/B	894	377	2.60	0.44	0.089	56
LSD (0.05): 406 kg/ha						

Note: LSD (0.05) values are calculated from mean values of 10 sample/plot for comparison of mean grain and straw yields for each rotation.

* Coefficient of kurtosis
** Coefficient of skewness
*** Kolmogorov-Smirnov statistics

As can be seen from Table 17, the replacement of fallow with a fertilized forage crop has a significant yield-increasing effect on grain and straw. When the fallow is replaced by unfertilized vetch or lathyrus, similar, but non significant trends were observed, and reference to Fig. 13 shows that the yields of barley follow very similar distributions. However, barley yields after vetch tend to be more stable (the STDs of the grain and straw yield of barley after unfertilized vetch are smaller than those following lathyrus). The mean grain yields of barley after fertilized vetch and fertilized lathyrus increase significantly but the STDs do not, suggesting that fertilizer applications to these forages stabilizes subsequent yields of barley (Table 17).

Replacing fallow with an unfertilized grazed forage legume increases the probability of achieving a barley grain yield of 814 kg/ha (the mean yield after fallow) from 0.50 to 0.68 and 0.69 following vetch and lathyrus respectively (Table 18). Similarly, the probability of achieving 1221 kg/ha of grain yield (50% higher than the mean yield after fallow) in the F/B rotation is only 0.12, but increased to 0.33 in the Vo/B rotation and 0.36 in the Lo/B rotation. However, where barley grew on residual phosphate fertilizer, the respective probabilities rose to 0.58 for V+/B rotation and 0.76 for the L+/B rotation.

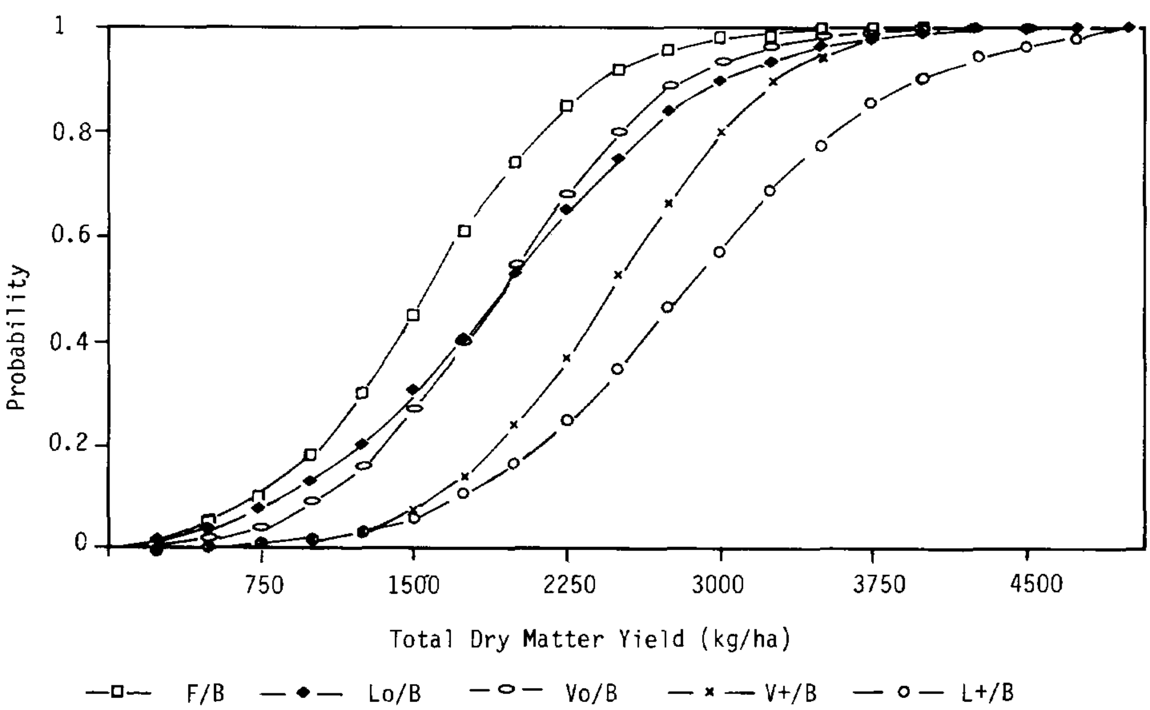

Figure 13 Cumulative probability functions showing the distributions of the Total Dry Matter Yield of barley in different rotations

Table 18 Probabilities of reaching the mean of TDM, GY and SY of the fallow/barley rotation, when the fallow was replaced by forage crops,* 1986 barley harvest

Rotation	Total Dry Matter (TDM)	Grain Yield (GY)	Straw Yield (SY)
F/B	0.50	0.50	0.50
V+/B	0.91	0.95	0.88
Vo/B	0.69	0.68	0.73
L+/B	0.93	0.94	0.90
Lo/B	0.66	0.69	0.65

* Calculated from information given in Table 17.

2.4.7 Conclusions

A probabilistic treatment of agronomy results which accounts for variation within and between years, is an essential step towards their use in whole-farm analyses. These measurements are planned to continue on barley crops following fallow and forages for two more seasons. Thus, by the 1988 harvest, two years of barley yield results will be available at the same locations.

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3. WHEAT BASED SYSTEMS RESEARCH

3.1 INTRODUCTION

As indicated in section 1.1 of this report, our research within the wheat based systems is component orientated towards the mandate crops of ICARDA which are predominantly grown in these wetter and higher potential farming systems, namely wheat and food legumes. Our long-term goals and objectives are:

Objectives

To enhance productivity, yield stability, and income of farmers in areas receiving more than 350 mm of rainfall where wheat, food legumes and summer crops are the predominant annually sown crops. Emphasis is placed on improvements in wheat and food legume production whilst ensuring that improvements in these components are evaluated in the context of whole farming systems.

Long-Term Goals

a) To evaluate, in cooperation with CP the potential for increased wheat production through improved husbandry, weed control, fertilizer use and variety introduction, and to assess, through on-farm research and testing, current wheat production practices and potential constraints to adoption of improved recommendations.

b) To assist National Programs in improving and extending current recommendations to wheat growers.

c) To assist FLIP in research and evaluation of improved food legume production practices, with special reference to improved BNF, weed control, and water use efficiency.

d) To assist FLIP and National Programs in evaluation, modification and extension of improved practices through surveys and on-farm testing and demonstration.

e) To evaluate potential improvements in wheat and food legume production in the greater context of both cropping and farming systems.

Last year we reported the initial findings of a survey of wheat producers in NW Syria (Rassam and Tully, 1986) which highlighted the considerable variability of wheat production practices in the area. This year we supplement that report with an economic analysis of farmers' yields in the 1984/85 which illustrates an associated variability of profit margins. We also report the results of a set of on-farm trials, designed to answer some questions raised in the survey analysis, which examined the interaction between crop rotation, N and P fertilizer use and herbicide application. This type of commodity focussed survey, and the information it provides, helps to focus and generate research activity of priority and relevance. Previous surveys of this type on lentil and barley have proved equally useful, and current surveys by our FSR project in Goubellat, Tunisia, are forming the basis of an expanded livestock/forage research program. As indicated in section 1.1, we consider the development of methodologies of survey design, execution and analyses, and their linkage with identification of research objectives to be a high priority for ICARDA and of great benefit for National Programs.

Initial results from our large plot two-course rotation trial at Tel Hadya are also presented. This trial examines the interaction of crop rotation, wheat stubble management and nitrogen fertilizer, and complements the results of our on-farm trials. Lastly, on wheat, we present a summary highlight of a PhD student's research on the soil and plant dynamics of urea fertilizer applied to wheat.

Our research on food legumes centers around on-farm testing and economic evaluation of improved production techniques for lentil and chickpea which were developed in cooperation with FLIP. Such on-farm research is very applied, and the results will be of direct benefit to the Syrian farmers. In this respect, we hope to expand such work in the future in collaboration with the National Programs. However, we are also well aware that in such trials there are special techniques associated with trial design, site selection, economic analyses and identification of specific recommendation domains for innovative production practices. These need to be thoroughly evaluated as a continuing part of our core research program in order that we may assist National Programs in the future.

3.2 ECONOMICS OF WHEAT PRODUCTION IN NORTHWESTERN SYRIA

3.2.1 Introduction

In the 1984-85 cropping season a diagnostic survey of wheat producers was carried out in the provinces of Aleppo, Idleb, Homs and Hama. Basic results were reported last year (Rassam and Tully, 1986). During the current season an additional visit was made to follow up the disposition of the previous year's crop and prices received. With this information it is possible to analyze wheat production budgets for the 1984/85 season. The season was somewhat worse than average due to frost, and the effect of this was irregular in severity (ICARDA 1986, p 4-7). Several years of data would be preferable to characterize the economics of wheat production. One season can, however, give a general idea of its profitability and especially the risks that farmers face.

3.2.2 Results and Discussion

Of wheat harvested in 1985, the average sample household sold 56%, consumed 30%, used 8% as seed and 6% as feed. In subsequent calculations, wheat produced will be valued at the price received for wheat sold.

In the following discussion a small number of farmers who had stated that they would not irrigate, but then used supplementary irrigation, are excluded because of uncertainty over the costs of their water use, which made calculation of net revenues impossible, it is also not clear how common it is for them to irrigate. However it is worth mentioning that supplementary irrigation was associated with high gross revenues in this season, averaging nearly SL 7000 compared to SL 2000 for others. The economics of supplementary irrigation require special attention and are being addressed in other FSP projects (see section 4.6).

As would be expected, there is considerable diversity in the costs, revenues, net revenues, and rates of return experienced by farmers. On a per-hectare basis, the average rainfed farm spent SL 942 on inputs and SL 454 on harvest, received gross revenue of SL 1964, for a profit of SL 569, which is 41 percent of total costs. However, this average is a rare situation, in fact 28% of farmers lost money, including 12% who turned the crop under after frost damage. Figure 14 shows the wide distribution of costs and revenues in the data set; individual variables are highlighted in Figure 15. Costs show considerably less diversity than revenue and rates of profit.

The farms were divided into four equally sized groups according to their total input costs to compare patterns of expenditures, revenues, and profits (Table 19). The lowest-spending farmers (Group 1) used minimum inputs and received the lowest gross revenues and net revenue of all groups, however, their profit was high as a percentage of input costs. Group 2 spent 42% more on inputs and more than covered their costs, this group of moderate spenders achieved the highest net revenue. Groups 3 and 4 have higher rates of investment, but in these groups both net revenue and rates of profit decline in spite of higher gross revenues, the increased yields are insufficient

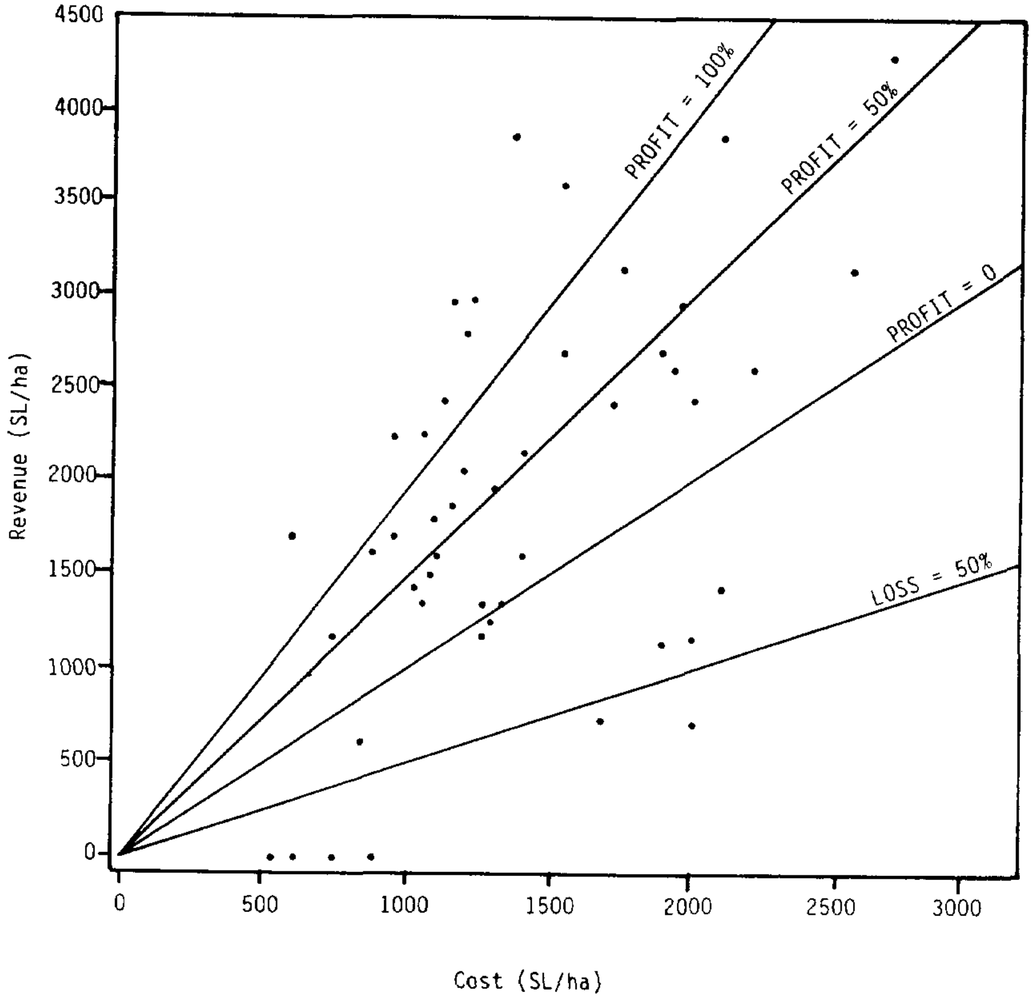
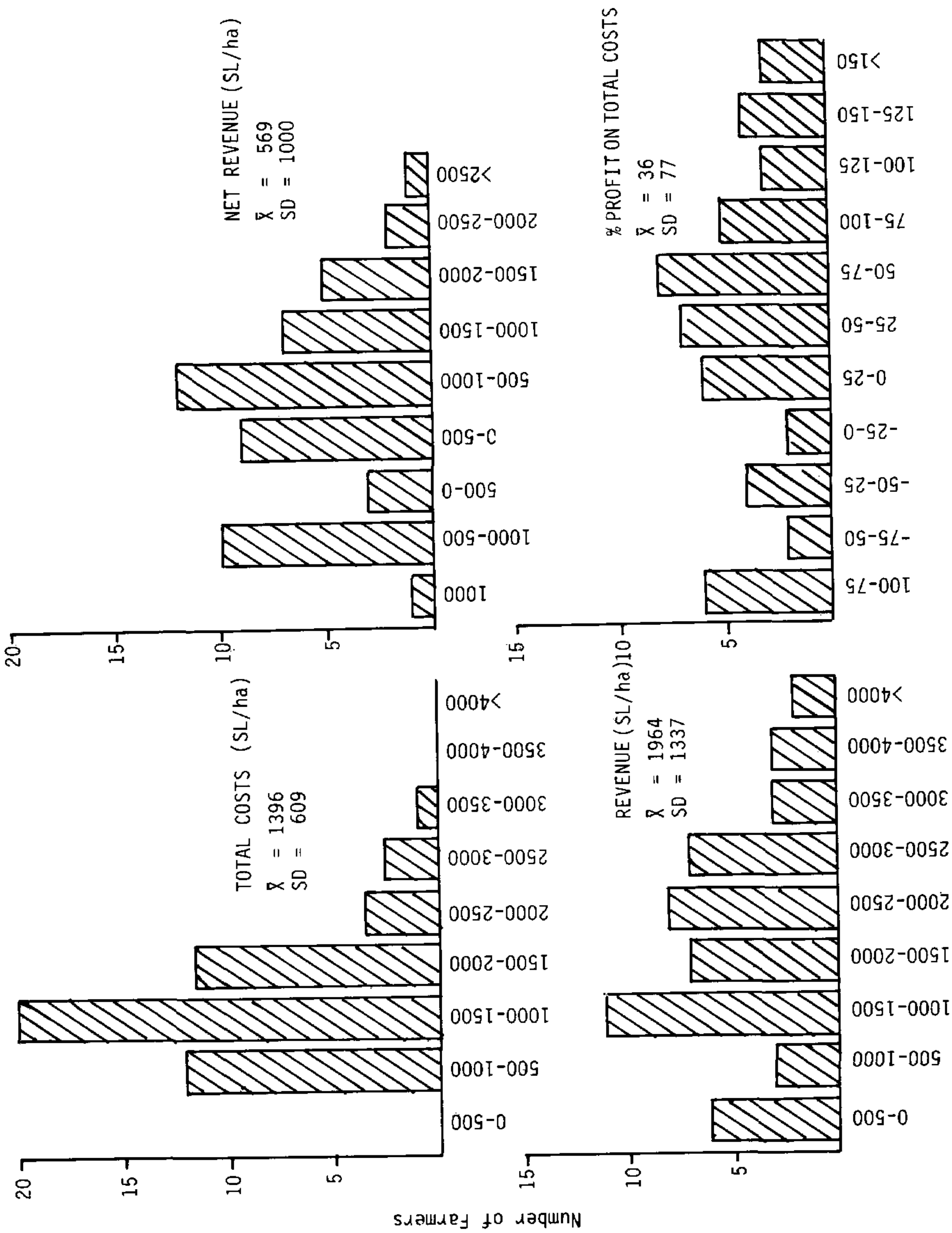


Figure 14 Distribution of revenues vs costs for sample wheat farmers (SL/ha).


NET REVENUE (SL/ha)
X̄ = 569
SD = 1000
% PROFIT ON TOTAL COSTS
X̄ = 36
SD = 77
TOTAL COSTS (SL/ha)
X̄ = 1396
SD = 609
REVENUE (SL/ha)
X̄ = 1964
SD = 1337
Number of Farmers

to repay the extra investment. Thus in this season a strategy of moderate investment in wheat production appears to have been optimal.

Table 19 Mean expenditures and revenues by farmers grouped according to their input costs (SL/ha)

Input Cost Group	1	2	3	4
Range (SL)	430-690	690-900	900-1060	1060-1700
Rainfall 84/85	415	405	436	646
Mean Costs of (SL)				
Cultivation	105	120	232	385
Phosphate	47	150	102	70
Nitrogen	138	201	261	286
Seed and Planting	259	271	324	445
Weed Control	19	67	75	189
Total Input Costs	568	809	994	1375
Harvest/Post Harvest	383	245	477	706
Total Costs	950	1053	1471	2080
Revenue	1383	1741	1956	2733
Net Revenue	432	688	485	653
Percent Profit, Overall	45	65	32	31
Percent Profit on Inputs	76	85	48	47

Costs for different inputs are not significantly correlated among themselves, with the exception of seed and nitrogen fertilizer ($r=.54$, $p<.01$) and phosphate with cultivation ($r=-.26$, $p<.05$). The latter is in fact a negative correlation. Thus it appears that in general, farmers make decisions about each input independently, rather than using them in fixed proportions.

Input use, soil quality, and rainfall are closely linked, for example, as reported last year, farmers determine their application of nitrogen after observing part of the seasonal rainfall. Therefore survey results (unlike trials) cannot be used to estimate the independent importance of these factors in determining yield. In combination, using multiple linear regression, input costs, soil quality (good vs. poor), and seasonal rainfall explain 42% of the variance in gross revenue. The remaining variance is presumably associated with more complex soil and environmental characteristics, and management. Interestingly, these variables explained much less of the variance in net revenue and rate of return, and only soil quality was significant in those equations.

As reported last year rotation plays an important role in determining input use. In particular, farmers growing wheat after irrigated summer crops apply more cultivation, seed and nitrogen than the amounts used after other crops. The resulting wheat crop more than covered costs. Mean net revenue after irrigated summer crops was SL 1501, compared to 965 after rainfed summer crops, 476 after legumes, and 135 after fallow. Rotation may well be associated with environmental factors determining yield, but the cases are too few for a combined analysis of variance (see also section 3.3 for rotation effects on economics of wheat production).

Farm size is also commonly cited as a factor affecting farm management, which includes decisions about input use and affects the return one receives on investment. In terms of simple correlations, owners of small farms appear to use more of most inputs, although they did not get significantly better net revenues or profits. (As mentioned above, users of high amounts of inputs did not do well this season.) We know from previously reported results (Rassam and Tully) that input use depends upon rainfall and soil type; farm size is also partially dependent on these variables, being smaller in more productive areas. Therefore it is necessary to include these variables while testing the effect of farm size.

By carrying out a regression on inputs, revenues and profits with farm size in combination with environmental variables, it can be demonstrated that investment in cultivation is significantly greater on small farms even after accounting for environmental factors; similarly, farm size explains 12% of the variance in input costs after soil and rainfall are taken into account. Thus farmers with limited land resources invest more money per hectare in their holdings even with environmental factors held constant.

Due to the increasing incidence of off-farm employment, it is important to determine its effect on the management of farms. There is some confounding in the data set because high levels of off-farm income are found in areas of poor soil. If these cases are removed, there appears to be no relationship between off-farm income and expenditures on any inputs. In spite of this, revenue per hectare is negatively correlated with the proportion of family income earned off-farm ($r=-.30$, $p<.05$), this is also true for net revenue ($r=-.36$, $p<.05$) and rate of profit ($r=-.24$, $p<.10$). While the direction of causality cannot be certain based on existing data, it is likely that the management and supervision required to get the best return on investment may be lacking if off-farm income is playing a major role in family finances. Survey work will be directed at this issue by the Agricultural Labor and Technological Change project in the 1986/87 season.

D. Tully, A. Rassam

3.3 NITROGEN, PHOSPHATE AND HERBICIDE EFFECTS ON FARMERS' WHEAT PRODUCTION

3.3.1 Introduction

Wheat is grown in wetter areas (over 325 mm mean annual rainfall) of Syria where a fairly complex mix of crops and rotations prevail. ICARDA has a regional responsibility for research on wheat and has engaged in wheat breeding and agronomy research since its establishment. Within the Farming Systems Program, results of research on wheat involving tillage systems, fertilization, weed control and rotations with nitrogen fixing legumes have been encouraging. Particularly earlier sowing, improved weed control and the use of nitrogen and phosphate have been found effective (ICARDA, 1984, p 5-12; ICARDA, 1986, p 56). However, these responses show large interactions; improved yields from one innovation may depend upon adoption of a set of associated practices. The feasibility of new technologies depends in part on the existing farming system. Therefore, a detailed survey of wheat producers in northwestern Syria was undertaken in 1984 to obtain additional information on wheat-based farming system. The aim of the survey work was to determine the relevance of current research results and to provide direction for new research (see section 3.2).

Survey results indicated that increased experimentation with different cultivation practices and the weed control-fertilization interaction in on-farm trials would interest farmers considerably. Therefore in 1985/86, unreplicated factorial trials were sown in 14 farmers' fields in NW Syria (Aleppo, Idleb, Hama and Homs provinces) and at Tel Hadya research station to assess the effect of crop rotation and rainfall on nitrogen and phosphate response surfaces of wheat and their interaction with herbicide use.

3.3.2 Methodology

Thirty-two treatment combinations of 4 nitrogen levels (0, 60, 120, 180 kg/ha N, half at planting, half at tillering), 4 phosphate levels (0, 50, 100, 150 kg/ha P_2O_5, at seeding) and 2 weed control levels ($\pm$ herbicide; bromoxynil + diclopmethyl 0.5 kg ai/ha + 1.0 kg ai/ha applied at 4 leaf stage) were tested. Experiments were planted according to farmers' tillage and sowing methods of broadcasting seed and fertilizer over ridged land and splitting the ridges to cover the seed and fertilizer. Plants per unit area, grain and straw yields, 1000 kernel weights, protein and vitreousness percentage of grain were measured in all plots. Weeds per unit area, and weed dry matter production were measured in 8 selected treatment combinations (0, 180 kg/ha N, 0, 150 kg/ha P_2O_5 and ± herbicide).

3.3.3 Results and Discussion

Without exception broadleafed weed infestation was much greater than grasses in each location. Across all locations 89% of the weedy plots were covered by broadleafed weeds (mainly Sinapis arvensis, Vaccaria pramidata, Euphorbia spp. and Vicia spp.) and 11% by grasses (mainly Phalaris spp. and Avena sterilis). Weed dry matter, as affected by previous crop and the treatments imposed, are given in Table 20. Herbicide was clearly effective in controlling weeds, and as would be expected, weeds responded to both nitrogen and phosphate fertilizer. Weed infestation was similar in wheat crops preceded by chickpea and rainfed summer crops, but was markedly less in wheat fields preceded by irrigated summer crops. The reason for this is not clear, but may reflect a generally better level of management on farms with access to irrigation water.

Table 20 Main effects of nitrogen, phosphate and herbicide on weed dry matter production (kg/ha) as influenced by previous crop.*

Previous crop		Chickpea	Rainfed summer crop	Irrigated summer crop
Herbicide	-	1204	1363	413
	+	67	33	3
Nitrogen (kg/ha)	0	335	575	140
	180	936	821	276
Phosphate (kg/ha)	0	607	582	149
	150	665	813	268

* Sampled at crop anthesis.

Soil analysis for N and P and average grain and straw yields for each location are shown in Table 21. Mean yields of grain and straw for the contrasting rotations were significantly ($p<.01$) different from each other and also varied from location to location within each rotation system. The large yields following irrigated summer crops, can be explained by the greater amounts of available-N and P in the soil, together with the probability of residual moisture from the summer irrigation. The superiority of wheat following rainfed summer crops over that following chickpea is not so easily accounted for. The nutritional status of the soils was not significantly different, but other studies have shown that summer crops such as melon do not utilize all stored water in the profile, and that subsequent wheat crops are able to utilize this moisture (ICARDA, 1984, p 40-45, Cooper, et al., 1986).

The main effects and interactions of N, P, and herbicide were analysed for grain and straw yields of wheat with locations grouped according to previous crop (Tables 22 and 23). Both grain and straw yields were significantly increased by nitrogen application on wheat following chickpea ($p<0.01$), but responses were less pronounced following rainfed summer crop where grain yield was only significantly increased when herbicide was applied, and no significant response was found for straw yields. In wheat crops following irrigated summer crops, no response to nitrogen was found, reflecting the high available nitrogen status of the soil (see Table 21).

Table 21 Soil analysis for N and P and average grain and straw yield in wheat on-farm trials, 1985/86.

Province	Village	Previous crop	kg/ha Grain	kg/ha Straw	Mineral-N ($NH_4^+ + NO_3^-$) ppm Mean (0-100 cm)	P-Olsen (ppm) (0-20 cm)
Aleppo	Alkamieh	Chickpea	3183	4768	7.3	5.2
Aleppo	Afrin	Chickpea	3851	4463	10.1	3.4
Aleppo	Der Sawan	Chickpea	2049	2557	6.8	4.4
Aleppo	Tel Hadya	Chickpea	1654	2855	13.0	7.8
Idleb	Taoum	Chickpea	2020	2742	6.4	4.9
Idleb	Jallool	Chickpea	3418	3043	10.8	6.0
Idleb	Dar Kbira	Chickpea	1906	2258	10.8	4.9
		Mean	**2583**	**3241**		
Idleb	Taoum	Rainfed s.c.	3487	3562	11.8	3.4
Idleb	Al-Dower	Rainfed s.c.	2238	2706	7.8	4.2
Idleb	Afes	Rainfed s.c.	4253	4318	8.2	3.4
Idleb	Afes	Rainfed s.c.	2606	2659	11.3	3.5
		Mean	**3146**	**3311**		
Homs	F. Sharkieh	Irrigated s.c.	4313	5012	15.7	15.4
Homs	F. Gharbieh	Irrigated s.c.	4531	6351	28.4	42.5
Homs	Fanto	Irrigated s.c.	3403	4846	9.2	16.7
Homs	Fanto	Irrigated s.c.	5429	5989	14.6	23.1
		Mean	**4419**	**5549**		

Table 22 Grain yield of wheat (kg/ha) following chickpea, rainfed summer crop and irrigated summer crop, 1985/86.

	N (kg/ha)				P_2O_5 (kg/ha)				
	0	60	120	180	0	50	100	150	Mean
				Previous crop - Chickpea					
-H	2033	2480	2620	2291	2234	2425	2365	2400	**2356**
+H	2334	2880	2953	3071	2659	2842	2829	2910	**2810****
Mean	**2184**	**2680** **	**2787**	**2681**	**2446**	**2634** NS	**2597**	**2655**	**2583**
				Previous crop - Rainfed summer crop					
-H	2998	2630 **	2596	2768	2825	2648	2810	2708	**2748**
+H	3168	3650	3487	3872	3373	3573	3515	3716	**3544****
Mean	**3083**	**3140** NS	**3041**	**3320**	**3099**	**3110** NS	**3162**	**3216**	**3146**
				Previous crop - Irrigated summer crop					
-H	4194	4677	4018	4041	4370	4348	4421	3792	**4233**
+H	4243	4616	4798	4766	4631	4437	4742	4613	**4606***
Mean	**4219**	**4646** NS	**4408**	**4404**	**4500**	**4393** NS	**4581**	**4202**	**4419**

LSD (0.05) (Chickpea): Nitrogen 223 kg/ha; Herbicide 158 kg/ha

LSD (0.05) (Rainfed summer crop): Nitrogen x herbicide 399 kg/ha; Herbicide 199 kg/ha

LSD (0.05) (Irrigated summer crop): Herbicide 327 kg/ha

* $p<0.05$
** $p<0.01$

Table 23 Straw yield of wheat (kg/ha) following chickpea, rainfed summer crop and irrigated summer crop, 1985/86

	N (kg/ha)				P_2O_5 (kg/ha)				
	0	60	120	180	0	50	100	150	Mean
				Previous crop - Chickpea					
-H	2366	2908	3178	3344	2941	3043	2845	2968	**2949**
+H	2788	3575	3856	3912	3403	3317	3672	3739	**3533****
Mean	**2577**	**3241** **	**3517**	**3628**	**3172**	**3180** NS	**3259**	**3353**	**3241**
				Previous crop - Rainfed summer crop					
-H	2811	2785	3017	2970	3043	2802	2930	2809	**2896**
+H	3617	3563	3730	3995	3831	3526	3675	3873	**3726****
Mean	**3214**	**3174** NS	**3374**	**3482**	**3437**	**3164** NS	**3302**	**3341**	**3311**
				Previous crop - Irrigated summer crop					
-H	5477	5690	5645	5393	5762	5341	5758	5344	**5551**
+H	5334	5809	5924	5125	6558	4925	5035	5674	**5548**NS
Mean	**5405**	**5749** NS	**5784**	**5259**	**6160**	**5133** **	**5396**	**5509**	**5549**

LSD (0.05) (Chickpea) Nitrogen 382 kg/ha; Herbicide 270 kg/ha

LSD (0.05) (Rainfed summer crop) Herbicide 198 kg/ha

LSD (0.05) (Irrigated summer crop) Phosphate 582 kg/ha

* $p<0.05$
** $p<0.01$

There were no positive responses to phosphate application in any of the three groups of crop rotations, but a significant negative response of straw yield was found in wheat following irrigated summer crops. This is probably associated with the much better phosphate status of these soils (Table 21). It is surprising that no response was observed in the other rotations where the phosphate status was considerably poorer, particularly in wheat following rainfed summer crops where the mean phosphate level was only 3.6 ppm Olsen-P. In the drier areas of Syria where barley is grown, substantial responses to P-fertilizer are observed in soils with similar P-status (ICARDA, 1986, p 20-23, section 4.5 of this report). Further work is required to assess the interaction between soil type, crop, rainfall and the critical level of soil available P above which no responses would be expected. Such work is a major component of the research planned for the coming 1986/87 season.

Herbicide application gave large and significant responses of grain and straw yields ($p<0.01$) in wheat following chickpea and rainfed summer crop, but had a less pronounced effect on wheat following irrigated summer crops where only a small response of grain yield ($p<0.05$), and no response to straw yield was observed, thus reflecting the level of weed infestation in these fields (see Table 20). In general, farmers involved with these trials indicated that they appreciated the value of herbicides and were able to judge if and when they needed to apply them. They were less clear, however, about suitable rates of fertilizer application, and thus in future on-farm trials will focus on this aspect, and uniform herbicide application will be made across each trial.

Since no response to phosphate was observed in any of the three groups of trials, economic analysis was limited to the application of nitrogen and herbicide. Increase in net revenue was calculated for the various nitrogen-herbicide combinations for wheat following chickpea and rainfed summer crops using the following cost/price assumptions:

Nitrogen	- 3.20 SL/kg N (including application cost)
Herbicide	- 319 SL/ha (including application cost)
Harvest cost	- 10% of the gross revenue (including bagging and transport)
Wheat grain	- 1.85 SL/kg
Wheat straw	- 0.63 SL/kg

Increases in net revenue were calculated and subjected to dominance analysis. The dominant treatments are given in Table 24.

Table 24 Economic analysis of nitrogen and herbicide application on wheat following chickpea and rainfed summer crop

Treatment	Increased revenue SL/ha	Increase cost SL/ha	Marginal rate of return %
	Previous crop - Chickpea		
N_{60} H-	859	309	278
N_{60} H+	1584	744	166
N_{120} H+	1973	967	174
	Previous crop - Rainfed summer crop		
N_0 H+	962	461	209
N_{60} H+	1542	739	209

The economic optimum is defined as the treatment which provides the greatest increase in net revenue without the marginal rate of return falling below 40%.

In wheat following chickpea, the application of nitrogen (60 kg/ha N) produced a good increase in net revenue at comparatively low cost with a very attractive marginal rate of return of 278%. However, when herbicide was also applied, increase in net revenue was nearly doubled and high marginal rates of return were maintained with both 60 and 120 kg/ha N. Where wheat was preceded by rainfed summer crop, decreases in net revenue were observed in all treatments where herbicide was not applied. The application of herbicide alone gave a substantial increase in net revenue with an attractive marginal rate of return of 209%. The application of herbicide and 60 kg/ha N nearly doubled net revenue, but maintained the same high marginal rate of return. Increasing the level of applied nitrogen above 60 kg/ha gave slight but erratic increases in net revenue with low marginal rates of return.

In conclusion, in both chickpea-wheat and rainfed summer crop-wheat rotations, herbicide plus nitrogen fertilizer application to wheat were economically very attractive. The data indicate that where wheat follows chickpea, higher levels of nitrogen application should be used.

M. Pala, A. Mazid, P. Cooper

3.4 PRODUCTIVITY OF WHEAT-BASED ROTATIONS AT TEL HADYA

3.4.1 Introduction

Wheat is the major food crop of West Asia and North Africa. It is the main source of calories and protein in the diet of people in this region, and regional per capita consumption is the largest in the world.

In Syria, as in other countries in the region, wheat is grown predominantly in wetter areas (> 300 mm of rainfall) where production exceeds household needs and surpluses are marketed. In these areas, wheat is grown in association with other crops in a quite complex farming system. It may be rotated with winter or spring sown food legumes, rainfed or irrigated summer crops, or fallow, in either two or three year rotations. A recent survey shows that about 40% is grown in two course rotations with either legumes, fallow or rainfed summer crop (Rassam and Tully, 1986).

A further component of the wheat based farming systems is livestock, mainly sheep, but also goats and cattle. These animals may be kept by farmers in the wheat growing areas and be a permanent part of the system, or they may be brought in seasonally from less favoured rainfall areas to graze on the residues of both rainfed and irrigated crops. The provision of a year-round feed supply for those stock kept permanently is an integral part of the functioning of the system.

ICARDA carries out research on many of the components of these systems - wheat, winter and spring sown food legumes and forage crops for animal feed stuffs. After several years of work on the individual components of the system, it was considered timely to begin to apply research results, under controlled conditions, to measure the potential productivity of contrasting cropping systems using the best production methods known to ICARDA.

3.4.2 Methodology

Both phases of a two course rotation of wheat with either food or forage legumes, or fallow, or summer crop were established on Tel Hadya in the 1983/84 season. Two seasons were allowed for the rotations to come to equilibrium, and in 1985/86 improved crop production methods were applied for the first time (Table 25).

Table 25 Cultivar, fertilizer, weed and insect control measures used in productivity of wheat based systems study, Tel Hadya.

Crop	Cultivar	Fertilizer	Weed control	Insect control
Wheat	Sham 1	P-60 kg P_2O_5 N-0, 30, 60, 90 kg	Brominal Plus post-emergence	--
Lentil	Local small (unimproved)	P-60 kg P_2O_5	Kerb pre-emergence Fusilade post-emergence Aretit post-emergence	Carbofuran
Chickpea	ILC 482	P-60 kg P_2O_5	Igran pre-emergence Fusilade post-emergence Hand weeding post-emergence	--
Vetch	Local	P-60 kg P_2O_5	--	--
Medicago	Mixed	P-60 kg P_2O_5	Slashed	--
Summer crop (melon)	Local	P-60 kg P_2O_5	Mechanical	Deprex
Fallow	--	P-60 kg P_2O_5	Mechanical	--

Plot size is 150 x 36 m, an area large enough to represent farmers conditions. In this season, phosphate was applied to the whole area as it had been cropped for several years without fertilizer. In future it will be applied to the wheat phase only. Contrasting N rates were applied to the wheat in a split plot design (sub-plots 37.5 x 36 m), with 20 kg per hectare at sowing and the remainder at tillering.

A complete inventory of all field operations, costs and yield data is recorded each year to allow a thorough economic analysis. Such an analyses will be undertaken after several years' results are obtained. In this first year, we report the biological data only.

3.4.3 Results and Discussion

With the very late start of the rains (late December) and slightly less than average seasonal rainfall yields were only moderate (Table 26). There were significant effects of rotation on wheat yields with the best being recorded following fallow or summer crop and the worst following wheat or Medicago. Thirty kilograms of nitrogen significantly increased yields, but there was no further response to larger amounts. There was no interaction between rotation and fertilizer nitrogen application. The absolute levels of production of wheat following chickpea and rainfed summer crop, and the nitrogen responses within these rotations can be usefully compared with those found in our on-farm trials (see section 3.3).

Table 26 Yield of crops in both phases of two course rotation, Tel Hadya, 1985/86.

Rotation	Grain yield (t/ha)					
Phase 1	N0	N30	N60	N90	Mean	SE
Wheat after fallow	2.17	2.55	2.75	2.82	2.57	
Wheat after summer crop	2.47	2.83	2.65	2.88	2.71	
Wheat after lentil	1.79	1.96	2.19	2.21	2.04	
Wheat after chickpea	1.65	2.05	2.16	2.14	2.00	
Wheat after vetch	1.86	2.26	2.20	2.20	2.13	
Wheat after medicago	1.12	1.26	1.42	1.44	1.32	
Wheat after wheat	1.02	1.43	1.46	1.60	1.38	
Mean	1.73	2.05	2.12	2.19		0.23
S.E.	0.07					

Phase 2	
Summer crop (melon) after wheat	2.04 t/ha (f. wt. edible fruit)
Lentil after wheat	1.27 (+ 2.75 t straw)
Chickpea after wheat	1.02 t/ha
Wheat after wheat	0.74 t/ha

The forage legumes were grazed. Vetch gave the equivalent of 2180 sheep grazing days/ha between March 19 and June 15, at a stocking rate of 26 per hectare. Grazing of medicago was delayed to allow seed set; it was then stocked at 7.5 sheep per hectare from May 14 to July 9 for a total of 415 sheep grazing days/ha.

The results must be regarded as preliminary and uncertain. The trial will need to continue for some time before firm conclusions can be drawn. In the interim it provides a venue for testing new production methods under the joint management of the Farming Systems

Program and the commodity Programs of ICARDA.

H. Harris

3.5 LABELLED UREA FERTILIZER EXPERIMENTS ON WHEAT

3.5.1 Introduction

The use of nitrogen fertilizer on rainfed crops, particularly wheat, is increasing throughout the region. Most of the increase involves urea. Currently, this material accounts for about 40% of all nitrogen applied, and that proportion seems bound to rise as new manufacturing capacity comes into production. Compared with other nitrogen fertilizers, urea is cheaper to make and, because of its high nitrogen content, cheaper per unit of nitrogen to transport. It does, however, have two potential disadvantages: applied to the seed bed, it may damage seedlings; and applied to the soil surface, it may lose nitrogen through the volatilization of ammonia. Work elsewhere has indicated that such losses may be particularly large from calcareous soils. Other factors involved include soil texture, moisture regime and temperature.

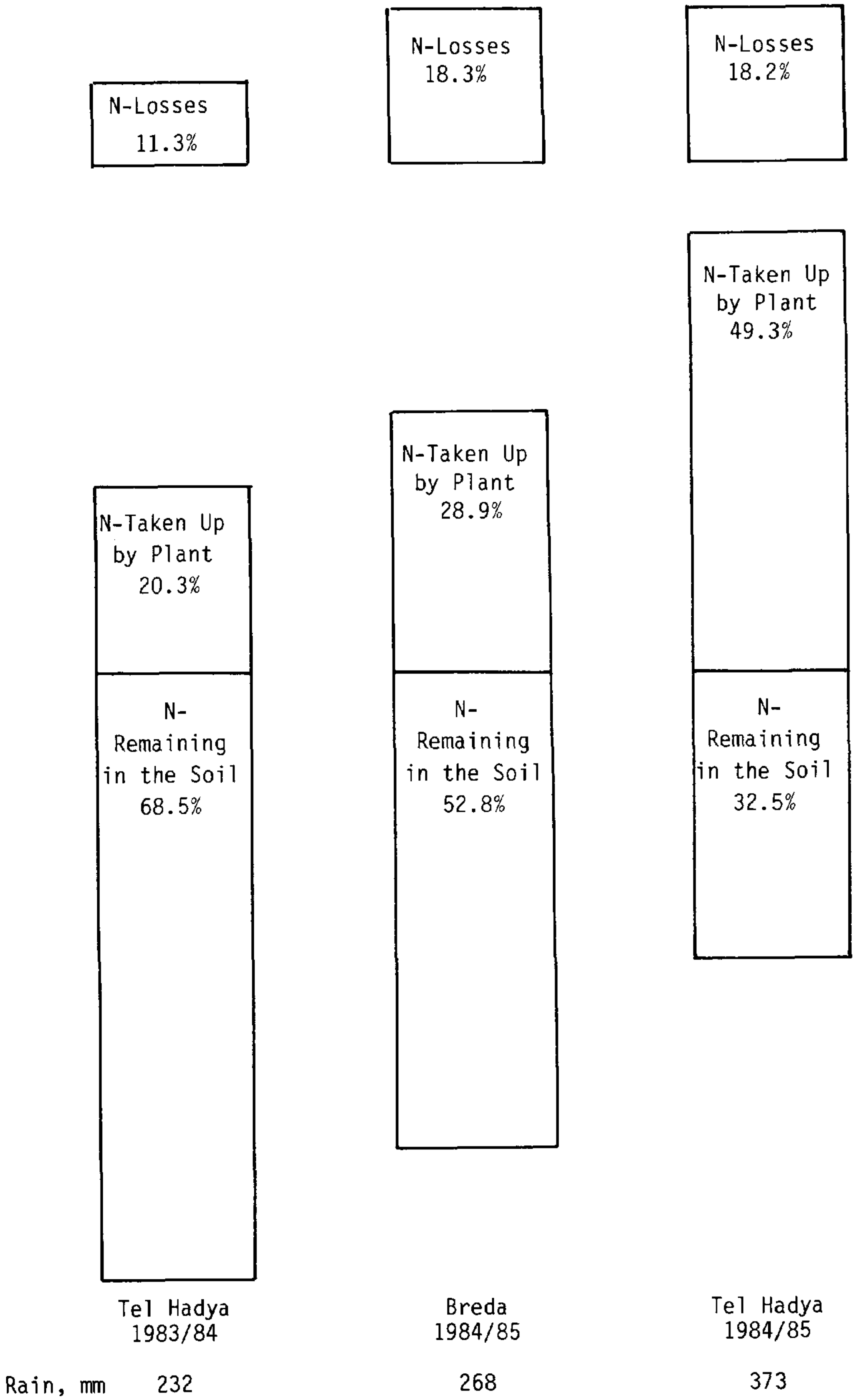
3.5.2 Results and Discussion

The mechanism of urea hydrolysis and ammonia volatilization was studied in the field at Tel Hadya and Breda. ^{15}N-labelled urea was applied to the surface of soil in metal cylinders sunk into the ground within a crop of wheat. There were five times of application, each well replicated, spanning 15 days during February, the usual time for top-dressing wheat. Subsequent transformations of urea were monitored by sampling and analysing whole cylinders at three-day intervals (Fig. 16). By the final sampling, 18 days after application, hydrolysis of urea was virtually complete in all but the last series of cylinders; and the labelled N was found either as ammonium, as nitrate (following microbial nitrification) or in organic form (immobilized in microbial tissue).

However, the variation in the proportions of these different forms of nitrogen, particularly at Tel Hadya, strongly suggests that the rate of urea hydrolysis decreased over the sequence of five application times. Temperature differences may have been involved. Late February (1985) had an unusual number of severe night frosts, and mean minimum temperatures at the soil surface decreased over the sequence; but at the same time, mean maximum temperatures at the surface and mean daily temperatures at 10 cm depth increased. More probably, the main factor was moisture. Initial soil moisture content at the surface and rainfall during the subsequent 18 days decreased over the sequence, and the final batch of urea must have been confined near to the surface of a drying profile. Nevertheless, nitrogen losses from the system showed no site difference or time pattern. They averaged 13.2% (3.4) at Tel Hadya and 14.8% (3.0) at Breda.

Losses were no higher over a whole season. This was evident from field trials conducted at both sites in 1983/84 and 1984/85 to study the effects of various rates of urea on yields of wheat, nitrogen

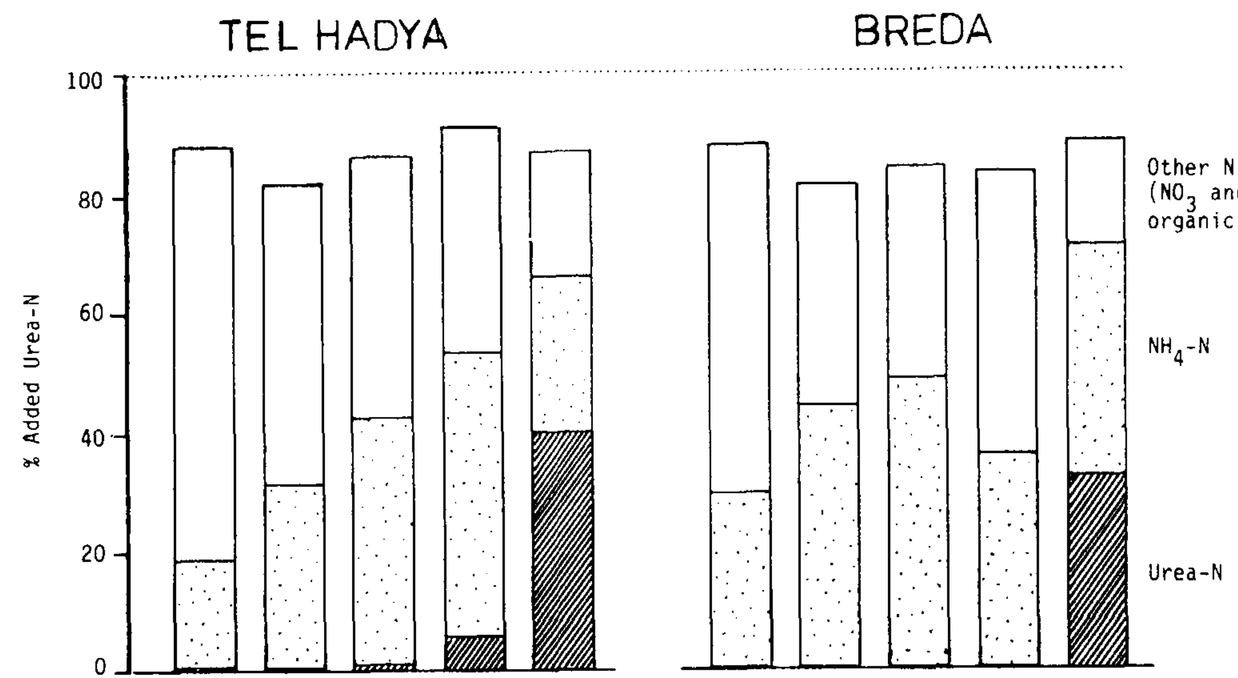
Figure 16 Nitrogen balance for 40 kg N/ha as urea applied to wheat at Tel Hadya and Breda



recovery by wheat and the residual nitrogen in the soil. Figure 17 shows the nitrogen balance for 40 kg N/ha topdressed as urea. Crop uptake depended strongly on seasonal rainfall, but most of the nitrogen not taken up remained in the soil and would be likely to remain available to a subsequent crop. Losses from the soil-plant system amounted to only 11-18%.

It is well known that where soil conditions favour rapid volatilization of ammonia, a decrease in the rate of hydrolysis of urea to ammonium can reduce losses. In such situations, the use of urease inhibitors (to slow hydrolysis) or various coated, "slow-release" forms of urea have been shown to be useful. However, in the present studies no significant differences were found between straight urea, urea + a urease inhibitor (phenylphosphorodiamidate) and bran-wax-coated urea in the yield and N-uptake of a wheat crop or in the nitrogen losses from the soil-plant system.

All these findings point to a little risk of serious nitrogen loss from surface-applied urea, despite the predominantly calcareous nature of the soils. This is probably because they also have large clay content and cation exchange capacity. Soils with such properties favour the retention of ammonium as exchangeable cations on the clay particles and thereby keep the concentration of ammonia in the soil solution at the soil surface at low levels. However, this result needs to be seen in context. The cool soil temperatures prevailing in February keep urea hydrolysis relatively slow whatever the moisture conditions. This is fine for topdressing wheat. But in much warmer



	Tel Hadya					Breda				
Urea application date	5/2	8/2	11/2	14/2	20/2	6/2	9/2	12/2	15/2	21/2
Initial soil moisture, %	29	40	34	35	27	26	26	25	27	24
18-day values:										
Total rainfall, mm	23	9	4	4	1	21	11	11	9	0
Soil surface temp. C., max	15.4	16.4	16.9	17.2	22.4	14.4	15.1	15.3	16.8	21.1
min	1.3	0.8	0.1	-1.3	-3.4	0.3	0.2	-0.8	-2.5	-4.3
10 cm mean temp., C.	6.9	7.3	7.7	8.0	10.1	7.8	8.4	8.2	8.0	8.6

Figure 17 Recovery of nitrogen fractions from soil 18 days after surface application of urea, in wheat plots, February 1985

conditions under, say, a summer crop, more rapid hydrolysis might produce a build-up of ammonium beyond the adsorptive capacity of the clay exchange sites. Moreover, not all the calcareous soils of the region are rich in clay. Soils of coarser texture have an intrinsically lower capacity to adsorb ammonium. In both situations, warmer ambient temperatures and sandier soils, and particularly when the two occur together, the risk of serious loss of nitrogen may be considerably greater than that demonstrated here.

M.A. Moneim, A. Matar

3.6 FOOD LEGUME ON-FARM TRIALS

Improved Production Practices for Lentils

3.6.1 Introduction

In 1985/86, factorial 2^4 trials were sown in 10 farmers' fields (2 reps/location) in the main lentil growing areas of NW Syria (Aleppo, Idleb and Hama provinces, zone 1 or 2) and in Tel Hadya research station (zone 2). The objectives of this work were to assess the main effects and interactions of date of sowing, sitona weevil control, phosphate fertilizer and chemical weed control on the yields and economics of lentil production in farmers' fields.

3.6.2 Methodology

Sixteen treatment combinations of date of sowing (early v. late), sitona weevil control (± Carbofuran, 20 kg/ha applied at seeding), phosphate fertilizer (0, 50 kg/ha P_2O_5) and weed control (± pre-emergence herbicide, 0.5 kg ai cyenazyne/ha + 0.5 kg ai pronamide/ha, applied just after seeding) were tested. Experiments were planted according to farmers' tillage and sowing methods: broadcasting seed and fertilizer (and also Carbofuran) over ridged land, then splitting the ridges to cover the seed. Plants and weeds per unit area, weed dry matter production, 1000 seed weight, total dry matter and grain yield of lentils were measured in all plots. At one site, local people harvested the experimental plots by mistake and no yield measurements were taken. The analyses of responses of lentil grain and straw yield to the various factors was therefore conducted on the pooled data from 10 locations. In the economic analysis, however, the variability of increased net revenue derived from individual treatment combinations was examined across locations to assess the risk associated with each treatment package.

3.6.3 Results and Discussion

As can be seen from Table 27, there was a significant interaction between the effect of date of sowing and herbicide application for both grain and straw yield. The dry start to the season delayed the germination of the early sown crop, and thus reduced the impact of early sowing to some extent. Nevertheless, as observed in previous years, weed infestations were greater in the early sown plots since the seed bed preparation operation for the later sowing killed weeds which had already germinated. The interaction illustrates that early sowing resulted in greater increases in yield of grain (23%) and straw (14%)

when herbicide was applied. It should be noted that, averaged across the original 11 sites, 38% of the weeds in the weedy plots were grasses (mainly *Avena sterilis*, *Phalaris brachystachis* and volunteer wheat), and 62% were broadleaves (mainly *Sinapis arvensis* and *Euphorbia spp.*).

Table 27 The main effects and first order interactions of date of sowing, sitona weevil control, phosphate and herbicide on lentil production in NW Syria, 1985/86 (average of 10 locations)

			kg/ha					
			Grain			Straw		
Main Effects								
Sowing (S) Early			965		NS	2038		*
Late			931			1809		
Sitona control (SC)	+		1036		**	2057		**
	-		861			1791		
P_2O_5 (P)	+		978		*	1979		**
	-		918			1869		
Herbicide (H)	+		1024		**	2003		**
	-		872			1845		
Interactions	S_E	S_L						
H+	-	-	1066	982	*	2168	1837	**
H-	-	-	864	879		1908	1781	
SE (CV%)			141 (15)			215 (11)		
LSD (Sowing date, 0.05)			154 kg/ha			195 kg/ha		
LSD (Sitona, P_2O_5, Herbicide 0.05)			44 kg/ha			77 kg/ha		
LSD (Sowing date x Herbicide 0.05)			62 kg/ha			95 kg/ha		

* $p<0.05$ ** $p<0.01$

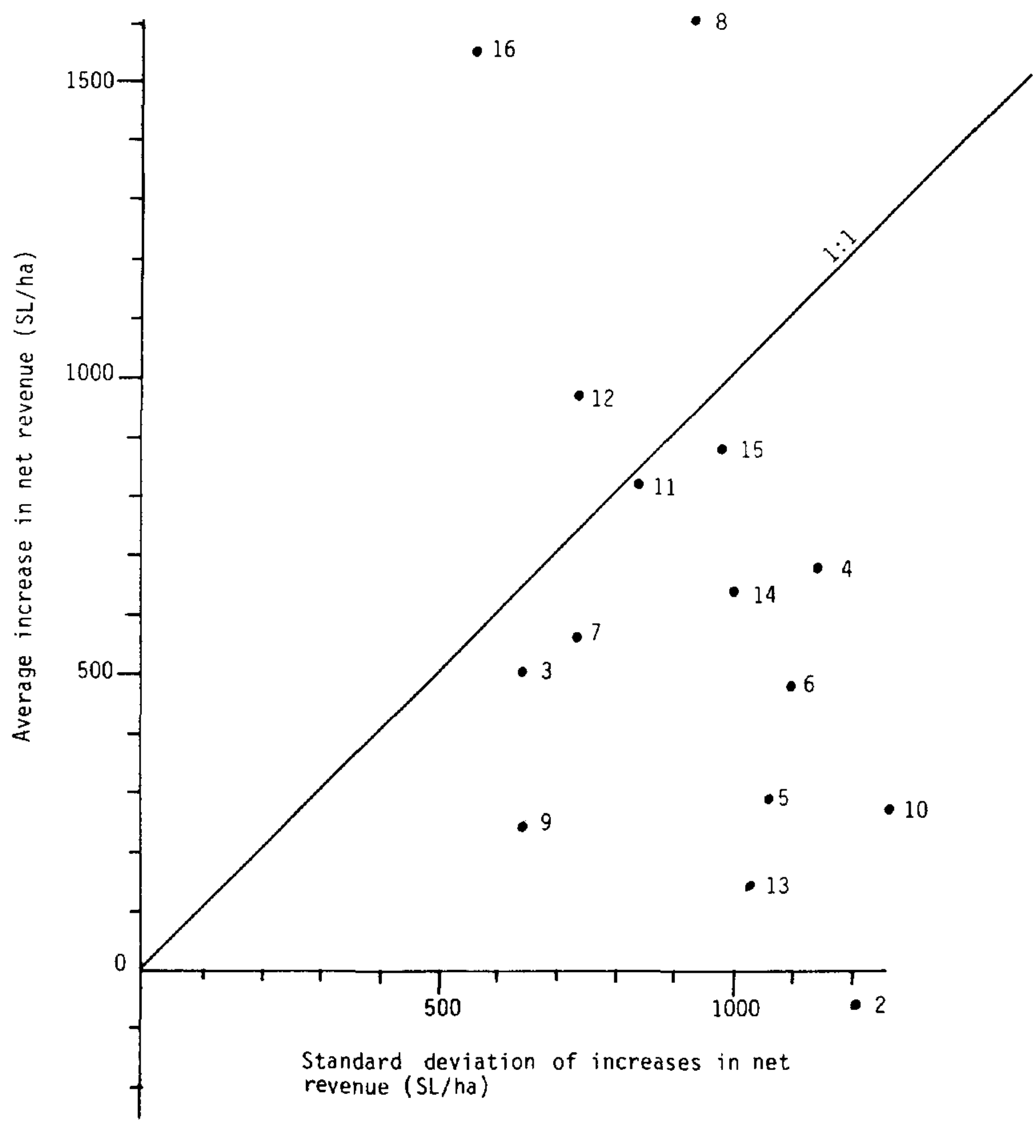
Sitona weevil control had substantial effects on both grain and straw yield but the grain yield response to insecticide use was much larger in the early sowing than the late sowing (25 and 16% yield increase in grain and 17 and 13% increase in straw by sitona control in early and late sowing respectively). According to the results of leaflet and nodule damage measurements done by FLIP staff, in 6 out of the 10 farmers' fields, average leaflet and nodule damages without sitona control were 11 and 35% respectively but fell to 3 and 9% with the application of insecticides. Average nodule damage in early sowing was more than in late sowing (27 and 16% respectively). This is consistent with the greater yield increases observed with early sowing and sitona control.

Phosphorus also increased grain and straw yield significantly, irrespective of the sowing dates (7 and 6% increase in grain and straw yield respectively).

Partial budget and risk analyses of the lentil agronomy results are presented next. For ease of discussion, each treatment combination is assigned a treatment number as indicated in Fig. 18. Treatment 1 (late sowing with no insecticide, herbicide or fertilizer applications) was taken as the basis for cost and revenue comparisons. Assumptions on factor costs, including both material and application costs, were the same for each of the ten locations: SL 331/ha for herbicide, SL 140/ha for insecticide, and SL 121/ha for phosphate fertilizer. Lentil grain and straw yields were valued at 3.25 and 1.0 SL/kg, respectively.

Figure 18 Risk analysis of lentil agronomy treatments at ten locations in NW Syria

Treatment Number:		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Sowing Date: Early (E),	Late (L):	L	E	L	E	L	E	L	E	L	E	L	E	L	E	L	E
Sitona control (0)	(+):	0	0	+	+	0	0	+	+	0	0	+	+	0	0	+	+
Herbicide (0)	(+):	0	0	0	0	+	+	+	+	0	0	0	0	+	+	+	+
Phosphate Fertilizer(0)	(+):	0	0	0	0	0	0	0	0	+	+	+	+	+	+	+	+



Other costs of production were ignored so that each treatment could be assigned a standard cost across all locations. Since yields varied across locations, the standard costs were subtracted from the respective values of yields at each location. "Increases in net returns" were derived by further subtracting the value of yields of treatment No. 1 at each location.

Except for treatment No. 2, all treatments with early sowing dominated the comparable late sowing treatments in terms of higher average increases in net revenues for the same increase in costs. The poor performance of early sowing, without weed and insect control, is consistent with results of on-farm trials conducted in four previous seasons (ICARDA, 1983, pp. 170-172).

Consistently positive effects on net revenues, across the ten locations, were found in only three treatments (8, 12 and 16), while all other treatments gave negative results at some locations. With treatment No. 1 as the origin in Fig. 18, the average and standard deviation of increases in net revenues, are plotted for the other fifteen treatments.

Treatments 8, 12 and 16 were further distinguished as giving the highest average increases in net revenues, and giving averages greater than their respective standard deviations; all other treatments failed this test.

Early sowing and sitona control were common to the top three treatments; treatments 8 and 16 also included the use of herbicides and gave exceptionally high average increases in net revenues (see Fig. 18). The most interesting result was that treatment 16 also had the lowest variation across locations, as measured by the standard deviation of increases in net revenues among all fifteen treatments.

The high variation in results across locations is an indication that future recommendations must include careful definitions of the recommendation domains (soil, climate and other conditions) under which they can be expected to hold true. Caution is also needed for interpretation of results such as these from a single season of on-farm trials. Earlier experiences in trials with rainfed lentils (see ICARDA loc. cit.) have demonstrated large year-to-year variations in addition to those due to location differences.

Improved Production Practices for Chickpeas

3.6.4 Introduction

In 1985/86, factorial 2^4 trials were sown in 10 farmers' fields (2 reps/location) in the main chickpea growing areas of NW Syria (Aleppo, Idleb and Hama provinces, zone 1) and in Tel Hadya research station (zone 2). the objectives of this work were to assess the main effects and interactions of date of sowing, Rhizobium inoculation, phosphate fertilizer and chemical weed control on the yield and economics of chickpea production in farmers' fields.

3.6.5 Methodology

Sixteen treatment combinations, of date of sowing (winter v. spring), Rhizobium inoculation (±), phosphate fertilizer (0, 50 kg/ha P_2O_5), and weed control (± pre-emergence herbicide, terbutryne + pronamide, 2.5 kg ai/ha + 0.5 kg ai/ha applied just after seeding) were tested. Experiments were planted according to farmers' tillage and sowing methods which is broadcasting seed and fertilizer over ridged land and splitting the ridges to cover them. Plants per unit area, weed number and dry matter production, 1000 seed weight, total dry matter and grain yield of chickpea were measured in all plots. At three of the eleven sites, local people harvested the trial plots by mistake and no yield measurements for these were used. The present analysis is based on results from eight sites.

3.6.6 Results and Discussion

The results of grain yield only (there is little economic value in chickpea straw) are presented in Table 28 for the pooled data set from the eight locations. As with the lentil on-farm trials, the economic analyses of these trials focussed on the variability of the increase in net revenue derived from the various treatments combinations for individual sites to assess the risk associated with each treatment package.

Table 28 The main effects and first order interactions of date of sowing, herbicide, phosphate and inoculum on the grain yield of chickpea in NW Syria, 1985/86 (average of 8 locations)

				Grain yield (kg/ha)		
Main Effects						
Sowing (S)	Winter			1409		NS
	Spring			1188		
Herbicide (H)	+			1400		**
	-			1198		
Phosphate (P)	+			1360		**
	-			1237		
Inoculum (I)	+			1331		*
	-			1265		
First Order Interactions		H+	H-			
S_W		-	-	1572	1246	**
S_S		-	-	1227	1149	
I+		-	-	1399	1265	*
I-		-	-	1400	1130	
P+		-	-	1423	1297	*
P-		-	-	1375	1098	
SE (CV%)				191 (15)		
LSD (Sowing date 0.05)				387 kg/ha		
LSD (Herbicide, P_2O_5, Inoculum 0.05)				67 kg/ha		
LSD (S x H, I x H, P x H 0.05)				94 kg/ha		

* $p<0.05$ ** $p<0.01$

The response to winter sowing was far less in this set of on-farm trials than has been previously observed (for example see Hawtin and

Singh, 1982). Two probable reasons were noted. Firstly, at all locations, the winter sown plots were more severely damaged by an attack of Heliothis spp. than the spring sown crop, in spite of being sprayed with insecticide. Secondly, it was noted that the herbicide caused some damage to winter sown chickpea resulting in an average decrease in plant population from 32 to 28 plants/m^2. It was suspected that this was associated with the variable planting depth achieved by the farmers' method of broadcasting, with shallower seeds being more susceptible to herbicide damage during cold weather. This aspect of winter sowing of chickpea will be investigated in future trials.

The effects of sowing date, phosphate application and inoculum all had significant interactions with herbicide application. Weed infestations were worse in winter sown chickpea (1174 vs. 274 kg/ha dry matter across all locations) and thus herbicide had a greater effect in winter sown crops which achieved their greatest advantage only when weeds were controlled.

In contrast, the effect of phosphate fertilizer and inoculum was greatest in the absence of weed control, presumably due to preferential stimulation of chickpea growth allowing better competition with weeds.

Significant second order interaction (not given in Table 28) indicated that phosphorus was especially effective in winter sown chickpea without herbicide where it gave a 30% yield increase. Another second order interaction indicated that inoculum was most effective in the absence of both phosphate and herbicide use.

Partial budget and risk analyses of the chickpea agronomy results are presented here. Again, each treatment combination is assigned a treatment number as indicated in Fig. 19. Treatment No. 1 (spring sowing, with no inoculum, herbicide or fertilizer) was taken as the basis for cost and net revenue comparisons. Assumptions on factors costs, including both material and applications costs, were the same for each of the eight locations: SL 90/ha for inoculum, SL 563/ha for herbicide, and SL 121/ha for phosphate fertilizer. Chickpea seed was assumed to have a sales price of SL 5.5/kg, while straw production was ignored due to its low value.

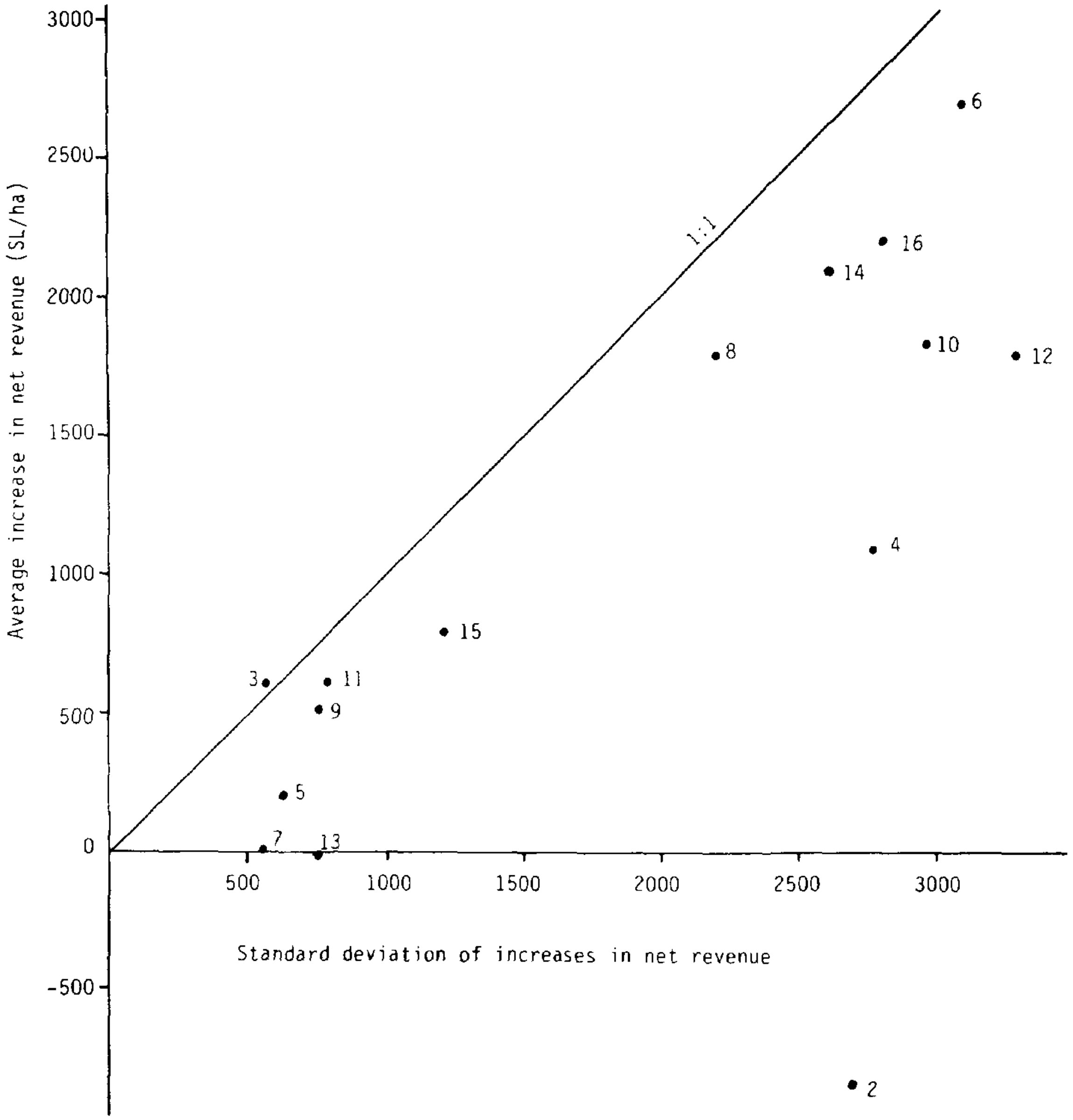
Other costs of production were ignored so that each treatment could be assigned a standard cost across all locations. Since yields varied across locations, the standard costs were subtracted from the respective values of yields at each location. "Increases in net revenues" were derived by further subtracting the value of yields of treatment No. 1 at each location.

With treatment No. 1 as the origin in Fig. 19, the average and standard deviation of increases in net revenues are plotted for the other fifteen treatments.

Except for treatment No. 2, all treatments with winter sowing (even treatment numbers) dominate the comparable spring sown treatments in terms of giving higher average increases in net revenue for the same increase in costs; the lowest average increase of the winter sown treatments (No. 4) was greater than that of the highest average

Figure 19 Risk analysis of chickpea agronomy treatments at eight locations in NW Syria

Treatment Number:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Sowing Date:Winter (W), Spring (S):	S	W	S	W	S	W	S	W	S	W	S	W	S	W	S	W
Rhizobium Inoculation (0) (+):	0	0	+	+	0	0	+	+	0	0	+	+	0	0	+	+
Pre-emergence herbicide (0) (+):	0	0	0	0	+	+	+	+	0	0	0	0	+	+	+	+
Phosphate fertilizer (0) (+):	0	0	0	0	0	0	0	0	+	+	+	+	+	+	+	+



increase among the spring sown treatments (No. 15).

However, the average increases in net revenues need to be considered in light of the variations from location to location. With the exception of treatment No. 3, the standard deviations of increases in net revenues were greater than the average increase, and it is notable that variations among the winter sown treatments were especially great. These results do not in any way suggest that winter sowing of chickpea will not be attractive to many farmers. For instance, in treatment 6 (winter sowing plus herbicide) across five of the eight locations, increased net revenues over treatment 1 (spring sowing with no herbicide) ranged from 2202-8355 SL/ha and averaged 4439 SL/ha. However, at the remaining three locations, increases in net revenue ranged from minus 575 to plus 1075 SL/ha only. This is a strong indication that future recommendations must include careful definitions of the recommendation domains (soil, climate and other conditions) under which they are expected to hold true. In the present analysis heterogenious locations have been pooled with mixed results and no uniform recommendation to farmers could be based on this.

M. Pala and T. Nordblom

4. INTERSYSTEMS RESEARCH

4.1 INTRODUCTION

Although we recognize contrasting farming systems within our region, which in most cases require specific research projects, we also recognize that many important research topics have special relevance across all farming systems in our region. Such research is reported in our Intersystems Research Project which has the following goals and objectives:

Objectives

To characterize the effect of the natural variability in climate, soils and socio-economic conditions on major agricultural issues of importance to all farming systems of the region. Such understanding will assist in the extrapolation of location/year specific research results across time and space.

Long-Term Goals

a) To develop agroecological characterization, classification and mapping methodologies to assist plant breeders and crop agronomists in the rationalization, adoption and extrapolation of research strategies and results.

b) To study socio-economic factors (particularly labor issues and crop/livestock interactions) at the whole farm level which are likely to affect the adoption and impact of new technology.

c) To improve the economic efficiency of fertilizer use (nitrogen and phosphorus) on annual sown crops through greater understanding of soil/climate interactions and consideration of macro-economic aspects of fertilizer allocation.

d) To improve the water use efficiency and economic return of small scale supplementary irrigation schemes practised in predominantly rainfed farming systems.

This year we are reporting research directed towards all four of our long-term goals. The impetus of our agroecological zonation work gained considerable momentum this year as a result of the Inter-Centers Workshop held in Rome (see section 5.4), and organized by FSP staff on behalf of other CGIAR Centers. As one consequence, ICARDA was invited to send an observer to a meeting of the Committee for Agricultural Meteorology of WMO, where it was decided to recommend to the WMO Congress a closer collaboration during the next ten-year period between the meteorological community and the International Agricultural Research Centers.

This is to be achieved through joint interdisciplinary research and the provision of agrometeorological information and knowledge of practical techniques.

Agricultural labor issues are of great importance in our region, especially when studied in terms of innovative technology. Labor requirement patterns can be radically changed by the introduction of some technologies (such as mechanization of farm operations), but can also provide constraints to other techniques which require a greater, or a different timing of labor input. Labor issues are therefore closely associated to both the potential adoption rates of new technology and its impact. This work also gained momentum this year with the initiation of a specially funded project on "Agricultural Labor and Technology Change".

The adoption of fertilizer use throughout the region has been widespread and rapid, and is likely to increase. However, resources, both at the National and farm level, are limited, and research is required to improve the efficiency of fertilizer recommendations and use. This year we illustrate how the calibration of soil tests with crop responses to fertilizer can assist in improving fertilizer recommendations. We also jointly organized with MIAC a regional workshop on Soil Test Calibration, and several countries (Turkey, Syria, Jordan, Morocco) are conducting cooperative work with us this year (see section 5.4).

Supplemental irrigation of winter sown cereals and food legumes is becoming increasingly common in the rainfed farming systems of the region. The resulting stabilization and increase in yields are economically very attractive, and yet in many instances farmers have access to only a limited supply of water for this purpose. Optimizing the efficiency of use of this scarce resource is the principal goal of our research, and this year we report the results of our first year's on-station and on-farm research conducted in cooperation with the Syrian Ministry of Agriculture and Agrarian Reform.

4.2 SPATIAL CLIMATE MODELING: OBJECTIVES AND METHODS

The merits of mathematical models in generating stochastic daily rainfall series for the analysis of rainfall regimes have been discussed previously (ICARDA, 1984, pp 60-65). However, besides providing an elegant method to determine the probabilities of occurrence of various rainfall events, (e.g. droughts, germinating rains), the usefulness of such models is limited, since to determine the model parameters, a long rainfall series of at least 20 to 25 years' length is needed (Richardson and Wright, 1984). If a series of this length is available, many of these probabilities can, however, be determined directly using simple empirical methods. The same is true for weather generators, more complex climate models which in addition to rainfall also incorporate daily minimum and maximum temperatures, solar radiation, and in some cases, potential evapotranspiration.

The usefulness of such climate models, which are reviewed by Hutchinson (1986), is dramatically increased, if they can be expanded to include the spatial aspects of climatic variability. In such instances, it becomes possible to generate stochastic daily weather series for sites for which no measured weather series of adequate length are available. Many sites where agricultural research is conducted are of this kind and Tel Hadya is a good example. Such a spatial climate model permits the quantification (in terms of probabilities) of environmental stresses to which crops are exposed at such sites, and would thus facilitate the interpretation of trial results and of agronomy experiments conducted over relatively few years. Even more important, by generating weather series for a great number of locations, a spatial climate model could be used to determine and map the recommendation domains of specific crop varieties and of agronomic practices, as long as the relationships between crop performance and climate are established quantitatively as functions of genetic make-up, management practices, and other environmental factors with known spatial distributions, such as soils. In addition, such maps would reflect the climatic suitability of land for different genotypes and agronomic practices.

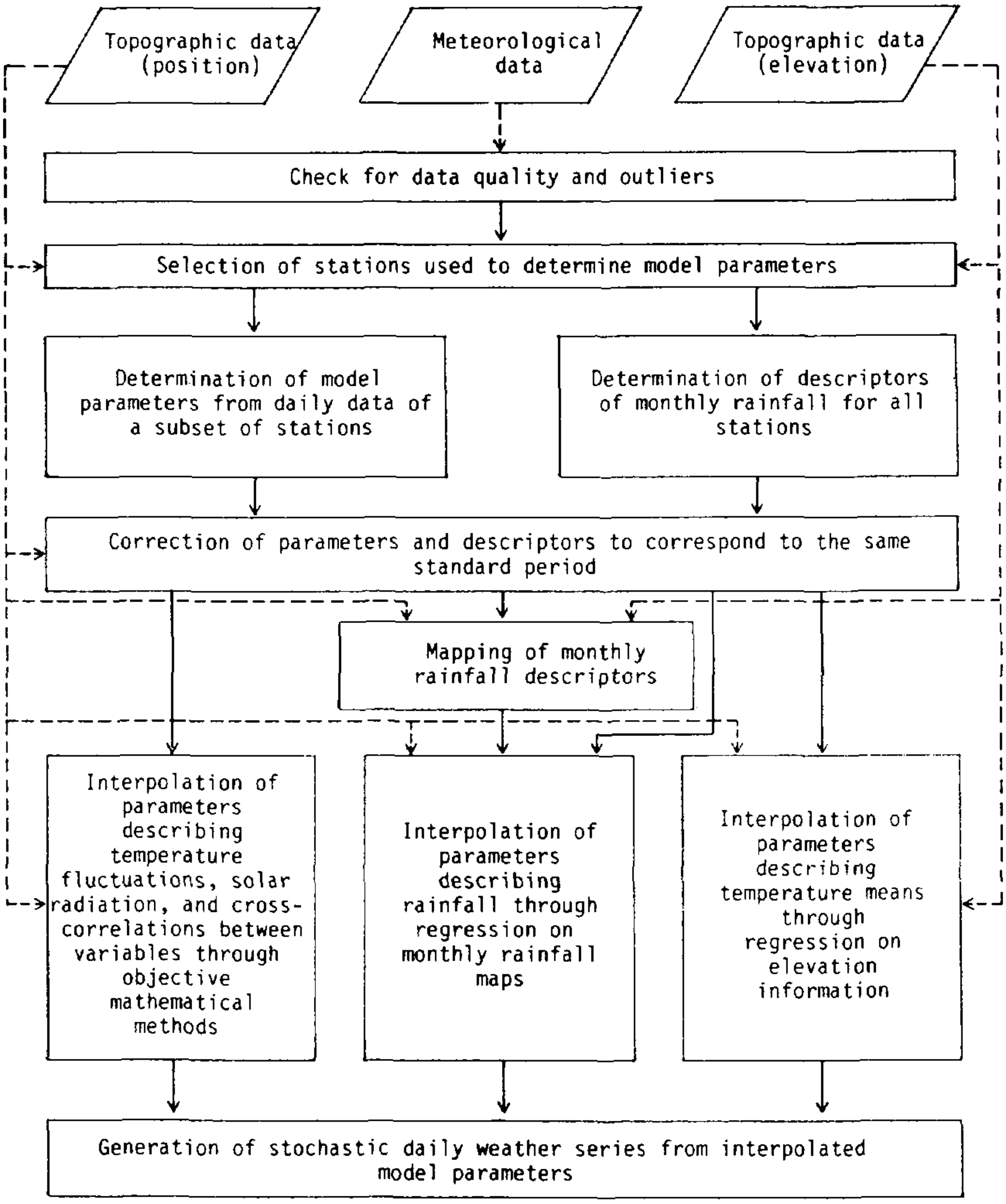
An operational spatial climate model could, for these reasons, make a substantial contribution towards increasing the efficiency of research within the region. A first step towards developing such a model was the generation of a long-term stochastic rainfall record for Tel Hadya from parameters obtained through linear interpolation between those of Aleppo and Saraqeb meteorological stations (Dennett, Rodgers, and Keatinge, 1983).

A number of genuine spatial climate models have been developed elsewhere in recent years (brief reviews in Hutchinson, loc. cit.; Coe and Stern, 1986). They have in common that they all employ objective spatial interpolation methods, most frequently spline methods or Kriging, to determine parameter values for locations between meteorological stations. This makes them unsuitable for regions where the network of meteorologial stations is not dense enough to capture all local variations of every parameter involved. Unfortunately, this applies to most of the geographical region in which ICARDA is conducting research. In this respect, model parameters describing rainfall are most sensitive. In a typical example taken from East Africa, van der Laan (1986) has demonstrated that many of the local gradients of rainfall are missed by straightforward interpolation methods. Similarly, because of the close relationship between mean temperatures and altitude, the same problems also exist for the parameters describing these variables. However, station networks are generally dense enough to allow the application of mathematical interpolation methods for parameters describing daily and seasonal fluctuations of temperatures, solar radiation, and the cross-correlations between the different climate variables (Richardson and Wright, loc. cit.).

Because of these problems within the region ICARDA serves, we are assembling our own version of a spatial climate model taking into account the limited availability of meteorological data in the region. The model, which is in an advanced stage of development, makes use of published methods whenever appropriate, adding new procedures where deemed necessary.

The model (cf. Fig. 20) generates daily rainfall, maximum and minimum temperatures, and solar radiation. As inputs, it requires daily data of these variables from a relatively wide-spaced network of meteorological stations (approximately 1 station per 1000 km^2 seems sufficient). If radiation data are not available, they are estimated from pan evaporation, windrun and temperatures. The daily data have to

Figure 20 Elements of the spatial climate model



be supplemented by monthly data on rainfall totals and numbers of rainy days from as many additional raingauges as possible. The data from each station have to cover the same standard period of at least twenty years in order to avoid distortions caused by records differing in length and covering different periods. Correction factors have to be applied to all parameters derived for those stations and raingauges whose records do not cover the entire standard period. The basic techniques for these adjustments are described by Thom (1966).

After a quality test and the elimination of doubtful data and outliers, the model parameters are determined for each station from its daily record. The method followed is closely related to that of the WGEN weather generator (Richardson and Wright, loc. cit.). The values of the parameters vary from month to month but are kept constant during each month. But in contrast to WGEN, higher order (1 1/2 or 2) Markov chain approaches are used to model the occurrence of wet days, since first order Markov chain models have been found insufficient for some subtropical and tropical climate types (Stern, Dennett, and Dale, 1982; Dennett, Rodgers, and Keatinge, loc. cit.). The introduction of additional parameters to describe the persistence of typical seasonal weather situations is being studied. It is thought that such parameters could improve the modeling of the tails of the distributions of wet and dry spell lengths.

The next step consists of the construction of maps of means and descriptors of dispersion of monthly rainfall and numbers of rainy days, making use of data from all rainfall measuring stations in the area covered by the spatial model, and of all available knowledge about the influence of topography on the spatial distribution of rainfall (Weischet, 1980). Satellite imagery can be helpful to identify or verify suspected gradients not expressed in the station data (van der Laan, loc. cit.). The model parameters describing rainfall can then be related to the mapped monthly rainfall descriptors with the help of regression techniques.

It is widely recognized that mean maximum and, though less so, mean minimum temperatures are closely related to altitude (for instance, Goebel and Odenyo, 1984). The corresponding model parameters for locations other than meteorological stations can, therefore, be derived by regression directly from topographic data. Corrections for exposition and for likelihood of temperature inversions may be desirable, but difficult to achieve.

A third group of model parameters, describing temperature fluctuations, solar radiation, and the cross-correlations between the different climate variables, exhibits a much lower degree of variability over short distances. These parameters are interpolated between stations either by Kriging (Delfiner and Delhomme, 1975) or through the use of Laplacian smoothing splines (Hutchinson and Bischof, 1983).

The spatial climate model will be validated with an extensive set of meteorological data from northern Syria, which has been supplied by the Meteorological Department, Ministry of Defence of the Syrian Arab

Republic, before it is applied to other areas in North and East Africa and West Asia in the course of the coming year.

W. Goebel

4.3 AGRICULTURAL LABOR AND TECHNOLOGICAL CHANGE

4.3.1 Introduction

Demonstrating ICARDA's increased awareness of the importance of designing feasible technologies which meet the needs and resources of our host countries, the Farming Systems Program has, in this season, initiated a project on Agricultural Labor and Technological Change. The availability of labor is considered to be one of the most important factors determining the adoption of technologies, and the effect on labor is an important component of a new technology's impact.

Technologies under development, at ICARDA and elsewhere, include changes in seed bed preparation and planting, improved weed and pest control, more precise fertilization, mechanization of legume harvesting, alternative crops, varieties, and rotations, and new crop-livestock interactions. All of these techniques can alter labor inputs, sometimes requiring more labor, sometimes less, and sometimes rescheduling activity. Thus, the availability of labor is among the most important influences on the adoption of new farming practices. New technologies may also require more skilled management; the availability of such managers must be assessed.

In this region, there has been substantial growth in non-agricultural employment, including international migration for work (Fig. 21, Table 29). This has been associated with mechanization and other technologies which replace or displace labor. However, shortages and high costs of agricultural labor continue to be reported in the region. Skilled labor in particular is drawn to new earning opportunities at home and abroad.

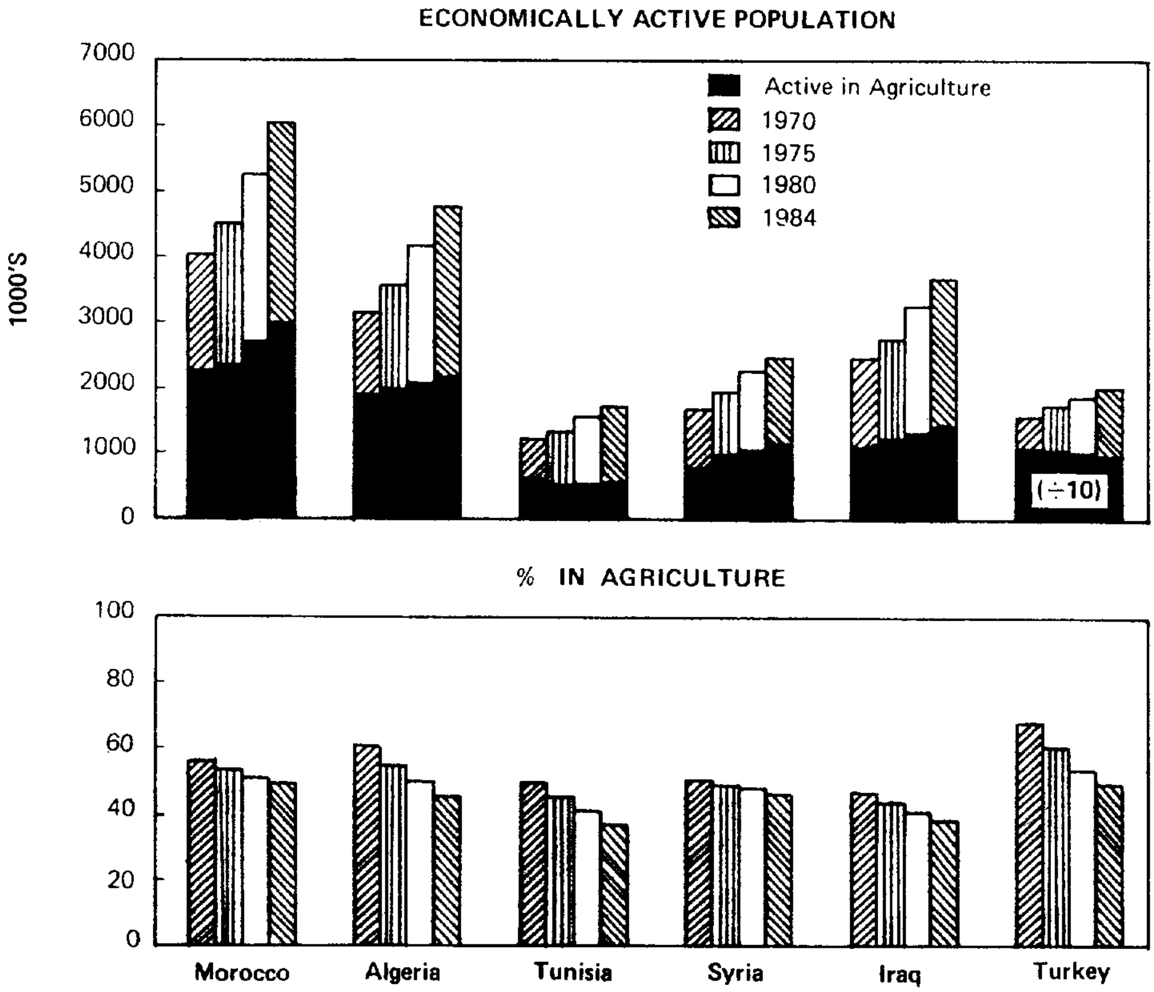
Table 29 Migration and domestic employment in Turkey ('1000s)

	1962	1975	1977	Mean Annual Change 1962-75	Mean Annual Change 1975-77
Total employment	12643	14668	14726	156	29
Agricultural employment	9740	9463	9100	-21	-182
Non-agricultural employment	2903	5205	5626	177	211
Workers abroad	13	795	815	60	10

Source: World Bank 1980: 131

On the other hand, technologies which reduce labor requirements may eliminate important sources of rural employment, especially for unskilled labor. Most countries do not wish to contribute to urbanization by reducing jobs in rural areas. It is necessary to assess the ef.fect of a new technology on rural employment, so this can be weighed against the benefits by policy makers.

Figure 21 Trends in agricultural and total labor forces (selected countries)



While there are some pitfalls to be avoided, there are also numerous possibilities for increasing agricultural productivity by eliminating labor bottlenecks or taking better advantage of available labor. Researchers and policy makers need guidance on these issues, to help them determine which technologies have the best chances for adoption, and will most improve overall social welfare.

Through cooperation between ICARDA and scientists of West Asia and North Africa, the present project will address these issues. There are four main objectives:

1. To gather existing information on agricultural labor in the region, and make it available to researchers, ministries, donors, and internationnal scholars.

2. To commission new research projects on these issues.

3. To integrate consideration of labor constraints into on-going development research.

4. To familiarize more scholars of the region with applied, interdisciplinary research techniques.

4.3.2 Project Organization

A full-time project coordinator, based at ICARDA headquarters in Aleppo, Syria, is now responsible for collaborating with national agricultural research centers and universities. The project has been organized into three components.

Component 1: Data base review

In all but a few countries, economic and development specialties are not well represented in internationally published work. Reports are often available only locally and transiently. Nevertheless, information does exist on issues related to labor and factor constraints in the region. Thus a primary and early goal of the project is to commission papers which review previous research and interpret existing data. A series of papers will be focused on topics such as labor allocation by the farm household, the process of substitution between labor and capital, the relationship between farmers and owners of machinery, and competition between on-farm and off-farm labor opportunities.

Component 2: Case studies

A major goal of the project is the production of new information through case studies in the main rainfed farming areas of West Asia and North Africa. The studies, based on original field research, will address issues of labor supply and demand that affect the feasibility of new agricultural technologies. The studies will be carried out by regional scientists in an interdisciplinary, farming systems framework.

Component 3: Coordination with on-going research on related issues

Both national and international centers are carrying out research on ways to improve rainfed agricultural systems. In addition, a number of major agricultural development projects are under way in the region. The coordinator will contact research teams and discuss the planned or potential role of research on labor issues in their work. He may assist in providing information or in setting up a study of labor issues and factor constraints related to the planned technological changes.

The Agricultural Labor and Technological Change project is intended to help agricultural scientists and policy makers of the region, as well as donors, to better use their resources by taking the needs and capabilities of farmers into account. Information produced by the project will be disseminated widely within the region and also in the international community of donors and development researchers.

D. Tully

4.4 ASPECTS OF AGRICULTURAL LABOR IN NORTHWESTERN SYRIA

4.4.1 Introduction

During the last thirty years changes have occurred both in the technique and in the organization of agricultural production. Mechanization of some tasks, new opportunities for off-farm employment, and the increase of skilled rural jobs have affected the division of labor inputs between household and hired and between males and females.

This study draws on a survey of 47 landowning households in four villages of Aleppo Province in Syria. Data were collected on farm labor for the 1982/83 cropping season. Interviews were conducted with husband and wife at three periods corresponding to different seasonal tasks. Numbers of hours spent by various categories have been calculated for each task and each crop.

4.4.2 Results and Discussions

In general adult males' and females' contributions to agricultural labor (in terms of hours of physical work and including both family and hired) are almost equally divided and tend to be complementary (Table 30)*. Household labor provides 61 percent of the total work hours in agricultural operations and females provide 57 percent of these. Hired labor is equally divided between males and females in the total agricultural enterprise. However, work provided by each group depends on the degree to which production is mechanized. For example, in cereal crops where most of the operations are mechanized, the contribution of hired males is higher than that of hired females (33 percent vs 5 percent). The opposite is found in legume crops where most operations, particularly harvesting, are not mechanized. Hired females' and males' contributions are 36 percent and 12 percent respectively.

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* To simplify the presentation we omit the contribution of children under the age of 13 (and usually over 10) who supply approximately 7 percent of labor hours.

Table 30 Contribution of males and females as percentages of the total time spent in on-farm agricultural production.

Contribution	Cereal crops	Legume crops	Summer crops	Tree crops	Total
A. Household labor					
Male	23	18	44	47	26
Female	39	34	42	28	35
Sub-total	62	52	86	75	61
B. Hired labor					
Male	33	12	9	24	20
Female	5	36	5	1	19
Sub-total	38	48	14	25	39
C. Grand total					
Male	56	30	53	71	46
Female	44	70	47	29	54
D. % of area allocated to each crop	50	25	19	6	100
E. % of hours spent in each crop	30	40	22	8	100
F. Mean hours/ha	46	135	94	99	--

Source: From villages surveyed in study.

This pattern is a reflection of the division of labor in agriculture, as shown in Table 31. Traditionally male-dominated activities such as seeding and winnowing continue to be carried out by males, and they also provide most labor for the use of new technologies such as herbicide and fertilizer. In tillage, male tractor operators

Table 31 Contribution of males and females as percentages of hours spent in legume and cereal production.

Agricultural Activities	LEGUME					CEREAL				
	% Hours spent by task	% Total adult input		Household only		% Hours spent by task	% Total adult input		Household only	
		Male	Female	Male	Female		Male	Female	Male	Female
Tillage operations	3.7	100	0	32	0	10.1	100	0	32	0
Seeding	1.5	86	14	30	14	5.1	86	14	19	14
Herbicide use	--	--	--	--	--	0.8	95	5	20	5
Fertilizer use	0.9	81	19	49	19	11.0	79	21	31	21
Hand weeding	16.1	14	86	13	67	20.6	5	95	5	95
Pest control	2.5	71	29	51	29	8.5	73	27	54	27
Harvesting	58.4	15	85	11	26	26.2	38	62	10	39
Transport	5.3	74	26	36	26	12.0	84	16	34	16
Threshing	6.6	57	43	31	43	4.6	62	38	35	38
Winnowing	1.6	89	11	48	9	0.4	83	17	47	17
Cleaning	2.4	34	66	34	66	0.4	27	73	21	61
Bagging	1.0	44	56	44	56	0.2	66	34	66	34
Total	100.0	30	70	18	34	100.0	56	44	23	39

Source: Villages surveyed in study.

have replaced male operators of ox-drawn implements, while in cereal harvesting, male combine operators have replaced both male and female hand laborers. Women predominate in manual activities such as weeding, hand harvesting, and cleaning of grain. Thus cereals, with their higher rates of labor-replacing technology, are characterized by lower labor hours per hectare and a higher proportion of male labor, often semi-skilled; legumes use more labor hours, much of it unskilled, and much of that female.

The predominant role of females in providing unskilled agricultural labor is amplified by the increasing availability for males of non-agricultural employment. In the four villages, such activities included construction work, running a business, teaching, and driving a taxi. No women from the survey villages did any non-agricultural work outside the village.

Working on or off-farm depends largely on farm size, the crop productivity and access to work opportunities. In the villages surveyed, where few landless households exist, 63 percent of income comes from crops and livestock and 37 percent from off-farm activities. Off-farm income provides only 29 percent of income in the wetter two villages (zone 1) compared to 44 percent in the drier, less productive area (zone 2).

The data were analyzed to determine factors affecting male and female labor inputs, and the relative importance of hired and household labor. Labor inputs in all categories were closely correlated with holding size; therefore multiple regression was used to consider the importance of other variables in combination with holding size. Three other variables were found to have significant impact on labor input: number of adults in the family, number of family members absent on a daily basis, and "excess of females" (number of adult females minus number of adult males).

For comparative purposes, normalized beta values are shown for all labor variables with all four independent variables (Table 32). There are interesting differences among the results.

First, it should be noted that male, female, and total household labor are primarily linked to number of adults, and female household labor is also related to the excess of females. Male household labor, as one would expect, is reduced by the number of absentees. Holding size is also important; all other things being equal, household members work more if their farms are larger. However, that variable appears to be less important than demographic factors.

Table 32 Multiple regression results on labor variables.

DEPENDENT VARIABLES	INDEPENDENT VARIABLES (Normalized Beta Values)				
Household labor	Holding size	Number of adults	Number of absentees	Excess of females (1)	Adjusted r^2
Male	.36**	.60**	-.42**	-.08(NS)	.54
Female	.22(NS)	.61**	-.18(NS)	.27*	.50
Total	.31**	.67**	-.33*	.11(NS)	.60
Hired labor					
Male	1.03**	-.45**	.25*	.08(NS)	.70
Female	.69**	.07(NS)	-.10(NS)	-.27**	.55
Total	.92**	-.15(NS)	.05(NS)	-.14(+)	.70
All					
Male	.70**	.33**	-.25*	-.04(NS)	.77
Female	.49**	.51**	-.19(NS)	.09(NS)	.68
Total	.61**	.45**	-.23*	.03(NS)	.77
Labor ratios					
hh/all	-.49**	.75**	-.26(NS)	.20(NS)	.20
Female/total hh	-.25(NS)	.05(NS)	.27(NS)	.49**	.24
Female/total hired	.25(NS)	-.05(NS)	-.20(NS)	-.45**	.18
Female/total all	-.50**	.67**	-.18(NS)	.07(NS)	.15

(1) Adult females minus adult males.
** t significant at .01
* t significant at .05
(+) t significant at .06
(NS) sig. of t>.1

By contrast, the only variable significantly determining total hired labor is holding size. Large farms hire more labor than small ones. Also the ratio of household to total labor is negatively associated with farm size and positively associated with family size. However, family size and number of absentees strongly affect total labor deployed on farms. Therefore, it appears that farmers do not hire as much labor as they would use if family labor were available. Either sufficient hired labor is not available, or family labor is valued more cheaply than hired labor.

Small families hire more males than large families, probably indicating less planting of labor intensive crops. Also, families with male absentees hire more males, and families with more females hire less female labor. Thus hired and household labor appear to be partial substitutes, and some of this substitution follows gender lines. This is related to the division of labor, since hired females are involved in manual labor which can also be accomplished by household females.

4.4.3 Conclusions

The pattern of labor input in agriculture in northwestern Syria has been presented. It was noted that male and female time contributions to crop production are approximately equal. Hired labor for mechanical operations is predominantly male, while that for manual operations is predominantly female. Continuing mechanization of production will continue to reduce female agricultural activities including both household and hired labor. The male agricultural labor force is reduced by migration and off-farm employment, but those remaining have been increasingly involved in using labor-replacing technologies. These changes have major implications for technology adoption, agricultural productivity, farm incomes and equity which need to be assessed.

A. Rassam and D. Tully

4.5 INCREASING FERTILIZER USE EFFICIENCY THROUGH SOIL TEST CALIBRATION

4.5.1 Introduction

In the more productive areas of West Asia and North Africa, where wheat and food legumes are grown, national researchers have been involved in extensive studies on the use of nitrogen and phosphate fertilizer on a variety of crops. This research has proved successful in allowing recommendations to be made to farmers, and survey work (for example see ICARDA 1986 p 43-56) indicates rapid adoption of fertilizer use on both cereals and food legumes.

On-going research in Syria (see ICARDA 1986 p 9-18 and this report, section 2.2) has also indicated economic responses of barley production to both N and P fertilizers in the drier areas (<350 mm) where farmers currently do not use fertilizer. Given the present rate of adoption of fertilizer use in the wetter areas, and its likely expansion into the drier areas, it is important that the efficiency of use is seriously considered to allow the maximum economic benefit to be derived from limited resources, both at the national and farm level.

Many factors will combine to affect the biological and economic optimum rate of both N and P application. Such factors include crop type, crop rotation, soil type, soil fertility, method of application, the residual effects of previous fertilizer application and probably most important, the year to year variability in potential crop productivity associated with climatic factors, principally rainfall. Nevertheless, in spite of the complexity involved, we believe that fertilizer use efficiency can be improved considerably through consideration of these factors. In other sections of this report we have presented results illustrating the effect of crop rotation on the nitrogen responses of barley and wheat (see sections 2.2 and 3.3), and the importance of soil fertility (available N and P) and rainfall in accounting for the variability associated with barley yield responses to fertilizer application.

In the following pages we discuss the role of soil analyses in assessing soil fertility status, and our preliminary work in calibrating these soil tests for N and P with crop responses to applied fertilizer. The results should not be judged as conclusive, but are presented to illustrate some of the methodologies being used, and the potential value of such work.

4.5.2 Standardization and Evaluation of the Soil Test for Phosphorus

A variety of soil tests for available soil phosphorus are used by the laboratories of the region, and one major goal of our soil test calibration work is to assist regional scientists in standardization of procedures. Each year we hold a soil/plant analyses training course for senior laboratory personnel, and in 1985/86 the participants in the course focused on a comparison of soil tests for phosphorus currently utilized for the calcareous soils of the region. We present the summary of results of their joint studies. A fuller report of procedures and results are available on request.

Five contrasting extraction procedures were compared, namely:

a) desorption by anion exchange resin
b) extraction with $NaHCO_3$ ($Sncl_2$ used as reducing agent)
c) extraction with $NaHCO_3$ (ascorbic acid used as reducing agent)
d) extraction with ammonium oxalate
e) extraction with ammonium lactate

Ryegrass was grown in pots filled with 2.2 kg of surface soil from 18 locations with contrasting soil properties and fertility. A basic dressing of nitrogen fertilizer was added to each pot at a rate of 1g ammonium nitrate per kg of soil. Two cuts of rye grass were taken 44 and 72 days after sowing (1/12/85).

Available P in the soil, as determined by each method and expressed as ppm available phosphate, was correlated with the total-P uptake (mg/pot) and total dry matter production (g/pot) of the ryegrass (cuts 1+2). The results are given in Table 33.

Table 33 The coefficients of determination (R^2) between soil test of available P by various methods and yield or P uptake by ryegrass

Yield components	Methods of P soil test used				
	$NaHCO_3$ ($SnCl_2$)	$NaHCO_3$ (Ascorbic)	Anion Resin	Lactate	Oxalate
Dry wt. (1+2) cuts	0.82	0.81	0.86	0.24	0.53
P-uptake (1+2) cuts	0.92	0.91	0.93	0.28	0.60

These results confirm that Anion Exchange Resin and the $NaHCO_3$ extraction techniques gave good estimates of soil available-P. In addition, it was noted that the estimates of available-P obtained by the anion exchange resin and the two methods using $NaHCO_3$ (Olsen method) were highly correlated. It was concluded that either the anion exchange method or the Olsen method were suitable soil test procedures for available-P in calcareous soils, but since the Olsen method (with either reducing agent) is considerably less laborious, it is recommended for all future soil test calibration studies.

4.5.3 Soil Test/Crop Response Studies for Barley

During 1984/85 and 1985/86, thirty-three N x P factorial trials with barley have been conducted in farmers' fields in collaboration with the Syrian Soils Directorate. These have been reported elsewhere (see ICARDA 1986, pp 9-18, and section 2.2 of this report). At the start of each season, mineral nitrogen (NH_4^+ + NO_3^-) was determined in the 0-20, 20-40, 40-60 and 60-100 cm soil horizons, and available-P (Olsen) was determined in the 0-20 cm horizon. The results from these trials are being utilized to relate crop responses to N and P fertilizer with soil tests for available nitrogen and phosphorus. Two methodologies for soil test calibration, namely the Cate-Nelson Graphical Analyses method and the Mitcherlich-Bray, are illustrated for phosphorus and nitrogen.

The Cate-Nelson method utilizes a graphical analysis of the plot of relative yield (ranging from 0-100%) of barley against the level of available-P in the soil at sowing. The relative yield for each location is the ratio of total dry matter of barley in the zero phosphate fertilizer treatments to the maximum yields obtained when P-fertilizer is added. Only N x P treatment combinations which assure the N-nutrition of the crop are utilized to avoid confounding P and N responses. The method is based upon dividing soils into two groups, those with a high probability and those with a low probability of P-responses and subsequent division of the diagram into quadrants which maximize the number of points in the positive quadrants and minimizes the number in the negative quadrants. This is illustrated in Fig. 22 which shows that the critical level of Olsen-P in the top 20 cm of soil is about 5 ppm, above which value crops are likely to achieve around 80% of their maximum yield in the absence of fertilizer application.

The same methodology can be used for nitrogen soil tests as illustrated in Fig. 23 which shows that the critical level for nitrate nitrogen in the top 40 cm of soil is about 25 kg/ha. In both these illustrations, it is clear that soil tests above do not account for all

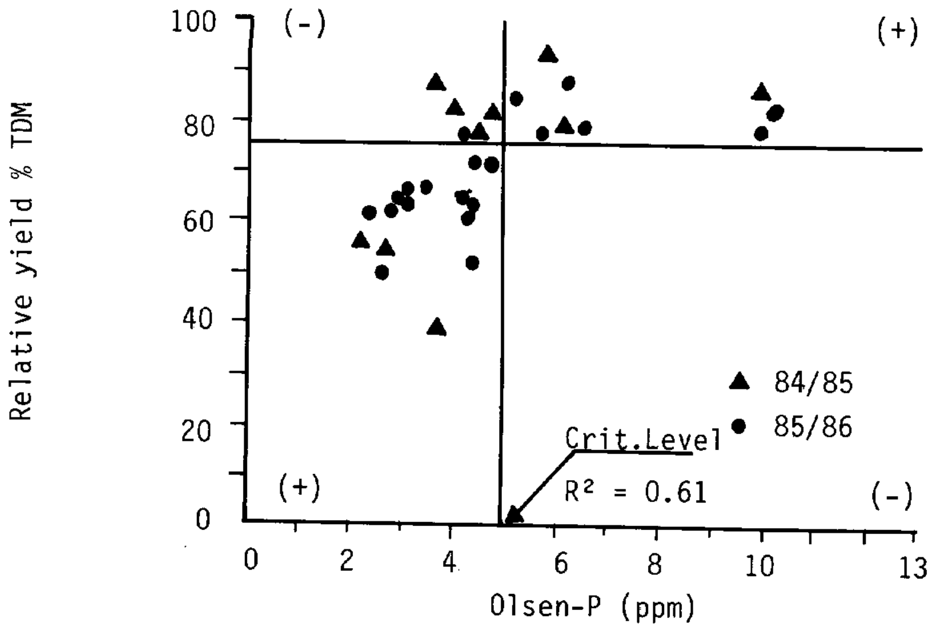


Figure 22 Scatter diagram of relative yield of barley total dry matter production vs Olsen-P test for the top 20 cm of soils

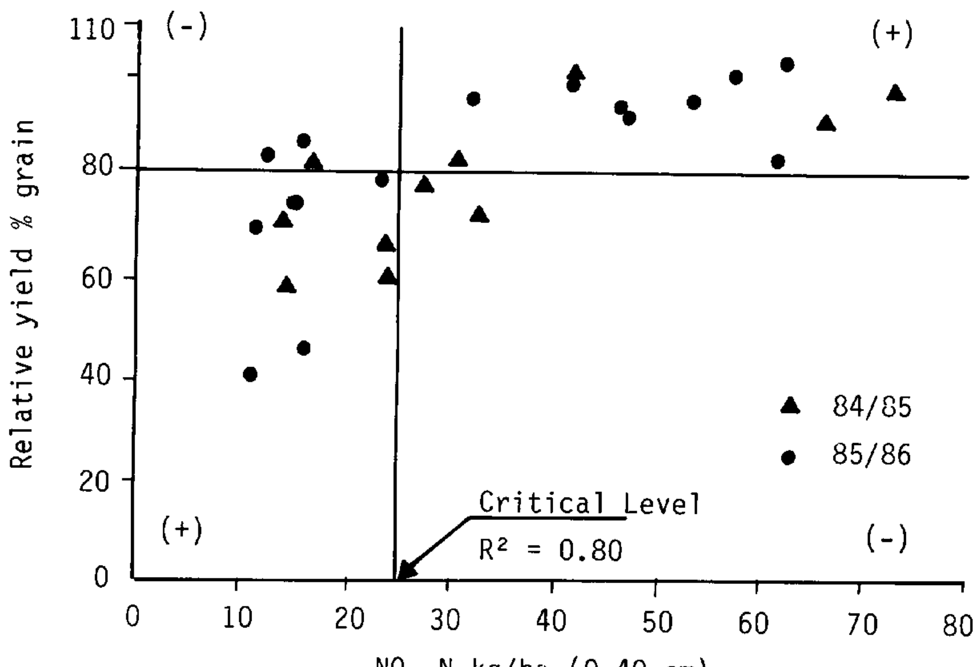


Figure 23 Scatter diagram of relative yield of barley grain vs nitrate nitrogen in the top 40 cms of soils

the variability associated with crop responses to fertilizer, but that they could have a useful role in improving the efficiency of fertilizer recommendations.

A second method of evaluating soil tests is the use of the Mitcherlich-Bray equation which has the following general form:

$$\text{Log } (A-Y) = \log A - c_1 b - c_2 x \qquad (1)$$

where: A is the maximum yield with optimum P fertilizer (kg/ha)

Y is the yield at any given phosphorus fertilizer rate (kg/ha)

x is fertilizer rate for yield Y (kg/ha P_2O_5)

b is the available P in the soil (kg/ha P_2O_5)

c_1 and c_2 are efficiency constants for b and x respectively.

This equation can also be expressed in terms of relative yield (Yr).

$$\text{Log } (100-Yr) = \text{Log } 100 - c_1 b - c_2 x \qquad (2)$$

where: $Yr = \dfrac{\text{Yield at fertilizer rate x}}{\text{Yield with optimum P fertilizer}} \times 100$

In both equations (1) and (2) we refer to yields of total dry matter production of barley.

Using equation (1), the coefficients c_1 and c_2 were calculated for each individual location as described by Yurtsever (1986), giving the following mean values for climatic zone 2 and 3

Coefficient	Zone 2	Zone 3	Zones 2 + 3
c_1	0.029	0.024	0.026
c_2	0.011	0.013	0.0126

Using these coefficients, and applying the zero fertilizer level to equation 2, the Mitcherlich-Bray equations for zones 2 and 3 were drawn on the scatter diagrams of relative yield v. Olsen-P test values (see Fig. 24 and 25). In general terms, the equations describe the observed relationship well.

Assigning a relative yield of 80% (in the absence of applied P fertilizer) to the equations in Figs. 24 and 25 indicates that the critical level of available-P in the soil is 4.7 ppm and 5.4 ppm for zones 2 and 3 respectively. These values are in close agreement with the value of 5 ppm obtained for zones 2 and 3 combined by the Cate-Nelson method (Fig. 22).

Furthermore, equation 2 can be utilized to predict the amount of phosphate fertilizer required to give varying percentages of maximum yield as affected by the level of available P in the soil at sowing. This is illustrated below utilizing the coefficients for zone 2 and 3 combined.

Olsen-P (ppm)	Rate of P_2O_5 required to give 90% of maximum yield	Rate of P_2O_5 required to give 98% of maximum yield
2	59	114
4	38	94
6	18	73
8	0	52
10	0	32

Such data alone are not sufficient to allow fertilizer recommendations to be made unless one assumes that a farmer's objective is to maximize his yield, regardless of the rate of return on money invested. In variable rainfall environments, farmers are well aware of

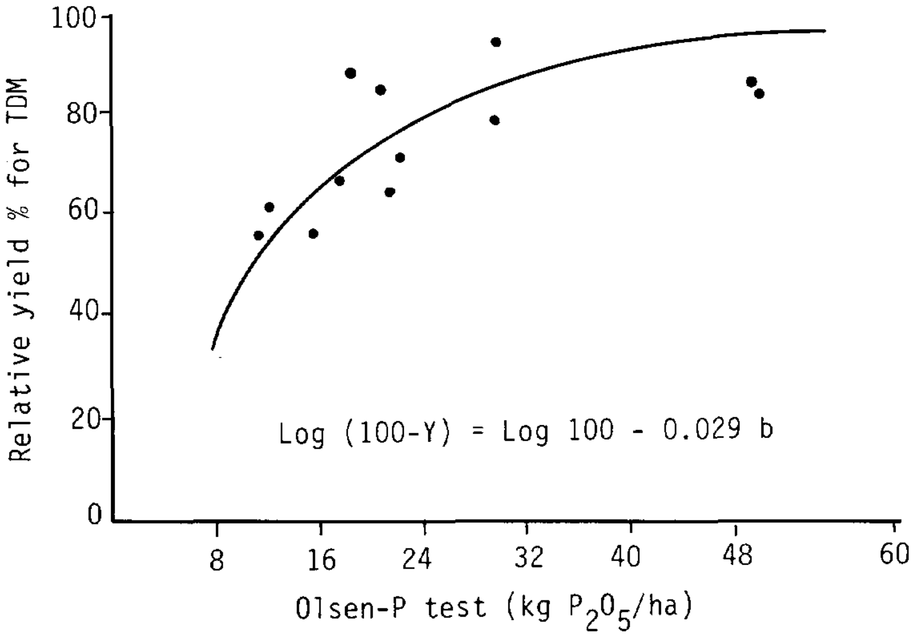


Figure 24 Scatter diagram of relative yield percentage of total dry matter of barley vs Olsen-P test in zone 2 of Syria

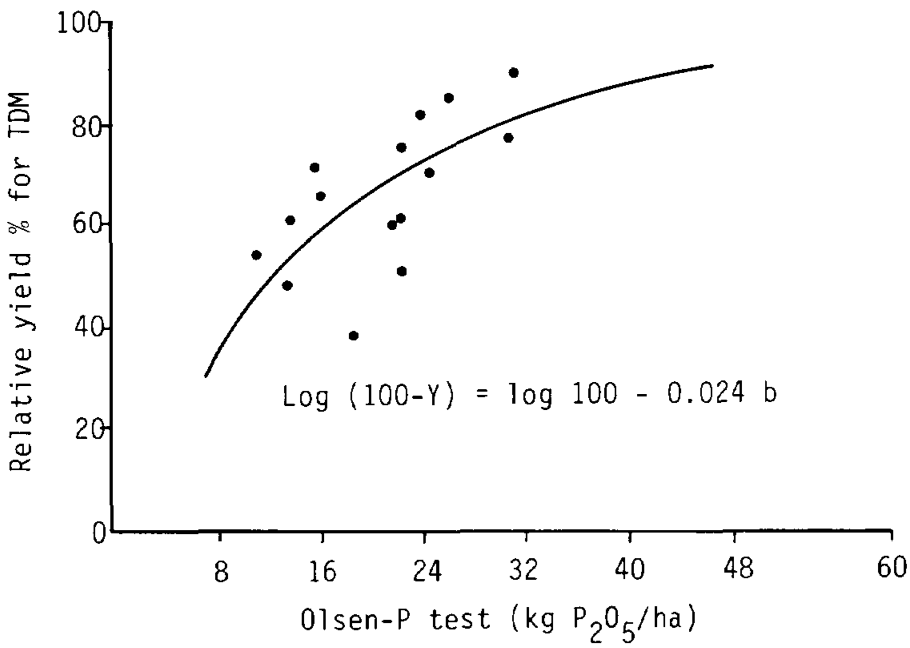


Figure 25 Scatter diagram of relative yield percentage of total dry matter of barley vs Olsen-P test in zone 3 of Syria

the risk associated with crop production, and thus an economic evaluation which calculates increase in net revenue and rates of return associated with different levels of fertilizer application is essential.

In conducting such an analyses, equation (1) which refers to actual yields is utilized. In doing so, it is necessary to define A, the theoretical maximum yield obtainable. Many workers (e.g., Yurtsever 1986) use the Mitcherlich-Bray equation itself to produce a theoretical maximum yield, a single value to represent the whole area for which the information is being derived. This maximum value will be very close to the mean of the maximum values observed at each location from which data is utilized. However, in moisture limiting rainfed environments we know that the maximum yield obtainable at any given location will depend not only on the available-P and level of applied fertilizer, but also the seasonal rainfall. For instance, in the present data set, over the two seasons, rainfall varied between 147 and 398 mm, and maximum total dry matter varied correspondingly between 1800 and 7500 kg/ha. A simple linear regression between maximum dry matter and rainfall (R) gave the following relationship:

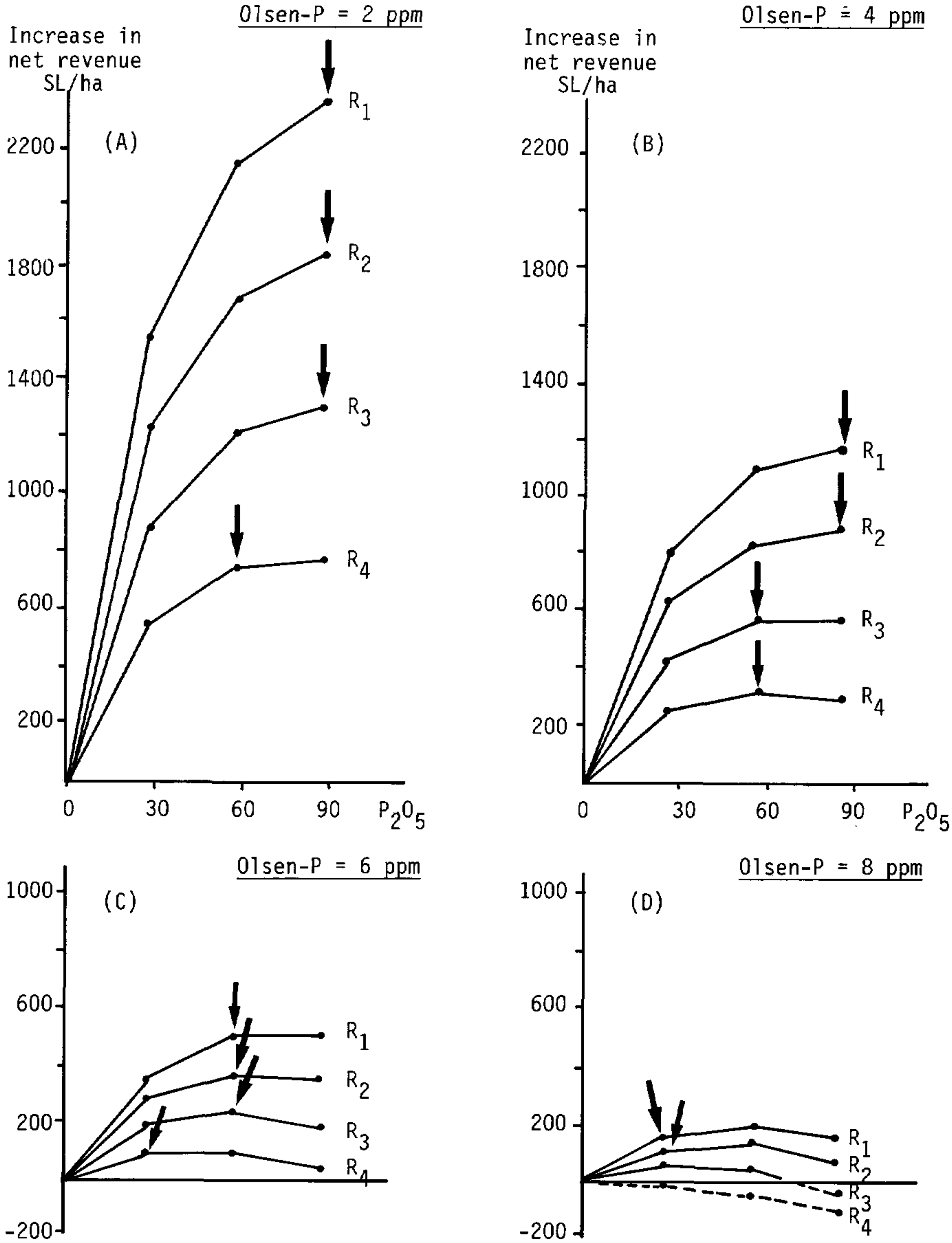
$$\text{Maximum dry matter (kg/ha)} = 27.81\ R - 1396 \qquad (R^2=0.59)$$

We have thus modified the standard Mitcherlich-Bray equation by utilizing this relationship in defining a variable theoretical maximum yield which is rainfall dependent. The equation thus has the form:

$$\text{Log}\ [(27.81R-1396) - Y] = \text{Log}\ (27.81R-1396) - 0.026\ b - 0.0126\ x$$

In this form, economic analyses allows the production of a family of curves relating increase in net revenue and rates of return to phosphate status of the soil, level of applied phosphate and rainfall received during the season. These are illustrated in Fig. 26, which shows the increases in net revenue (SL/ha) associated with different levels of phosphate application (30, 60, 90 kg/ha P_2O_5) on soils of contrasting fertility status (Olsen-P, 2, 4, 6, 8 ppm) in years receiving different seasonal rainfall totals (150, 200, 250 and 300 mm/season). Costs and prices utilized in the calculation of increased net revenue are given in section 2.2.1 of this report. The arrows in Fig. 26 indicate the point at which maximum increase in net revenue is obtained without the marginal rate of return on money invested in increased costs falling below 40%, judged as the economic optimum level of fertilizer application.

As stated earlier, these results are presented to illustrate the potential usefulness of soil tests for improving the efficiency of fertilizer use, and thus we would not wish to draw substantive conclusions at this stage. Nevertheless, several important points should be made. Clearly, seasonal rainfall has a major effect on the expected increase in net revenue from phosphate application to barley, especially in soils of low available P (Fig. 26a, 26b). Similarly, it will affect the economic optimum rate of fertilizer to be applied (Fig. 26a, b, c). Since the application of phosphate occurs at seeding time, before the seasonal rainfall is known, the recommendation of



R=Rainfall amount; R_1 = 300 mm; R_2 = 250 mm; R_3 = 200 mm; R_4 = 150 mm

Figure 26 The effect of soil available P (Olsen-P ppm), rainfall (mm) and applied phosphate fertilizer (kg/ha P_2O_5) on the increase in net revenue derived from barley production in N. Syria.

economically optimum rates of application (and the expected increase in net revenue) for any given location will ultimately depend on an analysis of long term rainfall records which define the probability of receiving different amounts of seasonal rainfall.

As would be expected the level of available-P in the soil also has a profound impact on increases in net revenue and rates of return on P-fertilizer application (compare 26a and 26b). On-going research will need to define the effect of phosphate fertilizer use on the level of available-P in the soil. Residual effects of P-fertilizer persist for 2-3 years in these dry barley growing environments (ICARDA, 1986 p 62-67), and therefore regular fertilizer use will result in an increased amount of available-P in the soils. A static recommendation for phosphate fertilizer use on barley is therefore likely to be unsuitable in the long term, and a methodology must be found which allows the effect of previous fertilizer application to be taken into account.

4.5.4 Conclusions

The results and discussions presented here on phosphate application to barley illustrate some of the major considerations required in improving phosphate fertilizer use efficiency in variable rainfall environments. Our on-going research program aims to refine these procedures, and is expanding the work to other crops such as wheat, chickpea and lentil. Similar considerations must be given to nitrogen fertilizer use on cereals, but different approaches will be required for several reasons. Firstly, nitrogen, unlike phosphate fertilizer, is mostly top-dressed in late winter, when a large part of the seasonal rainfall has occurred, and the "potential" of the season can therefore be ascertained with greater certainty. Secondly, as illustrated in this report, crop rotation will have a major impact on nitrogen responses. Thirdly, the chemistry of nitrogen dynamics in the soil (and thus the residual effect of fertilizer) are affected by different and less predictable processes to those of phosphate.

A. Matar, P. Cooper, A. Mazid

4.6 IMPACT AND POTENTIAL OF WATER MANAGEMENT WITHIN RAINFED AREAS

4.6.1 Research Managed Field Trials: Controlled and On-Farm

In the 1985/86 growing season, the research managed controlled field trials for Durum wheat variety, Sham I, at Tel Hadya were a split block design which examined the effect of the rate of nitrogen fertilizer on yield of Durum wheat for different schedules of supplemental irrigation with four replications. The main plots were four nitrogen fertilizer rates of none, 70, 140, and 210 kg of N/ha arranged in a 4 x 4 latin square. Subplot treatments were four schedules of water management; rainfed, with supplemental irrigation scheduled at 1/3 water balance, 2/3 water balance and 3/3 water balance. Research managed on-farm trials were located at Tel Dhaman subdistrict (Breda, climatic zone 2);

and, Mare'a subdistrict (Om Hoche, climatic zone 1). The water management treatments and wheat variety were the same as the research managed controlled field trials at Tel Hadya. The on-farm studies followed a randomized complete block design which examined the effect of different schedules of supplemental irrigation on yield with three replications.

The objectives of the water management studies were to improve supplemental irrigation practices, to predict level of nitrogen application, to estimate the consumptive use, and to determine irrigation scheduling requirements under local conditions for increased production of crop yields. The effective and efficient implementation of supplemental irrigation required scheduling by the water balance method using climatic information. Whether to irrigate or not was decided purely on the estimated profitability of doing so which underscores the importance of scheduling supplemental irrigation by *minimum* -- *not maximum* -- crop water requirements.

At planting time, all plots were sown by broadcasting wheat at a rate of 140 kg/ha. Phosphorus (P_2O_5) was broadcast at a rate of 80 kg/ha, and nitrogen (Urea) was applied at a rate of 40 kg/ha on all nitrogen treatments for Tel Hadya and for all on-farm plots. For the research controlled studies, the remaining quantities of nitrogen (30, 100, and 170 kg/ha) were applied at tillering near the end of February. For the on-farm trials, before tillering, near the end of February, the final application of nitrogen was applied at the rates of 80 kg of N/ha at Om Hoche, and 60 kg of N/ha at Breda. Plots were shaped into furrowed basins for surface irrigation following sowing and fertilization. The water balance method using daily rainfall and pan evaporation was calculated to determine irrigation scheduling.

4.6.2 Results

The seasonal rainfall (September through May) at Tel Hadya was 315.1 mm, at Breda 220 mm, and at Om Hoche 356 mm. After seeding, a 30 mm irrigation was applied to all plots for germination. For the research managed trials at Tel Hadya and the on-farm trials at Breda, a total of 4 irrigations were added. Table 34 shows the addition of water to the supplemental irrigation treatments during the growing season. The Durum wheat plants were under no moisture stress throughout the growing season at the 3/3 water balance treatment. At Om Hoche, the trials were confounded by subirrigation of water from higher ground and a lack of farmer cooperation with the specified irrigation regime; therefore, these data are not presented.

Table 34 Quantity of water (mm) added in 4 applications of supplemental irrigation for the 1985/86 growing season at Tel Hadya and Breda

Irrigation levels	Rainfall: Tel Hadya	Rainfall: Breda	Water added at germination	Supplemental irrigation	Total Added: Tel Hadya	Total Added: Breda
Rainfed	315.1	220	30	0	345.1	250
1/3 WB	315.1	220	30	120	465.1	370
2/3 WB	315.1	220	30	240	585.1	490
3/3 WB	315.1	220	30	360	705.1	610

Plant heights shown in Table 35 for Tel Hadya were measured at maturity. The data show that without nitrogen and supplemental irrigation height was depressed, however, there was a response to low levels of nitrogen and low quantities of irrigation. Sham I reached a plant height of 60 cm without irrigation or nitrogen and about 90 cm with supplemental irrigation and nitrogen. No lodging of the plants was observed with larger amounts of nitrogen and supplemental irrigation. Plant heights measured at Breda are shown in Table 36. The level of supplemental irrigation increased plant height; however, the same result with Sham I is shown where additional supplemental irrigation have little or no effect on height.

Table 35 Effect of level of nitrogen (kg/ha) and supplemental irrigation treatment (SIT) on plant height (cm) of wheat, 1/5/86 at Tel Hadya

Irrigation levels	Levels of nitrogen (a)				Irrigation means (b)
	None	70	140	210	
Rainfed	59	77	72	69	69
1/3 Water balance	71	91	80	86	82
2/3 Water balance	70	86	89	90	84
3/3 Water balance	76	87	89	91	86
Nitrogen means (c)	69	85	83	84	

(a) LSD, 5% among SIT for same nitrogen level = 11
among SIT for different nitrogen levels = 14
(b) LSD, 5% = 5 (c) LSD, 5% = 11

The analysis of variance showed:
1. Levels of nitrogen -- significant (F=4.87, df=3/6)
2. Supplemental irrigation treatments -- significant (F=15.30, df=3/9)

Table 36 Effect of supplemental irrigation treatment (SIT) on plant height of wheat at Breda, 11/5/1986

Supplemental Irrigation	Plant height (cm) Mean	Std. Dev.	% Coef. Var.
Rainfed	67	6.7	10.1
1/3 Water balance	81	6.8	8.3
2/3 Water balance	85	8.2	9.6
3/3 Water balance	90	4.3	4.8

LSD, 5% = 6

The analysis of variance showed:
Supplemental irrigation treatments -- significant (F=27.0, df=3/9)

Results of data analyses for Tel Hadya studies showed that only supplemental irrigation had a significant effect on the length of grain head which ranged from 4.1 cm to as much as 5.7 cm. The effect of nitrogen on length of grain head was not significant. This increased length of grain head undoubtedly contributed to increased yields.

Table 37 shows that at Tel Hadya a small amount of supplemental irrigation (1/3 water balance) and the addition of 70 kg/ha of nitrogen had a significant effect on straw weight. The amount of straw increased from 2.61 t/ha without irrigation or nitrogen to as much as 8.02 t/ha with 1/3 water balance treatment and 70 kg of N/ha. Straw weight is a critical component of wheat production because straw may be as important to farmers as yields.

Table 37 Effect of level of nitrogen (kg/ha) and supplemental irrigation treatment (SIT) on straw weight (t/ha) at Tel Hadya

Irrigation levels	Levels of Nitrogen (a) None	70	140	210	Irrigation means (b)
Rainfed	2.61	5.00	3.62	4.05	3.81
1/3 Water balance	3.87	6.42	5.63	6.77	5.67
2/3 Water balance	4.56	8.02	8.01	5.97	6.64
3/3 Water balance	3.82	7.31	7.54	7.73	6.60
Nitrogen means (c)	3.71	6.68	6.20	6.13	

(a) LSD, 5% among SIT for same nitrogen level = 2.39; and among SIT for different nitrogen levels = 2.40
(b) LSD, 5% = 1.19 (c) LSD, 5% = 1.23

The analysis of variance showed:
1. Levels of nitrogen -- significant (F=12.11, df=3/6)
2. Supplemental irrigation treatments -- significant (f=10.06, df=3/9)

Grain yield of Sham I at Tel Hadya (Table 38) increased from 2.10 t/ha to as much as 8.64 t/ha. Grain yield maximized with 70 kg of N/ha and at the 1/3 water balance for supplemental irrigation. The response to nitrogen was similar, where the 70 kg treatment produced the same grain and straw yield as treatments of 140 and 210 kg of N/ha. At Breda, yields increased from 2.63 t/ha to as much as 6.42 t/ha (Table 39). The differences in yield data at Breda reflect plot variability as shown by the percent coefficient of variation; nonetheless, these increases in grain yield exceed the government's suggested goal of five t/ha with supplemental irrigation.

The percent harvest index at Tel Hadya showed the relationship as that of the previous data for supplemental irrigation which averaged 48.1%, with rainfed = 43.9%, however, there was no significant difference attributable to the levels of nitrogen. At Breda, the average harvest index percentage = 34.9% but was not significantly different for supplemental irrigation.

Table 38 Effect of level of nitrogen (kg/ha) and supplemental irrigation treatment (SIT) on yield of grain (t/ha) at Tel Hadya

Irrigation levels	Levels of Nitrogen (a)				Irrigation means (b)
	None	70	140	210	
Rainfed	2.10	3.56	2.74	3.46	2.97
1/3 Water balance	3.37	8.64	5.03	6.23	5.82
2/3 Water balance	4.26	7.10	7.18	6.50	6.26
3/3 Water balance	3.53	6.36	6.10	6.17	5.54
Nitrogen means (c)	3.32	6.41	5.26	5.59	

(a) LSD, 5% among SIT for same nitrogen level = 2.14; and among SIT for different nitrogen levels = 2.25
(b) LSD, 5% = 1.07 (c) LSD, 5% = 1.28

The analysis of variance showed:
1. Levels of nitrogen -- significant (F=10.81, df=3/6)
2. Supplemental irrigation treatments -- significant (F=15.7, df 3/9)

Table 39 Effect of supplemental irrigation treatment (SIT) on yield of grain (t/ha) for on-farm trials at Breda

Irrigation levels	Means	Wheat yield (t/ha) Std. Dev.	% Coef. Var.
Rainfed	2.63	0.86	32.6
1/3 Water balance	5.55	1.18	21.3
2/3 Water balance	6.42	0.81	12.7
3/3 Water balance	4.02	1.86	46.2

LSD, 5% = 1.68

The analysis of variance showed:
Supplemental irrigation treatment -- significant (F=11.86, df 3/6)

4.6.3 Agro-Economic Survey Results

Preliminary data collection were completed at locations in Aleppo province, 1985, and Al Hassakeh province, 1986:

1. Mare'a subdistrict, 45 km north of Aleppo
2. Tel Dhaman subdistrict, 45 km southeast of Aleppo
3. Kahtanyeh subdistrict, 20 km east of Kamishly; and
4. Tel Brack subdistrict, 40 km north of Al Hassakeh.

Several techniques and information sources were used: official documents, field observations, informal interviews with farmers and governmental officials, agricultural machinery dealers, and well drilling professionals. The impact of water management on rainfed farming systems at the four study sites is important agriculturally, economically, and socially.

Water supplies were available from both surface and groundwater sources at the study sites, with the exception of Mare'a where only groundwater was available. Depth to groundwater was lower at the Al Hassakeh sites (50-120 m) than at the Aleppo sites (30-80 m). However, water flow capacity of the wells was less in Aleppo (30-50 m^3/hr) than in al Hassakeh (40-60 m^3/hr).

Table 40 General information on water management at the four study sites

	Aleppo		Al Hassakeh	
Details	Mare'a	Tel Dhaman	Kahtanyeh	Tel Brack
Irrigated area, ha	2,830	7,000	6,569	10,850
% Total cultivated area	16	8	8	9
Total No. of villages	19	114	165	247
Villages with irrigation	15	52	40	128
Water source: surface	No	Yes	Yes	Yes
groundwater	Yes	Yes	Yes	Yes
No. of wells	459	150	240	462
Depth of water table, m	30-80	50-60	50-120	60-70
Pumping depth, m	40-100	70-80	80-150	150
Water flow capacity, m^3/hr	30-50	30-40	40-60	40-50
No. of irrigations/season:				
Wheat, normal rainfall	3-4	3-4	3-4	3-4
low rainfall	4-5	4-5	4-5	4-5
high rainfall	2-3	2-3	2-3	2-3
Faba bean	3-6	1-3	----no crop----	
Winter vegetables	2-3	2-3	3-4	3-4
Maize and sesame	4-6	4-6	5-7	5-7
Cotton	12-15	12-15	15-16	15-16

Although summer crops are given more irrigations per season in Al Hassakeh than Aleppo, winter crops receive the same number of supplemental irrigations. General information on water management is presented in Table 40.

With supplemental irrigation, fallowing was eliminated and cropping intensity increased from 65 to 100% without irrigation to a minimum cropping intensity of 105% at Aleppo and 114% at Al Hassakeh. New profitable cash crops (vegetables, cotton, maize, etc.) have been introduced and the total cultivated area has increased for summer crops by more than 50% from a small area previously planted to melons but now planted to a wide variety of crops. New improved and high yielding varieties of most crops have become available and are now intensively grown by farmers in both provinces. Adoption of other capital inputs such as machinery, fertilizer, herbicides, and pesticides have increased with water management (Table 41).

Table 41 Comparisons of agronomic practices used for supplemental irrigation and rainfed farming for Aleppo and Al Hassakeh provinces, Syria

Details	Aleppo		Al Hassakeh	
	SI	Rainfed	SI	Rainfed
Cropping intensity, %	105	65-100	114	75-100
Winter crops, %	50	65-67	50	75-70
Summer crops, %	55	0-33	64	0-30
Fallow, %	0	35-0	0	25-0
Wheat cultivation:				
Variety	Improved	Local	Improved	Local
Seeding method	Mechanical	Manual	----Mechanical----	
Seeding rate	120-150	100-120[1]	120	150[3]
	150-180	Not Grown[2]	150-200	120-140[4]
Seeding date	Dec-Jan	Nov-Dec	Jan	Oct-Nov
Fertilizer application	N, 150	100[1]	200	175[3]
	P_2O_5, 100	80	150	150
	N, 160	30[2]	330	150[4]
	P_2O_5, 105	45	220	100
Yield, t/ha				
Improved varieties	4-6	1-2	2-4	1-2
Local varieties	2-3	1-2	2-3	1-2

1 Mare'a subdistrict; 2 Tel Dhaman subdistrict;
3 Kahtanyeh subdistrict; 4 Tel Brack subdistrict.

With supplemental irrigation, the risk associated with agricultural production decreased and larger, and farmers claimed, more stable yields were obtained. For example, wheat yields increased from an average of 1.5 t/ha with rainfed farming to 3 t/ha in Al Hassakeh and 5 t/ha in Aleppo with supplemental irrigation. Similar yield increases were obtained for barley, faba bean, vegetables and summer crops. A quantitative assessment of the impact of supplementary irrigation on yield stability will be made through village surveys in the coming season.

Supplemental irrigation had an effect on animal production at all study locations. Sheep are the principal animal for production; however there are fewer sheep on farms that use supplemental irrigation than on farms of comparable size that do not. Total number of sheep within each sub-district was 150,000 at Kahtanyeh, 110,000 at Tel Brack, 100,000 at Tel Dhaman, and 12,000 at Mare'a. While supplemental irrigation had no effect on dairy cattle production in Al Hassakeh, the number of dairy cattle increased in Aleppo. The number of dairy cattle at each subdistrict were 3,000 at Kahtanyeh, 900 at Tel Brack, 100 at Tel Dhaman, and 180 at Mare'a. Forage crops were rarely grown in the study areas and those farmers using supplemental irrigation did not increase the forage production. Recently, the government has encouraged forage crop production by providing farmers with seed, mechanical harvesting, and marketing opportunities.

Net income per hectare of supplemental irrigation farming was 3 to 5 times that of rainfed farming in Al Hassakeh and 6 to 10 times that in Aleppo. The difference in net income of the two provinces received from supplemental irrigation farming can be attributed to (1) higher productivity achieved by Aleppo farmers, and (2) greater production of vegetables and other profitable crops with better marketing conditions in Aleppo.

Where there is supplemental irrigation, migration (temporary and permanent) decreased to a minimum or even ceased in some cases.

Supplemental irrigation also gave higher yields and a greater cropping intensity ratio, which resulted in substantially greater and more stable incomes. Better marketing conditions of agricultural commodities also appeared to be associated with areas where supplemental irrigation was widely practiced.

4.6.4 Conclusions

In all measurements for the Sham I variety of Durum spring wheat, the 1/3 water balance of supplemental irrigation produced the same yield as increased amounts of irrigation, i.e., 2/3 water balance and 3/3 water balance. The 30 mm of water added to all plots to ensure germination *may have contributed to the increase in yield for the rainfed* treatments. In addition, at Tel Hadya, the lower level of nitrogen (70 kg/ha) produced the same yield as increased amounts of nitrogen, i.e., 140 and 210 kg/ha. These data show that scheduling of supplemental irrigation of at least 30 mm per application is more important than the quantity of water applied. Also, when nitrogen is applied as 30 kg/ha at planting time and 40 kg/ha before tillering (near mid-February in Aleppo province) further additions of nitrogen may not be beneficial.

With supplemental irrigation, rural families have better living conditions and general welfare, better housing, more valuable and comfortable furniture, access to agricultural machinery, transport vehicles, TV sets and other electrical facilities.

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5. TRAINING AND AGROTECHNOLOGY TRANSFER

During the 1985/86 season a number of training activities were carried out by FSP staff. These activities will be detailed in the following sections.

5.1 CONTRIBUTION TO OTHER PROGRAMS' RESIDENTIAL TRAINING COURSES

These courses were offered by CP, FLIP and PFLP. As in previous years, FSP staff contributed to these courses through: (1) lectures and practicals on approaches to FSR and (2) lectures and practicals on weed control principles and methodology.

5.2 FSP RESIDENTIAL TRAINING COURSE

The first FSP Annual Residential Training Course was held during the period 15 February - 5 April, 1986. The objectives of this course were (1) to introduce personnel from the region's national agricultural research programs to FSR approach, (2) to provide participants with sound technical knowledge in their chosen fields of agricultural research and (3) to promote contacts and information exchange between ICARDA and national programs. The course was attended by 19 participants representing 12 countries of the region. These countries included Pakistan, Iran, Iraq, Jordan, Turkey, Morocco, Tunisia, Libya, Sudan, Ethiopia, Saudi Arabia and North Yemen.

5.3 SHORT COURSES

Two short courses were held during the season. The first was the Soil and Plant Analyses Training Course which was held at Tel Hadya during the period 12-24 January, 1986. The course objectives were: (1) to provide participants with sound technical knowledge in methods of soil and plant analysis, (2) to compare the methods of analysis commonly used in the region and (3) to correlate results of soil analyses with plant response. The course was attended by 9 participants from 5 countries of the region namely Syria, Jordan, Egypt, Tunisia and Morocco.

The second course was an in-country training activity held in Alata, Turkey during the period 24-28 March, 1986. The course addressed the topic "Economics in Agricultural Research". The objective of the course was to promote interdisciplinary research with a farming systems perspective. It was attended by 17 Turkish participants.

5.4 WORKSHOPS

Three workshops were held during the season. The first was the Third ICARDA Regional Farming Systems Workshop for West Asia and North Africa which was held at NARC in Islamabad during the period 7-10 April, 1986. The objective of this workshop was to familiarize the participating group with each others' perceptions of FSR by outlining current programs of research. The workshop was sponsored by PARC, CIDA, ICARDA, USAID and Ford Foundation. It was attended by 35 participants.

The second one was the Inter-Center Workshop on "Agro-Ecological Characterization, Classification, and Mapping." It was held at FAO premises, Rome during the period 14-18 April, 1986. The purpose of the workshop was: (1) to compare objectives, expectations and need of the IARC's in the field of agro-ecological characterization, classification and mapping, (2) to examine applicable methodologies and (3) to explore the possibilities of cooperation between IARC's and other institutions through the sharing of data and methods. The workshop was sponsored by a number of agencies, organized by IARC's of the CGIAR in collaboration with FAO and was attended by 67 participants.

The third workshop was held in Aleppo during the period 23-25 June, 1986. It addressed the topic "Soil Test Calibration". The objectives of the workshop were: (1) to facilitate professional contacts among scientists in the region who are conducting research on calibration of soil tests by field experiments under rainfed conditions, (2) to critically review, discuss and evaluate the previous work accomplished in the region on soil test calibration carried out with the specific purpose of correlating the results of soil analysis in the laboratory to expected fertilizer response in the field and (3) to formulate guidelines for regional experimentation and future cooperative work need among countries of the region. The workshop was funded by ICARDA, IDRC and MIAC (Morocco) Project and was attended by 20 participants.

5.5 INDIVIDUAL TRAINING

During 1985/86 season the FSP staff were associated with the supervision of 10 postgraduate students: 6 MSc and 4 PhD. Three of these joined the program during 1985/86 season and the remaining candidates were continuing from previous seasons. Six of these postgraduate students will finish their studies before the beginning of 1987. Names, degrees, cooperating universities and thesis topics of these students are given in Table 42.

Table 42 Individual training, degree-related

Name	Country	Degree	Cooperating University	Thesis Topic
A. Wahbi	Syria	PhD	Reading, U.K.	Barley root development
N. Mona	Syria	PhD	Texas A&M, USA/ Aleppo, Syria	Structure and price responsiveness (barley)
Y. Sabet	Syria	PhD	Paris, France	Rainfall intensity/soil erosion
U. Marz	Germany	PhD	Hohenheim, Germany	Economics of intensified sheep and crop production
S. Dozom	Syria	MSc	Aleppo, Syria	Tillage, weed control and fertilization effects
O.B. Shoaib	S.Yemen	MSc	Aleppo, Syria	Herbicide and fertilizer effect on wheat
T. El-Masri	Jordan	MSc	Jordan	Evaluation of cultural practices on forage legumes
G.A. Karaki	Jordan	MSc	Jordan	Response of lentil to drought
H.M. Dahroug	S.Yemen	MSc	Aleppo, Syria	Wheat agronomy
F.S. Yousif	Sudan	MSc	Gezira, Sudan	Faba bean marketing in Sudan

A number of nondegree-related individual training programs were conducted during the 1985/86 season. The training periods ranged from 1 week to 1 year. Names of participants, countries, subject and duration of these training courses are given in Table 43.

Table 43 Individual training, nondegree-related

Name	Country	Subject	Duration
A. Rashed	Pakistan	Field experimentation	3 weeks
K. Mahmood	Pakistan	Agricultural economics	3 weeks
M. Islam	Pakistan	Soil fertility	2 weeks
A. Ali Saeed	N. Yemen	Field experimentation	3 1/2 months
M.E. Mourid	Morocco	Crop model use	3 weeks
F. Jarkas (Mrs.)	Syria	Soil & plant analysis	1 week
S. Masri (Ms.)	Syria	Weed control	1 week
M. Azhari (Ms.)	Syria	Soil moisture	1 week
B. El-Bunny (Ms.)	Syria	Data analysis	4 months
Y. Khalaf	Syria	On-farm fertility trials	1 year

5.6 MISCELLANEOUS ACTIVITIES

A number of scientists from countries of the region and elsewhere visited the FSP during the season and participated in discussing with program scientists. Staff also participated in presentation days and in training students from Aleppo University.

M. Bakheit Said

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