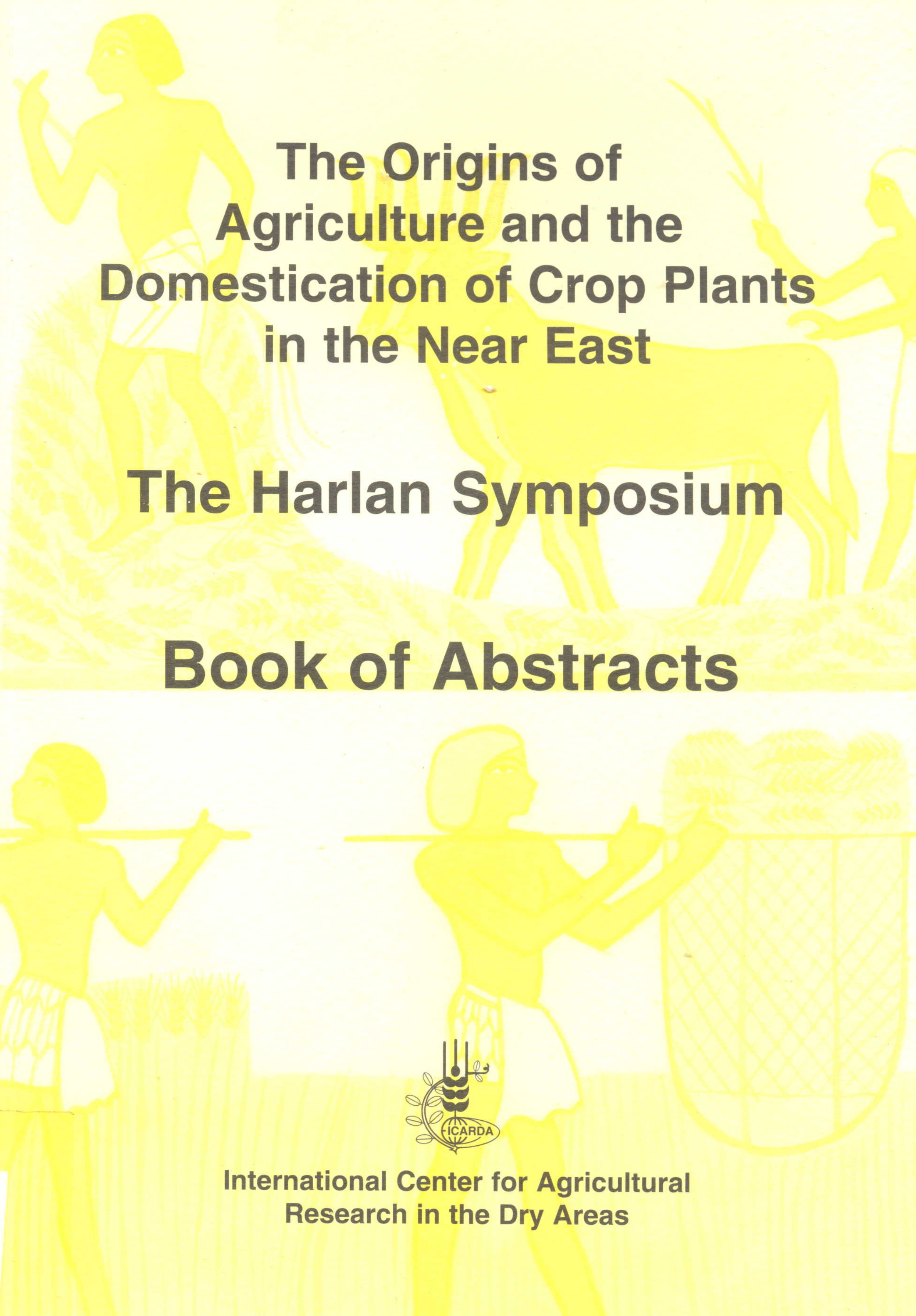


The Origins of Agriculture and the Domestication of Crop Plants in the Near East

The Harlan Symposium

Book of Abstracts

International Center for Agricultural
Research in the Dry Areas

About ICARDA

Established in 1977, the International Center for Agricultural Research in the Dry Areas (ICARDA) is governed by an independent Board of Trustees. Based at Aleppo, Syria, it is one of the 16 centers supported by the Consultative Group on International Agricultural Research (CGIAR), which is an international group of representatives of donor agencies, eminent agricultural scientists, and institutional administrators from developed and developing countries who guide and support its work.

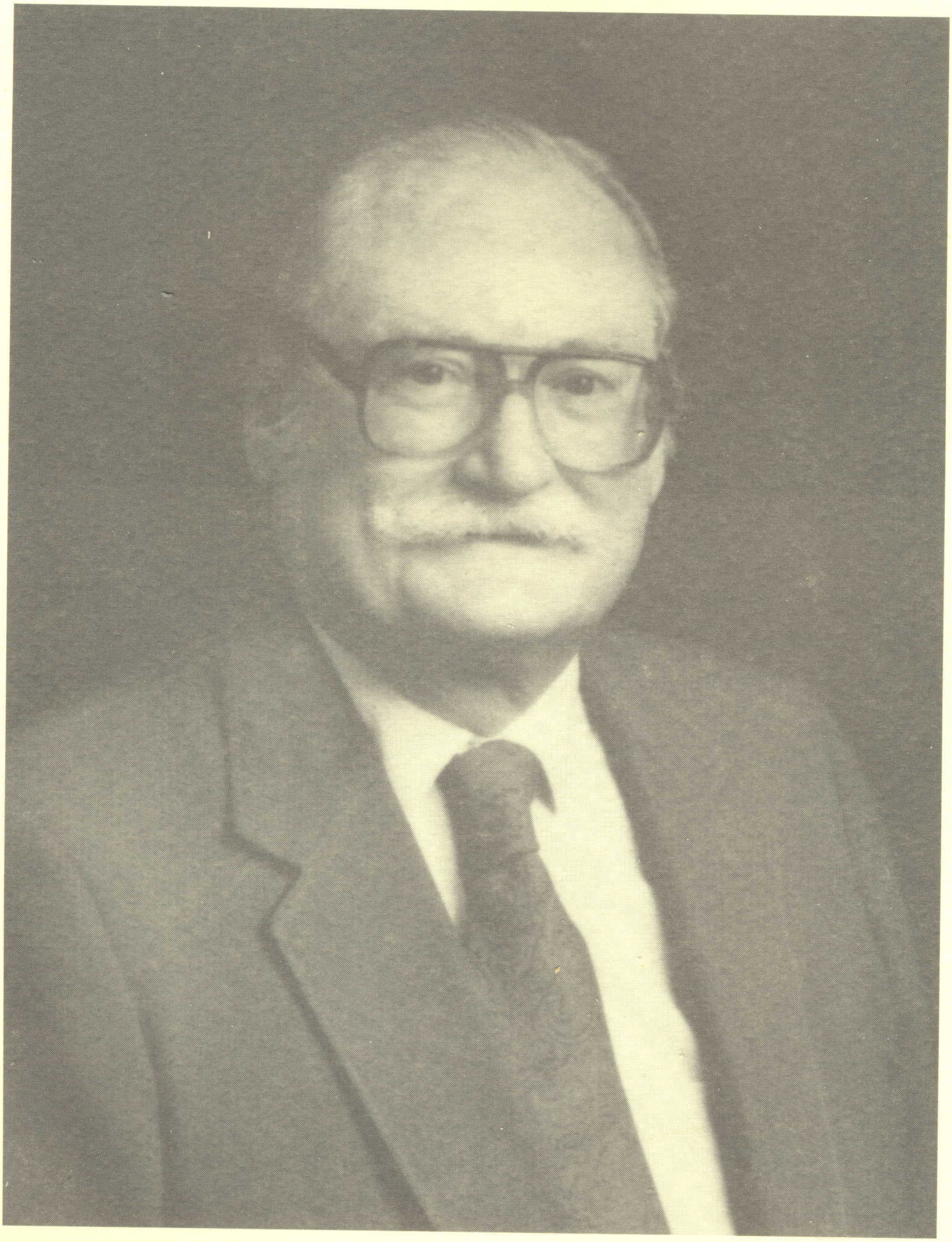
The mission of the CGIAR is to promote sustainable agriculture to alleviate poverty and hunger and achieve food security in developing countries. The CGIAR conducts strategic and applied research, with its products being international public goods, and focuses its research agenda on problem-solving through interdisciplinary programs implemented by one or more of its international centers, in collaboration with a full range of partners. Such programs concentrate on increasing productivity, protecting the environment, saving biodiversity, improving policies, and contributing to strengthening agricultural research in developing countries.

In the context of the challenges posed by the physical, social and economic environments of the dry areas, ICARDA's mission is to improve the welfare of people in the dry areas of the developing world by increasing the production and nutritional quality of food, while preserving and enhancing the resource base. ICARDA meets this challenge through research, training, and dissemination of information in partnership with the national agricultural research and development systems.

ICARDA serves the entire developing world for the improvement of lentil, barley and faba bean; all dry-area developing countries for the improvement of on-farm water-use efficiency, rangeland and small-ruminant production; and the West Asia and North Africa region for the improvement of bread and durum wheats, chickpea, and farming systems. ICARDA's research provides global benefits of poverty alleviation through productivity improvements integrated with sustainable natural-resource management practices.

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

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



Prof. Jack R. Harlan

The Origins of Agriculture and the Domestication of Crop Plants in the Near East

The Harlan Symposium

10-14 May 1997

Aleppo, Syria

Book of Abstracts

Compilers and editors

A.B. Damania and Jan Valkoun

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International Center for Agricultural Research in Dry Areas (ICARDA)

International Plant Genetic Resources Institute (IPGRI)

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AGROVOC descriptors: *Aegilops; Hordeum spontaneum*; *Hordeum vulgare*; rye; *Triticum aestivum*; *Triticum dicoccum*; *Triticum monococcum*; *Triticum spelta*; *Lathyrus*; *Lens culinaris*; *Vicia faba*; *Pisum sativum*; *Vicia sativa*; *Papaver somniferum;* pistachios; cereals; legumes; barley; hard wheat; soft wheat; faba beans; peas; *Gossypium*; cotton; olives; sesame; safflower; fruit crops; *Amygdalus*; *Cornus*; *Prunus*; *Celtis*; *Vitis*; history; domestication; agriculture; land races; wild plants; plant physiology; plant anatomy; botany; diversification; genetic resources; germplasm conservation; DNA; genetic markers; cultivation; plant introduction; adaptation; climatic change; vegetation; equipment; Middle East; Mediterranean countries; South Asia; Armenia; Mexico.

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Foreword

Wheat and barley together with lentil were among the earliest crops to be domesticated in the "Fertile Crescent," an arc of land that connects the river valleys of the Euphrates and the Tigris with that of the Jordan. It has become increasingly clear that studies on crop-plant domestication can no longer rely solely on archaeological data but would have to combine the findings of archaeobotanists, archaeozoologists, anthropologists and ecologists to put together all the pieces of the puzzle as to how agriculture actually began.

A Symposium dedicated to the work of Prof. Jack R. Harlan on the "Origins of Agriculture and Domestication of Crop Plants in the Near East" was held at the International Center for Agricultural Research in the Dry Areas (ICARDA), 10-14 May 1997 as part of ICARDA's 20th Anniversary Celebrations. There was a good response to the call for papers for presentation at the Symposium from scientists of diverse disciplines. There were over 60 participants from more than 23 countries. Over 30 papers and posters were presented.

One may well ask as to how a Symposium on this topic can have any relevance to the crop-improvement programs of international centers such as ICARDA? Man has an unsatiable urge to learn more of his past. It is only by fully knowing our past, and perhaps learning from its successes and failures, that we can chart our course for the future.

ICARDA is happy to bring out the *Book of Abstracts* of the Harlan Symposium, to serve as an immediate reference for those who are interested in the subject but could not participate themselves. This *Book of Abstracts* will no doubt also stimulate interest in the proceedings volume not only among scientists working on crop evolution but also among those involved in related fields of study.

ICARDA and its co-sponsors are privileged to be associated with the Harlan Symposium, the first of its kind to be held in the West Asia and North Africa region. I hope that the presentations and discussions that took place will lead to a much better understanding of our agricultural past and pave the way for improved farming systems to tackle the increased demand for food production in West Asia and North Africa during the next century and beyond.

Adel El-Beltagy
Director General
ICARDA

Preface

The holding of the Harlan Symposium on "Origins of Agriculture and Domestication of Crop Plants in the Near East" came about in a curious way. Some time in 1992, George Willcox wrote to me at the Genetic Resources Unit (GRU) at ICARDA. Subsequently we met and he told us about his interesting archaeobotanical work, including the fact that scientific evidence of harvest of *Triticum baeoticum*, a wild wheat progenitor, with stone sickles was found at the D'jade site on the middle Euphrates. We in turn showed him our research results and field experiments. Later we developed a proposal to hold a jointly-sponsored Symposium on this subject.

Efforts to hold the Symposium in 1993 at ICARDA were not successful as the CGIAR Centers were plunged into a severe financial crunch. Several activities were being cut and hosting international meetings was given low priority. Then I proceeded on a terminal sabbatic leave for over a year to the Genetic Resources Conservation Program (GRCP) at the University of California, Davis, and all hopes of ever holding the meeting were abandoned and regular contact with George was severed. However, it was during exchange of communications in late 1994 with George and Mark Nesbitt in connection with contributions to a special issue of *Diversity* magazine that the proposal of organizing the meeting on the "Origins of Agriculture..." was rekindled.

I hesitatingly approached Calvin Qualset, Director of GRCP, as to what he thought of the proposal. To my surprise Cal said it was a great idea. Also, Jack Harlan's new book *The Living Fields* was about to be published and Cal mentioned that it would be an excellent opportunity for participants to discuss its contents at the meeting with the author.

The enthusiasm and momentum thus generated gathered pace and an *ad hoc* International Organizing Committee was formed consisting of George Willcox (France), Calvin O. Qualset (USA), Ardeshir B. Damania (India), Jan Valkoun (ICARDA), Geoffrey Hawtin (IPGRI), Mark Nesbitt (UK), and Enrico Porceddu (Italy). The decision to hold the Symposium immediately after the "III Triticeae" was based on the premise that some participants of the latter meeting would take advantage of their presence in Syria and extend their stay to attend the "Origins of Agriculture..." Symposium as well, and I am glad to report, that 10 of them did.

We wrote to Jack Harlan inviting him to the Symposium and to accept an award. He agreed at once to participate and gave us his topic for a keynote address. In the end, he could not travel to Aleppo due to an injury sustained in a car accident. At almost the last moment we requested David Harris, of the Institute of Archaeology, University College London, to fill in for Harlan and he did the job magnificently by delivering the keynote address on "Agricultural Origins: Retrospect and Prospect," a topic not far removed from the one suggested earlier by Harlan. The International Organizing Committee wishes to thank Dr Harris for this valuable contribution.

Since the announcements of the Symposium were mailed at the end of 1996, authors had insufficient time to prepare their full papers and hence it is useful to bring out a *Book of Abstracts* fairly soon after the Symposium. The speeches delivered during the morning session on the opening day have been included at the beginning to put things in their proper perspective. The sequence of the abstracts in this book does not correlate entirely with the sequence in which they were presented at the Symposium. Some authors' abstracts have been moved from one session to another in order maintain a logical flow of topics. A full proceedings volume is under preparation and will be published in due course after peer review of the papers submitted.

The Symposium was honored by the presence of two Directors General of International Agricultural Research Centers at the inaugural session: Prof. Dr Adel El-Beltagy of ICARDA and Dr Geoffrey C. Hawtin of IPGRI. The International Organizing Committee also wishes to thank Prof. Dr El-Beltagy for his unwavering support and personal interest in this Symposium, and Dr Hawtin for taking time off from an extremely busy schedule to attend the Symposium, to preside over the award ceremony to Jack Harlan *in absentia*, and to inaugurate the scientific sessions.

We are also very thankful to the diplomatic missions, especially the Embassy of France for its financial support, and Syrian television for covering the morning session of the opening day.

I would like to also mention the assistance of Ms Nuha Sadek, the GRU Secretary, in making several arrangements for the Symposium. Many messages of appreciation and thanks were received from participants and others for the good execution of the program and efficient organization of the meeting. For this ICARDA's support staff deserve full marks.

And Guy Manners of ICARDA's Communication, Documentation and Information Services (CODIS) is to be thanked for assisting with the production of this publication.

And lastly I would like to thank all participants and contributors for their support in coming to this Symposium and submitting their abstracts and papers on time.

Ardeshir B. Damania
Symposium Coordinator
c/o Genetic Resources Unit
ICARDA

Contents

Opening Session

Introduction

Mohammed Muslim
Assistant Director of Museums and Antiquities
Aleppo, Syria

Good Morning, Ladies and Gentlemen:

I have the honor to represent the Director General of Antiquities and Museums, Dr Sultan Muhesen, at the opening of your interesting Symposium. We welcome all participants to the historic and ancient city of Aleppo and to the main research station of ICARDA at Tel Hadya. Dr Wahid Khayata, Director of the Department of Antiquities and Museums at Aleppo could not be here today and hence on his behalf and mine I wish you every success in your Symposium and hope you have a wonderful stay in Aleppo.

At the outset I would like to throw some light on the history of human civilization in this part of the Old World. There was a significant transition from obtaining food through hunting and gathering to establishing agriculture and animal husbandry. These developments took place from the 9th to the 6th millennia BC and led to the construction of villages and the development of primitive tools and agricultural implements. Such tools have been found at Abu Hureyra and Tell Mureybit settlements which are now at the bottom of the flooded area of Lake Assad. But we have other similar sites in Syria, Lebanon and Palestine where early agriculturists began to abandon their way of nomadic life and build settlements in the open areas, preferring the banks of rivers or areas where there was water.

The architectural achievements based on early technologies which led to the construction of walls, dwellings and containers for the safe storage of food grains can be seen at the site of Bouqras excavated by archaeologists from the University of Amsterdam near the modern city of Deir Ezzor. These discoveries give us an idea about the beginnings of the civilization, which included making clothing, as well as domesticating plants and animals.

In the later Stone Age (Pre-halaf) we come across more sophisticated tools including knives, pots and storage containers for grains. Subsequently during the fifth millennium BC, evolution of agricultural tools, construction of granaries and irrigation canals took place as can been seen at Kaskashouk on the Habur river. We also have paintings of animals which existed during that period but are now extinct or have immigrated to other areas due to change in climate.

Educational institutions also began here and later spread to Europe and other areas. From the Stone Age to the early Bronze Age, archaeological discoveries made during the past 27 years in Syria, under the patronage of President Hafez Al-Assad, show that Syria was not merely a bridge between the great civilizations of Egypt, Mesopotamia and Anatolia but an important civilization in its own right. Ancient kingdoms and city-states like Mari, Ebla and Ugarit, harbor enough evidence for this assumption. For example, the first written alphabet was found in Ugarit.

A professor who excavated ancient Mari said that everybody in the world has two homes: Syria and the home in which he or she was born.

I wish you once again great success with your Symposium.

Welcome Address

John H. Dodds
Assistant Director General (Research)
ICARDA, Aleppo, Syria

On behalf of the Director General of ICARDA, Prof. Dr Adel El-Beltagy and the entire staff, I take this opportunity to welcome you all to ICARDA for the Symposium on "Origins of Agriculture and Domestication of Crop Plants in the Near East." This Symposium follows from an October 1992 Symposium on "Evaluation and Utilization of Biodiversity in Wild Relatives and Primitive Forms for Wheat Improvement." It was at that meeting that a recommendation was made to convene a workshop to review the theories of origins and processes of domestication of the major field crops of the Near East.

In the last decade or so, new approaches to investigating these events have arisen with a mutual recognition by archaeologists and plant biologists that each held only a part of the key to unravel the mysteries of the origins of agriculture and domestication of crop plants. Recent archaeobotanical finds indicate that morphologically wild species were cultivated for a long time before their domestication. Inevitably these discoveries have resulted in a series of reports in diverse journals and other publications that shed new light on a fundamental aspect of the life of mankind. The scope of this meeting will include all the crop plants that have been domesticated in the Near East, such as the cereals – wheat, barley and rye –, pulses – chickpea and lentil –, forage legumes, and oil and fiber crops. The Symposium will address the two principal sources of evidence: the cytogenetics and the distribution of the wild relatives of crop plants, and the archaeological evidence for the use of these plants in the past.

It is expected that deploying a wide range of approaches to these topics will improve our understanding of how best to conserve and utilize genetic resources for crop improvement and other objectives. I would like to acknowledge the support to the Symposium from ICARDA, IPGRI, the Genetic Resources Conservation Program of the University of California, Davis, the Institut de Préhistoire Orientale, France, the Department of Antiquities, Syria, the Institut Français de Archéologie au Proche Orient (IFAPO), Syria, and the Embassy of France in Damascus.

We are here in the homeland of agriculture; consider ICARDA as your home and we welcome you. I hope that this meeting is successful in its deliberations and outcome.

Award Presentation to Jack R. Harlan

Geoffrey C. Hawtin
Director General
IPGRI, Rome, Italy

Your Excellencies, Members of the Diplomatic Corps, Government Officials, Participants, Ladies and Gentlemen:

It gives me very great pleasure to participate in these ceremonies honoring Prof. Jack R. Harlan, one of the first scientists to recognize the importance of genetic diversity and whose studies have contributed so much to our understanding of the origins, structure and nature of that diversity – an understanding that is so vital to our ability to conserve it and use it to meet human needs.

Indeed, Prof. Harlan was among the few foresighted individuals whose efforts contributed to the establishment of the institute that I represent, the International Plant Genetic Resources Institute, IPGRI. Thirty years ago this year, he served on an FAO Panel of Experts on Plant Exploration and Introduction and, together with other leading pioneers in the field such as Prof. Jack Hawkes, Sir Otto Frankel, Erna Bennett and John Creech, first began to call attention to the problems of genetic erosion and the need take concerted global action.

In 1972, FAO and the Technical Advisory Committee (TAC) of the newly founded Consultative Group on International Agricultural Research (CGIAR) convened a small expert meeting in Beltsville, USA, with the ambitious aim of designing a "World Network of Genetic Resources Centers." Professor Harlan was a leading member of this group, which again also included Prof. Jack Hawkes and John Creech, as well as T.T. Chang, Dieter Bommer and others. As a result of this meeting, it was agreed to establish the International Board for Plant Genetic Resources (IBPGR), the organization that was later to become IPGRI.

Jack Harlan was born 7 June 1917 in Washington, DC. He earned a BS Degree (with distinction) from George Washington University in 1938 and then went on to take his PhD in genetics from the University of California, Berkeley, in 1942. There he was the first graduate student of Dr G. Ledyard Stebbins.

Professor Harlan, who was greatly influenced by his father Harry V. Harlan, a well-known barley breeder with USDA, began his professional career with USDA in 1942 at Woodward, Oklahoma, where he directed the Forage Crops and Rangeland

Improvement Program. In 1951, while still with USDA, he transferred to Oklahoma State University, Stillwater. It was during this period that he began to develop his theories on the origins and evolution of crop plants.

In 1961, Dr Harlan joined the faculty of Oklahoma State University as a full-time Professor, and in 1966 he moved to the University of Illinois at Urbana-Champaign as Professor of Plant Genetics in the Department of Agronomy. A year later, with the well-known Dr J.M.J. de Wet, he founded the Crop Evolution Laboratory. In 1984, he retired from the University of Illinois as Professor Emeritus.

During his long and illustrious career, Prof. Harlan has received many honors and awards, including the John Simon Guggenheim Memorial Fellowship (1959), the American Grassland Council Merit Award (1962), the Frank N. Meyer Memorial Medal (1971), Crop Sciences Award (1971), the International Service in Agronomy Award (1976) and in 1986 he received the Distinguished Botanist Award from the Society for Economic Botany. In 1972, he was elected a fellow of the US National Academy of Sciences.

In the field, Prof. Harlan has undertaken plant explorations in Africa, Southwest Asia, and Latin America. In 1948, he led a USDA-sponsored plant exploration trip to Turkey, Syria, Lebanon and Iraq. In 1960, he led explorations in Iran, Afghanistan, Pakistan, India and Ethiopia. He was a consultant to FAO in 1970/71 and was closely involved with the work of the International Board for Plant Genetic Resources (IBPGR) from its inception in 1974, and especially in the early years up to 1979.

Unknown to many in agricultural circles, Prof. Harlan also has a keen interest in archaeology and has participated in several archaeological digs. From 1960 to 1963, he was a member of the Iranian Prehistory Project of the Oriental Institute, University of Chicago. He joined the Turkish Project in 1964 and was a member of the Dead Sea Archaeological Project in 1977, 1979, and 1983.

I believe it is extremely appropriate that this Symposium, which brings together plant specialists and archaeologists, should honor the lifelong work of Prof. Harlan in this his 80th year. The plaque that we are giving him today is made up, most appropriately, of seeds which he himself collected during his explorations in this part of the world in 1948.

We wish Prof. Harlan a full and rapid recovery from the effects of the accident he suffered last Christmas, and I now have the pleasure to call upon Prof. Calvin Qualset, a friend of Jack's for many years, to accept this award on his behalf.

Jack R. Harlan: An Appreciation

Calvin O. Qualset
Director
Genetic Resources Conservation Program (GRCP)
University of California, Davis, USA

I am very pleased to accept this unique and appropriate token of appreciation on behalf of Jack Harlan. Professor Harlan was most disappointed that he could not be here to receive this recognition in person and to participate with his friends and colleagues in the discussions during the Symposium. As you know, he was involved in an automobile accident last December, but his recovery was steady and he and his son had made travel arrangements. Subsequently, Jack had a fall, reinjuring his knee and finally could not travel. He, however, made an audio tape with a few words for us:

> "I wish to extend greetings to colleagues, students and users of plant genetic resources. I regret sincerely that I am unable to participate with you, but I wish you all success with the meeting and your deliberations. The reason I am unable to come is that I have fallen and broken a leg and am physically not up to this trip."

Jack had also produced a video tape of the lecture he planned to deliver, but he was not entirely satisfied with the quality of his own performance and would not release the tape to us. He was in a great deal of discomfort and if you know Jack Harlan you will know that he can tolerate a great deal of pain and discomfort, but he just could not participate this time. The essence of his lecture is abstracted elsewhere in this publication.

He did want to talk a great deal about what he has written in his most recent book *The Living Fields: Our Agricultural Heritage*, published by Cambridge University Press in 1995. The book represents his personal statement of his career work, as well as a scientific and scholarly treatment of the issues related to origins of agriculture and crop evolution. N.I. Vavilov was a close personal friend of Jack's father, Harry V. Harlan, and Jack had aspirations of studying with Vavilov in Russia. He even studied Russian language as an undergraduate. Jack recounts this episode in his career in *The Living Fields*, which I repeat below.

> Harry Harlan was in correspondence with Vavilov and, since those were troubled times for Vavilov, they had established a code such that if Vavilov began his letter with "My dear Dr. Harlan ..." there was something wrong at Vavilov's institute in Russia. If he

> responded with "Dear Dr. Harlan ...", things were more or less normal. So when Harry Harlan wrote to Vavilov about young Jack studying in Leningrad the reply came immediately "My Dear Dr. Harlan, what you said about Chinese barley is very interesting ..." Since Harry Harlan had said nothing about Chinese barley it was an indication that things were not going well for Vavilov and hence Jack would not be going to Russia after all. Instead, he went to the University of California at Berkeley and studied under G. Ledyard Stebbins, another giant in the field of plant evolution.

Jack was a very keen follower of Vavilov's work, but as he studied it and observed crops and wild species throughout the world, he could see that the centers of origins described by Vavilov were in fact centers of diversity and centers of long-standing agricultural activity. In *The Living Fields* (p. 237) he says:

> How did the Vavilovian theory fare? We can credit him with three bull's eyes: Peru, Oaxaca [Mexico], and Palestine are dead center in three of his eight centers. Furthermore, agriculture also evolved independently in China, Southeast Asia and Ethiopia, centers of origin in his scheme. Ethiopia is the only country in sub-Saharan Africa visited by Vavilov and the Russian scientists did not know Africa well until the last two decades. This left some gaps in the theory. There were also other independent origins, but by and large his essay of 1926 was a landmark and still influential. As of that date it was a remarkable perception, but based more on intuition than data.

Jack's work was to find more and more of the missing data and he will be pleased to know that other contributors to that goal are attending this Symposium. Jack's views are summed up in two observations (*The Living Fields*, p. 239–240):

> First, we will not and cannot find a time or place where agriculture originated. We will not and cannot because it did not happen that way. Agriculture is not the result of a happening, an idea, an invention, discovery or instruction by a god or goddess. It emerged as a result of long periods of intimate coevolution between plants and man. Animals are not essential; plants supply over 90% of the food consumed by humans. The coevolution took place over millennia and over vast regions measured in terms of thousands of kilometers. There were many independent tentatives in many locations that fused over time to produce effective food production systems. Origins are diffuse in both time and space.

I think his philosophy of the origins of agriculture will be echoed throughout this Symposium. Jack Harlan was the John Wayne of the crop evolution/crop collector's world; if you have known Jack and seen John Wayne movies you will understand what I mean. Jack was always ready to rough it out and ready to put his hands to the ground to gather critical data. We are very proud that Jack had such a strong influence in our field. When we invited Jack in 1995 to participate in this Symposium, I called at his home in New Orleans, Louisiana he said, "Well, I will be in my 80th year and the probability is getting lower every year that I may not be able to attend, but I am pleased to accept the invitation." Jack's pragmatism prevailed, and we are sorry he is not here.

This is Jack's 80th year. Happy Birthday, Jack. We dedicate this Symposium to you with great respect and affection.

Inauguration of the Scientific Sessions

Geoffrey C. Hawtin
Director General
IPGRI, Rome, Italy

It gives me great pleasure to open the scientific sessions of this symposium – a particular pleasure for me personally, having spent eight extremely enjoyable and memorable years living in the fascinating city of Aleppo, and working at such a dynamic and important International Agricultural Research Institute as ICARDA.

Throughout my time here, it was impossible not to be conscious of the fact that Aleppo lies at or near the heart of a region, often referred to as the "Fertile Crescent," where so many important crops originated: crops that today provide such a vast array of different foods and other products for people throughout the world. Among the crops that originated in this region can be counted many of the world's major cereals (e.g. wheat, barley, rye and oat), food legumes (e.g. pea, lentil and chickpea), oil seeds (e.g. safflower, rape seed and linseed) and numerous vegetables, fruits, pasture species, herbs, medicinal plants and other important crops.

The work begun by the first agriculturalists did not stop with the creation and early spread of agricultural techniques, but has continued over the millennia, and even today farmers in may parts of the region continue to consciously select their crops to meet their changing needs and to adapt them to the myriad different environments.

The domestication of wild plant species by the world's first agricultural communities has provided a legacy that remains crucial to meeting current and future basic human needs, not only in this region but throughout the world. This genetic diversity has a vital role to play in helping meet the challenge of doubling global annual food production over the next 25 years: an increase that will be needed just to keep pace with the demands of the rapidly growing human population.

However, this priceless diversity is perhaps more threatened today than at any other time in human history. The widespread replacement of landraces by new and often more genetically uniform varieties, coupled with the development and introduction of new farming systems designed to meet new social and economic needs, has already resulted in the loss of much of the diversity of the region's original landraces and farmers' varieties. Likewise environmental degradation due to such factors as overgrazing and urbanization, and the spread of agriculture and pastoralism into new areas, are threatening the continued existence of many crop ancestors and wild relatives. This frightening loss of diversity threatens to limit our future options, for without this genetic diversity where will we find the genes needed to meet future challenges? Can we afford to rely only on the power of the new biotechnologies for our needs?

IPGRI is very proud to be associated with this Symposium which is so relevant to our work to conserve the genetic heritage of this region, and similar legacies of diversity throughout the world. We are also pleased that so many of our partners in this important task are represented here at this workshop – and I would like to take this opportunity in particular to thank the co-sponsors of this symposium: the University of California, Davis, USA, the Center National de la Recherche Scientifique, France, the Department of Antiquities, Syria, the Institut Français de Archéologie au Proche Orient in Damascus, and last, but certainly not least, our sister institute ICARDA. I would like to thank them all for their foresight in recognizing the importance of gaining a better understanding of the origins of agriculture and the domestication of crops not only as an academic exercise, important though such a historical understanding is in its own right, but as a topic of great importance in our efforts to conserve and use, for the betterment of present and future generations, the priceless heritage of this region.

It is now my great pleasure to invite Prof. David Harris, of the Institute of Archaeology, University College London, and a world renown expert on the origins of agriculture and the early domestication of crops, to deliver the Keynote Address.

Keynote Address
Agricultural Origins: Retrospect and Prospect

D.R. Harris
Institute of Archaeology, University College London
31–34 Gordon Square, London WC1H 0PY, UK

It is an honor to stand in for Prof. Jack Harlan – who I had the privilege of knowing as a colleague for many years – at the opening of this Symposium, but it is a matter of great regret that he is unable to be here in person. In my remarks I aim simply to set the scene for the substantive sessions that will follow, when we hope to gain new insights into the perennially fascinating questions of how and why agriculture began.

The transition from foraging to farming was part of a fundamental restructuring of human society. We know that it began about 12,000 years ago, here in the Near East, and that it brought about profound changes in the relationships of people to each other as well as to plants and animals. But despite much archaeological and biological effort to elucidate the "origins of agriculture," we remain largely ignorant of just how, when and where, let alone why, the transition occurred.

The archaeologist V. Gordon Childe encapsulated the importance of this great transition by labeling it the Agricultural or Neolithic Revolution, and the botanist Nikolai Vavilov profoundly influenced its study through his successive delineations of world centers of crop diversity. The seminal contributions of these two pioneers in the 1920s and 1930s had been preceded by the speculations of several famous 19th-century scholars – notably Alexander von Humboldt, Charles Darwin and Alphonse de Candolle – and were followed by the work of a succession of archaeologists and botanists, for example Robert Braidwood, Lewis Binford, Jack Hawkes and of course Jack Harlan, who further developed the scientific study of early agriculture and crop evolution.

By the late 1960s, the earlier assumption that agriculture was a "natural," if not an inevitable, stage in humanity's progressive development came to be widely rejected and replaced by the more challenging question of why it had developed at all. The ways in which hunter–gatherers exploited wild plants and animals were shown to be much more varied and complex than had been thought, and sharp distinction between foraging and farming gave way to a more general process of intensifying interaction between people, plants and animals. This paradigm shift arose mainly from a close reading of the ethnographic and historical evidence; and it remains very difficult to demonstrate directly from archaeological and paleo-ecological data the complexities in patterns of past plant and animal exploitation that the ethno-historical evidence suggests.

However, a cluster of new analytical techniques is now being applied by biologists and archaeologists, and is beginning to yield more precise data on the beginnings of agriculture. They include, for example, sophisticated statistical analysis of archaeological assemblages of plant remains, phytolith analysis, micromorphological analyses of archaeological deposits, chemical analyses of organic residues in pottery and on stone tools, use-wear analysis of artefacts, a range of genetic and molecular techniques including isozyme analysis, and radio-carbon dating by accelerator mass spectrometry (AMS). There is also invigorating research on the climatic changes that occurred in the late Pleistocene and early Holocene which may have induced shifts to more sedentary life and acted as casual agents in the transition to agriculture. As the Symposium will demonstrate, many of these new techniques are now being applied in the Near East – which retains its primacy as the region in which the transition to agriculture first occurred and set humanity on the path to what we choose to call civilization.

Session I

Crop Diversity in the Near East and the Influence of Climate Change on Vegetation

Diversity of Major Cultivated Plants in the Near East: A Review

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Alphonse de Candolle, in his 1882 book *Origine de Plantes Cultivées*, was among the first to indicate broad regions where plant domestication may have taken place: China, Southwest Asia including Egypt, and Tropical Asia. Then in 1926, N.I. Vavilov expounded his theory of centers of origin of crop plants. The centers recognized by Vavilov were: China, India, Indo-Malaya, Central Asia, the Near East, the Mediterranean, Ethiopia, Southern Mexico and Central America, South America, and Chile. It is alleged that Vavilov may have been influenced by Willis' "Age and Area" hypothesis which, in a nutshell, said that the longer a plant species has been present in an area the more diverse it will be.

The Near East is a center of crop plant diversity recognized by most authors as one of the major centers of origin. However, this center overlaps in places with the Mediterranean Center and hence crops of the latter with wide distribution in the Near East are also included here for comprehensiveness. The Near Eastern region is one of the most important centers of early Neolithic civilization, evolution of crop plants, and innovations of agricultural techniques. The major genera, about 50 in number, and their species which have their greatest diversity and/or were domesticated in this region, are listed in this paper by their botanical families in an alphabetical order.

* * *

The Spread of Agriculture to the Eastern Arc of the Fertile Crescent: Food for the Herders

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A delay of 1000 years in the introduction of agriculture to the Zagros mountains from its heart in the southern Levant is attributed to a combination of climate change, vegetational associations, and cultural practices. A further delay in the spread from highlands to lowland steppe is attributed to topography and patterns of transhumance. It is proposed that the primary means of transmission of agriculture into the eastern zone of the Near East was via the herding of sheep and goats.

Session II

Wild Progenitors of Crop Plants and Their Domestication

Molecular Analysis of the Domestication Process in Common Bean

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Common bean (*Phaseolus vulgaris* L.) represents an interesting case for the study of domestication and evolution of a crop. Its wild, conspecific relative has wide distribution from northern Mexico to northwestern Argentina. Archaeological remains have been uncovered principally in Mexico and Peru. Its high level of phenotypic diversity, undoubtedly a result of a broad range of cultural influences within and outside of its centers of domestication, is especially striking. This diversity also, however, presents a particular challenge when one wants to unravel the history of domestication of the crop and its subsequent evolution. Recent studies using a wide range of biochemical and molecular markers have helped us understand where common bean was domesticated in the Americas and how it has evolved since domestication.

Phaseolus vulgaris presumably originated in Ecuador and northern Peru, from where it was disseminated – before domestication by unknown means – both northwards to the northern Andes, Central America and Mexico, and southwards to southern Peru, Bolivia and Argentina. During the process of dissemination, the two migration branches diverged to generate two distinct geographic wild gene pools, in the Andes and in Mesoamerica. Domestication took place separately in Mesoamerica and in the southern Andes to generate two domesticated gene pools that mirror the ancestral gene pools. Subsequently, divergence within these two gene pools generated three races in each gene pool. These races can be distinguished on morphological, phenological, ecological and agronomic grounds, but the cause or mechanism of divergence has yet to be determined. Molecular analyses have been instrumental in documenting a sharp reduction in genetic diversity ("bottleneck") during and after domestication, as has been observed for other crops. This reduction in diversity is consistent with a domestication process that was initiated from a limited number of original populations, involved selection for very specific phenotypic traits (the "domestication syndrome"), and was further accentuated under domestication by selection for local adaptation, genetic drift and dissemination.

A quantitative trait locus (QTL) analysis of the domestication syndrome reveals that major genes are involved (in addition to minor genes), that a large part of the phenotypic variance can be accounted for in genetic terms (i.e. the traits generally have high heritability), and that many genes tend to be clustered. These observations, together with similar observations made in maize, suggest that there was no genetic impediment to a relatively rapid domestication. Overall, tools of molecular biology can provide a bridge between the main study fields of crop evolution – archaeobotany and plant science – by providing information on putative centers of domestication, potential identification of plant (and human) migration patterns from the center of domestication, the time-frame for the domestication process, and a molecular characterization of archaeological remains.

* * *

The Grain Legumes: Evidence of These Important Ancient Food Resources from Early Pre-agrarian and Agrarian Sites in Southwest Asia

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The remains of cool-season grain legumes appear in the archaeological record concurrently with those of the first domesticated cereals. They are thought to have been taken into cultivation at about the same time. However, since evidence of their domestication usually is not detectable in the morphology and micromorphology of the seeds, circumstantial indicators are used to determine their wild or cultivated status. This paper examines the position of the grain legumes as an ancient human food resource from evidence gathered from the published accounts of the plant assemblages recovered from Epipalaelithic and Early Neolithic sites in Southwest Asia.

* * *

Genetic Evidence on the Origin of *Triticum aestivum* L.

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Triticum aestivum (genomes AABBDD) is a complex of naked and hulled forms which originated from hybridization of allotetraploid emmer wheat (*Triticum turgidum* L., genomes AABB) with diploid *Aegilops tauschii* (genomes DD). Restriction fragment length polymorphism (RFLP) at 69 single-copy loci was investigated in the D genome of 177 accessions of naked forms and 76 accessions of hulled forms of *T. aestivum* and 169 accessions of *Ae. tauschii*. The hulled forms of *T. aestivum* were represented by accessions of subsp. *macha*, subsp. *vavilovii* and subsp. *spelta* from Europe, Transcaucasia, Iran, Tajikistan and Afghanistan. *Aegilops tauschii* was represented by 30 accessions of subsp. *strangulata* and 139 accessions of subsp. *eusquarrosa*. In *Ae. tauschii*, the greatest genetic diversity was in the Azerbaijan and Transcaucasian populations, followed by those from the Southeastern Caspian. The lowest genetic diversity was in the populations from eastern Turkey and western Iran, followed by those from China and Afghanistan. In the D genome of *T. aestivum*, the RFLP levels were similar among the various forms, and were lower that those in the least polymorphic populations of *Ae. tauschii*. All forms of *T. aestivum* showed the shortest Nei's genetic distance to the *Ae. tauschii* populations from the Southwestern Caspian, suggesting that this may be the center of the origin of *T. aestivum*. In this putative center of the origin of *T. aestivum* and neighboring regions, Transcaucasia and the Southeastern Caspian, genetic distances were shorter to *Ae. tauschii* subsp. *strangulata* than to *Ae. tauschii* subsp. *eusquarrosa*, substantiating previous observations that subsp. *strangulata* was the principal source of the wheat D-genome gene pool. Only a single *Ae. tauschii* allele was found at 64 loci and two *Ae. tauschii* alleles were found at five loci in *T. aestivum*. Three of these five loci are linked on the short arm of chromosome 2D. These findings suggest that *T. aestivum* owes its origin to several hybridization events involving *Ae. tauschii*. The findings of multiple

hybridization events in the phylogenetic background of *T. aestivum* creates uncertainty as to whether only subsp. *strangulata* was ancestral to *T. aestivum* or whether subsp. *eusquarrosa* also participated in the evolution of the wheat D genome, and whether *Ae. tauschii* populations in other geographic regions, in addition to that in the Southwestern Caspian, contributed to the wheat gene pool.

* * *

On the Origin and *in statu nascendi* Domestication of Rye and Barley

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A short review of different views on the origin and domestication of cultivated rye and barley is presented together with a survey of the author's data on the allozyme variability in the cultivated rye and barley, and their wild relatives. The wild and cultivated rye and barley share common allozyme gene pools which form a part of the gene pools detected in wild perennial rye and barley, respectively. A hypothesis according to which both rye and barley have been domesticated *in statu nascendi* from a progeny of spontaneous hybrids between wild species by collecting of rare non-brittle mutants for a separate cultivation is discussed.

* * *

Utilization of Ancient and Obsolete Tetraploid Wheat Species to Improve Drought Resistance in Durum Wheat (*Triticum durum* Desf.)

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Use of ancient, but now obsolete tetraploid wheat species for drought-resistance improvement in modern cultivars of durum wheat (*Triticum durum*) seems promising not only for morphophysiological traits related to drought resistance, but also for

resistance to biotic stress and grain quality. Some accessions of ancient and obsolete wheat species (*T. dicoccum*, *T. carthlicum* and *T. polonicum*) were used in a physiology-based crossing program with cultivars of durum wheat developed for planting in dry areas. Direct selection for yield and indirect selection for traits related to drought resistance was applied under water stress in segregating populations.

Selection for relative water content (RWC), and carbon isotope discrimination (Δ) in F_2 population was effective. Results also revealed that these traits are under complex genetic control; broad- and narrow-sense heritabilities were high. In photochemical quenching of chlorophyll fluorescence (qQ) and root parameters, narrow-sense heritability and response to selection were low. Evaluation of the F_4 and F_5 lines obtained in this research program for different morphological traits, yield and yield components has been carried out under field conditions. Populations selected for RWC and Δ exhibited greater drought resistance under field conditions (early growth vigor, high harvest index, grain yield and biomass production). Direct selection for yield using the F_2 progeny method confirmed that early selection in F_2 and F_3 progenies produced some lines which performed better then their durum parents under various conditions.

Evaluation for grain quality showed that high SDS values and protein content had been incorporated into advanced interspecific lines.

Improvement of total biological and grain yields was possible both through direct or indirect selection. However, some back-crosses with durum wheat varieties will be necessary, especially in crosses involving *T. timopheevi* and *T. carthlicum*, for better utilization of these ancient forms in durum wheat improvement for the dry areas.

Session III

Genetical, Physiological and Morphological Aspects of Domestication

The Variation of Grain Characters in a Living Collection of Diploid and Tetraploid Hulled Wheats and its Relevance for the Archaeological Record

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A large collection of diploid and tetraploid hulled wheats was studied for grain characters. Whereas there was a tendency for larger grains with increasing ploidy level, and also among cultivated forms in comparison with wild types within the same ploidy level, a separation of the overlapping cases by seed characters may not be easy. It is particularly difficult to differentiate between two-grained einkorn and emmer. The two-grained character is rather common in recent material of einkorn and its wild relatives.

* * *

Identifying Pre-domestication Cultivation Using Multivariate Analyses

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By applying simple correspondence analysis to assemblages of charred plant remains, it was found that certain early Syrian sites (dating to the Epipaleolithic, PPNA and PPNB) were distinguished on the basis of the wild/"weed" taxa in their samples. The implication being that the archaeobotanical record preserved a vegetational "fingerprint" for each of the sites. On further investigation it was discovered that when correspondence analysis was applied to "non-crop" taxa in the assemblages from the different phases of occupation at the sites it also produced significant clustering of samples, thus indicating that the vegetational "fingerprints" were established within relatively short periods of time. Ecological classification of the wild/"weed" taxa at a very basic level enabled interpretations of the differences between sites and chronological phases in terms of changing use of resources in the landscape, of changes in the management of the landscape and/or of the changing composition of the landscape.

At Tell Mureybit, the phases of occupation were as clearly defined in the analyses, and possible explanations for the distinction between periods include the inception and intensification of management of the wild cereals found on the site. Whereas the possibility of pre-domestication cultivation has been proposed at certain sites it has remained unprovable, correspondence analysis applied to sets of samples from early multi-period sites may be a means by which we can identify plant management prior to the emergence of domestic cereal crops.

* * *

The Application of Some Modern Semi-quantitative Methods to the Analysis of Certain Phenotypic Parameters in Opium Poppy (*Papaver somniferum* L.)

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The interest in the cultivation of plants with industrial utilization has led to various investigations involving both genetics and mathematics, among other theoretical and applied sciences. The present study was based on some recently developed semi-quantitative methods provided by the specialized software package Chaos Data Analyzer, applied at the level of the phenotypic parameters expressed in the *Papaver somniferum* L. (opium poppy) capsule. The state space reconstructed using the delay coordinates and the correlation dimension computation were the main tests able to detect the chaotic and quasi-periodic patterns in a *Papaver* micro-population.

* * *

Origins and Domestication of Mediterranean Olive Tree Through RAPD Marker Analyses

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A study of similarities with RAPD markers was performed to reconstruct the history of olive tree (*Olea europaea* L.) domestication. Sixty-four cultivars from the

Mediterranean basin, 25 uncultivated trees in Corsica, northern Morocco and southern France, and wild related species from Asia (*O. cuspidata*) and Africa (*O. maroccana*, *O. africana*) were studied. Out of 30 primers, 6 were selected for polymorphism and checked for their ability to differentiate among these individuals. One hundred and one markers were noted. From these data, factorial correspondence analyses were performed, and phenograms were constructed based on genetic distance.

On the basis of similarities, three groups of individuals were determined. The cultivars are grouped with the wild forms from the Mediterranean basin. A subgroup comprising six cultivars closely related to oleasters from Corsica and Morocco suggested that selection has occurred in places. The second group comprised the three trees from Asia belonging to *O. cuspidata*. The third group comprised *O. africana* and *O. maroccana*, which sustains the hypothesis that *O. maroccana* is a variant of *O. laperrinei* and suggests that this species is related to East African forms (*O. africana* and *O. chrysophylla*). In our sampling, *O. cuspidata*, *O. africana* and *O. maroccana* were not related to cultivars. This could mean that they have not been involved in the domestication of olive.

* * *

Early History of Sesame in the Near East

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There is botanical and textual evidence for sesame (*Sesamum* spp.) cultivation in the ancient Old World. Excavations at the Indus civilization site of Harappa have yielded charred sesame seed from a stratum attributed to 3500–3050 BC. The Vedic scriptures (*ca.* 1000 BC) contain frequent references to sesame. The existence and identity of *Sesamum indicum* as a Mesopotamian oil source have been controversial since 1966 when H. Helbaek reported that not a single seed of sesame had been found in the Near East from earlier than Islamic times. The Chicago Assyrian Dictionary and some cuneiformists subsequently have translated *še-giš-i* (Sumerian) and *šamaššammū* (Old Akkadian) as "linseed" (flax). Helbaek's assertion that no ancient sesame remains have been excavated is inaccurate, but the reported finds (King Tutankhamon's tomb *ca.* 1350 BC; Karmir Blur in Armenia, the ancient Urartu, *ca.* 600 BC; Gordion in Turkey also *ca.* 600 BC; and Hajar bin Humeid in South Arabia, *ca.* 450 BC) are late. Sesame was a major item of agriculture in the Urartian economy and that kingdom was a northern neighbor of Mesopotamia.

In the fifth century BC, Herodotus wrote that sesame was the only oil used in Babylonia. The crop was well known to ancient Greek and Roman authors. The most helpful ancient sources are cuneiform texts that indicate that the barley harvest (in spring) was followed by the sowing of *še-giš-i*, a summer crop in Mesopotamia. Sesame can be distinguished clearly from flax, a cool-season crop, and their growing seasons differ as would be expected. New evidence collected in Syria, following the discussion at the May 1997 Harlan Symposium, supports the previous suggestion that the Mesopotamian oil plant is sesame. In a survey, villagers 100 km north and south of Deir Ezzor in Syria said that they would be planting sesame in more than half of the fields once they finished harvesting barley in about a month, and that sesame was harvested by uprooting the entire plant.

Session IV

Archaeobotanical Evidence for Agricultural Transitions

Archaeobotanical Evidence for the Beginnings of Agriculture in Southwest Asia

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Over the last twenty-five years tens of thousands of archaeobotanical remains have been sampled from more than 30 archaeological sites in southwest Asia. These remains are providing a clearer picture of the changes in man/plant relations and vegetation history for the end of the Pleistocene and the beginning of the Holocene. Information regarding climatic change has come from further afield, particularly interdisciplinary studies of ice cores. Archaeobotanical remains from southwest Asia indicate that wild progenitors (pulses and grasses) grew over a wide area at the end of the Pleistocene as part of a forest–steppe environment. These finds show that wild cereals were exploited for several millennia prior to the appearance of their domestic counterparts, and that there was a relatively long period when both wild and domestic types occurred together. From three sites dating to the 10th millennium BP there is evidence for a gradual increase in domestic forms at the expense of the wild forms over a period exceeding a millennium. When plant remains from this period are compared, the major cereal component (barley, emmer or einkorn) varies considerably among sites located in the northern Fertile Crescent. This indicates that crop evolution, at least during the initial stages, developed independently at at least three different sites from locally available dominants occurring in nearby wild cereal stands.

By the beginning of the ninth millennium BP, we begin to see the deliberate introduction of crop plants, especially flax, emmer and hull-less wheat. However, wild types still make up an important part of the crops. This may have been because, at this stage, wild and domestic types were still so similar that they were difficult to separate, but also because there may not have been a rapid transfer from gathering to cultivation, both strategies having occurred simultaneously over a considerable period. During the ninth millennium, farming became more systematic, leading to high selective pressures for domestic types which dominate the archaeobotanical samples. The appearance of consistently domesticated cereals coincides with the emergence of rectilinear architecture, considerable increase in village size, the domestication of sheep and goats, and probably a more organized socio-cultural system which became increasingly reliant on a highly managed agricultural system. Once agriculture became well established, the now increased human populations became dependent on a production economy and expanded into outlying areas where domestic emmer, barley, hull-less wheats and pulses were introduced.

* * *

Archaeobotanical Evidence for Agricultural Transitions: the Case of Yumuk Tepe, Mersin, Turkey

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Yumuk Tepe is a prehistoric–historic mound which is now lies within the town of Mersin on the southern coast of Cilicia in southern Turkey. Earlier excavations of the site by J. Garstang had shown the stratified sequence of the site from early Neolithic to Medieval times. Recent excavations have revealed even earlier and deeper levels which were dated to 7000–6600 BC. The site is of special importance due to its geographic location – intermediate between the sites in the eastern Anatolian Plateau and those in East Turkey, Syria and the Levant. It is, therefore, assumed that during prehistoric times Yumuk Tepe could have played an important role in the trade of obsidian tools as well as the spread of crop plants.

The paper presents the results of the analysis of archaeobotanical material retrieved during the 1994 and 1995 excavation seasons. The excavated layers belong to the Neolithic (6300 BC) and Chalcolithic (4328 BC). Large quantities of material have been recovered from both layers. Comparison of domesticated crop plants and fruit trees of the layers reveals several interesting points. There is solid evidence for the domestication of emmer wheat (*Triticum dicoccum*), barley (*Hordeum vulgare*), lentil (*Lens culinaris*), pea (*Pisum sativum*) and grass pea (*Lathyrus sativus*) during the early phases of occupation of the site. Chickpea (*Cicer* spp.) on the other hand, appears only in the plant assemblage from the Chalcolithic.

The results of the archaeobotanical research, when combined with the archaeozoological evidence for animal domestication, indicate that the inhabitants of the earliest settlement had practised animal husbandry and had domesticated sheep, goats, cattle and pigs by 6700 BC. The subsistence pattern thus depended on the domestication of animals, cultivation of cereals and pulses, as well as the collection of fruits from the wild. There is evidence for a sedentary life organization and exploitation of natural resources such as fishing. This pattern persisted during the Chalcolithic with a tendency towards a more specialized agricultural system and the introduction of new crops. Finally, the role of anthropogenic activities in the environmental change in the vicinity of the site is discussed with special reference to the replacement of the forest landscape by a more arid steppeland.

* * *

Investigations on Archaeobotanical Remains at Nevali Çori, PPNB, Turkey

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Nevali Çori is located near the town of Urfa (37°8' N, 38°45' E) at an altitude of 490 m amsl. The Carbon-14 date is *ca.* 10,400 BP. In 1991, some 267 archaeobotanical samples were obtained at this site from Pre-Pottery Neolithic B (PPNB) layers. The average volume of the sample was 10 L, and floatation was done by hand-sieve (0.35 mm). The sample contained in all 34,911 archaeobotanical remains, of which 27,569 were spikelet forks, glume bases and rachis fragments.

Cereals (*Triticum* wheats): one-grained type, 661 remains; two-grained type, 129 remains. Both types are domesticated and/or cultivated. The spikelet forks are from non-brittle spikes, and the grains are fully developed. Hence, their harvest before maturity is unlikely. Most of the grains recovered are 4.5–5.5 mm long. A detailed study of current samples of *T. baeoticum* (one grained) and *T. dicoccoides* (two-grained) indicate that the two species cannot be identified by comparative morphology on the basis of charred remains of grains and spikelet forks only. It is speculated that the remains at Nevali Çori may be one-grained or two-grained forms of *T. baeoticum* or *T. urartu*, and *T. dicoccoides*. They could also belong to *T. monococcum* and/or *T. dicoccum*. It is extremely difficult to ascertain the ploidy levels of wheat on the basis of charred remains found at sites of early agriculture. However, there were spikelet forks in sufficient quantity within the remains to suggest that tetraploid wheats were in use by the inhabitants. However, the most important wheat in use was perhaps *T. baeoticum*.

Narrow grains of *Hordeum distichon* or *H. spontaneum* were also found at all layers, but there is no clue as to whether they were cultivated or wild.

Legumes (*Lens, Pisum, Vicia ervilia, Lathyrys sativus* and *Vicia faba*): except for the seeds of *Lens* spp. all other seed sizes were similar to present-day forms. The diameter of *Lens* seeds was 2.2 mm.

Fruits (*Amygdalus, Cornus mas, Celtis, Pistacea*, and *Vitis*): fruits were probably gathered and they complete the picture of the diet of the PPNB peoples of Nevali Çori.

* * *

Evidence for Good Crop Water Availability from a Neolithic Pre-Pottery Site on the Middle Euphrates Based on the Carbon Isotope Discrimination of Seeds

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The analysis of carbon isotope discrimination (Δ) in plant remains from archaeological sites may help to assess the water availability during the growth period of these plants. This study presents the analysis of Δ in seeds of hull-less wheat (*Triticum aestivum* and *T. durum*), a domesticated cereal crop whose carbonized remains were found at Tell Halula which is a Middle and Late Pre-Pottery Neolithic B (PPNB) and Late Neolithic (Pre-Halaf Culture) site (8700 to 7700 BP) located in the valley of the middle Euphrates in Syria. Remains of seeds of lentils (*Lens orientalis* and *L. culinaris*), a legume plant, and flax (*Linum* spp.), an oil-producing plant, from the same period were also studied.

Seeds of flax showed consistently higher values of Δ than wheat kernels and lentil seeds throughout the period (temporal sequence) studied. Lentil seeds also tended to show higher Δ values than wheat. This could reflect the growth habit, lentils being less determinate plants than the cereals. On the other hand, Δ values of wheat were much higher than those reported in present-day durum cultivated under rain-fed conditions in northwest Syria under environments with similar or somewhat higher rainfall than Tell Halula. These results strongly suggest that wheat was grown at Tell Halula under much wetter conditions than those existing in Syria at present. The presence of flax and its very high Δ values also support this conclusion. Cultivation under more humid conditions could have been possible due to more humid environmental conditions prevailing at this time or by planting in alluvial areas.

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Problems in Correlating Pollen Diagrams of the Near East: A Preliminary Report

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In this preliminary report, problems with respect to the correlation of the diagrams of the Hula, Ghab and Eski Acigöl are discussed. The comparison is made on the basis of tree pollen and a selection of non-arboreal pollen. An additional curve for the tree pollen has been calculated with correspondence analysis. The pollen diagrams of Hula and Acigöl have been subdivided into 5 corresponding zones. The boundaries of these zones differ considerably in age, even if corrections of radio-carbon dates are taken into account. A correction of the radio-carbon date of the Ghab diagram enables a better correlation with the Hula diagram.

* * *

Lithic Tools for Agriculture in the Middle Euphrates: The Sites of Tell Mureybit and Tell Halula

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This paper focuses on the study of the lithic tools used for agriculture at the sites of Tell Mureybit and Tell Halula in Syria. The use-wear analysis of lithic tools has shown the evolution of the use of these instruments between the PPNA (10,000 BP) and the Pre-Halaf (7800 BP). In recent periods, the use polish on the sickle elements is more striated. This should be understood as a progressive tendency towards (1) more intense harvesting activities, (2) the cutting of dryer stems, and (3) cutting close to the soil. Sickles from the PPNA to the middle PPNB are made with flint blades parallely inserted into the shaft. In the Pre-Halaf period, sickles with curved shafts and oblique insertions are present. Both innovations should have represented a great advantage in harvesting techniques. Finally, some lithic tools from the middle PPNB of Tell Halula, made of limestone, are interpreted as hoes. Agricultural intensification during the PPNB most probably led to the use of lithic tools for soil removal.

Session V

Archaeology and Explanations for the Origins of Agriculture

Distributions of Agricultural Origins: A Global Perspective

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The origins of cultivated plants have been treated rather extensively in modern times beginning with the landmark essay of Alphonse de Candolle in 1866. Thinking in this century has been heavily influenced by the writings of Nikolai Ivanovich Vavilov in the 1920s and 1930s. He developed the concept of centers of origin, named them and listed a suite of plants for each one. The studies were on a global scale but, in some areas, incomplete. For example, in Africa he placed a center of origin in Ethiopia but did not investigate sub-Sahara where some important crops were domesticated. He explored the highlands of South America, but did not treat the lowlands which have a different set of cultivated plants. Nevertheless, he was a giant among investigators of the origins of plant domestications; a little bit has been added here and modified there, but the overall conclusions are almost the same. All of us who are interested in this subject are his students.

* * *

Back to Vavilov: Why Were Plants Domesticated in Some Areas and Not in Others?

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The paper attempts to throw light on the reasons why plants were primarily domesticated only in certain regions of the world, even though plant diversity is widespread. A clarification of the areas of domestication, the biological mechanisms of species survival and the processes of domestication is attempted. A commentary on Vavilov's eight centers of origin is given, related to more recent concepts of crop plant origins.

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Vavilov's Work on the Theories of Domestication of Crop Plants in the Old Mediterranean

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The theory of centers of origin of cultivated plants was initiated and developed by N.I. Vavilov on the basis of analysis of crop data performed by the staff of VIR during several years which involved hundreds of cultivated plants collected all over the globe. The boundaries of the centers and the range of crops grown there were constantly updated by Vavilov to gain more precision mainly with the help of the method of infraspecific (differential) systematics. E.N. Sinskaya performed the analysis of the composition of cultivated plant resources not only on the specific and infraspecific levels, but she also traced the distribution and endemicity of genera, thus expanding the methods of defining the centers of origin, and attracted our attention to the fact that the notion of a center of origin was more and more associated by Vavilov with wide geographic territories. Recent crop-oriented research, archaeological and other data have added supplemental and more precise information, but the basic theory of diversity of cultivated plants peculiar to certain territories is not subject to revision.

Examples are presented concerning distribution of taxa of the economically most important genera within the Old Mediterranean area as a region of historical development of cultivated plant diversity – the notion which Vavilov used more and more often in respect of the centers of origin of cultivated plants. For the genus *Triticum*, the infraspecific taxa are discussed.

The detailed study of phenotypic and genotypic diversity of cultivated plants not only leads to a more precise characterization of the areas of origin, but is also necessary to avoid losses of biological diversity *in situ* and *ex situ*.

* * *

N.I. Vavilov in Syria

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In 1926, N.I. Vavilov of the All-Union Institute of Plant Industry (VIR) undertook a major collecting mission to Mediterranean countries. After having explored a

greater part of the countries surrounding the Mediterranean Sea, he left the island of Cyprus on 16 September 1926, arrived at Beirut, Lebanon, and immediately made his way to Damascus, Syria. The first excursions to crop fields showed the unique nature of cultivated plants in Syria with a great number of endemic forms. Dominating the crops grown was durum wheat (*Triticum durum*). Among these wheat forms, Vavilov identified a unique subspecies which he termed *horanicum* Vav.

In barley, he discovered varieties endemic to the Near East, namely var. *syriacum* Vav. & Orl. and var. *palestinicum* Vav. & Orl. Among the very rich collections of *Vicia faba* L., endemic form var. *syriaca* Murat. was identified.

Plant material from Syria made it possible to supplement an Asian subspecies *Lens esculenta* (= *L. culinaris*) subsp. *macrosperma* with a number of new forms endemic to the Near East – vars. *syriaca*, *atrogrisea*, *virgidula*, etc. – and also to discover a new large intermediate group of lentil. Interesting from a practical point of view were the pea samples (*Pisum* spp.) from Syria which represented an Asian subspecies.

Exploration in Syria led to the identification of valuable forms of flax (*Linum* spp.), sesame (*Sesamum indicum* L.), and alfalfa (*Medicago sativa* L.) among other crops.

The detailed study of the collected material at various experimental stations in the VIR network in the former Soviet Union formed the basis of Vavilov's definition of the origin of cultivated plants and the routes of their dispersion. The material also helped confirm the general concepts of Vavilov, namely the problem of species as a system, law of homologous series in hereditary variation, and the concept of the use of initial material for plant breeding.

* * *

Use of Historic and Archaeological Information in Lentil Improvement Today

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Lentil (*Lens culinaris* Medikus) was domesticated in the Near East arc and is today an important food legume around the Mediterranean Sea and in South Asia. ICARDA has a world mandate for research into the improvement of the crop and its main research station at Tel Hadya is located within the area of its origin. Knowledge of its early spread out of the Near East is directly relevant to the design of current breeding strategies at ICARDA and any new "spread."

The putative wild progenitor of the cultivated lentil is *Lens culinaris* subsp. *orientalis* (Boiss.) Ponert. An overlap in the distribution of the wild lentil and of

Neolithic archaeological finds of lentil indicate that it was domesticated in the Near East. Lentil is associated with the start of the "agricultural revolution" in the Old World, initiated by the domestication of einkorn and emmer wheats, barley, pea, flax and lentil. It spread as part of the assemblage of Near-Eastern grain crops throughout the expanding realm of Mediterranean-type agriculture to reach its current Old World range about 3000 years BP.

Variation among landrace populations indicates the selective forces at play during the early spread of the crop; these include the result of human selection on morphological traits, particularly seed characters, and also of selection for climatic and edaphic factors on a range of cryptic eco-physiological characters. An extreme example of the result of such selection pressures is the bottleneck of lentil in South Asia, where the founder population around 2000 BC was small in number and low in variability. This limits breeders' progress today. To break this bottleneck, we have used plant introduction, hybridization and mutation breeding.

* * *

Plant Gathering Versus Plant Domestication: an Ethnobotanical Focus on Leafy Plants

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A recent ethno-archaeological and ethnobotanical study of wild-plant gathering in contemporary villages of Central Anatolia (Turkey), showed that local tradition still maintains its importance in the cultural life of its inhabitants. Wild greens constitute a significant part of a farmer's diet. Out of over 100 wild plants, including mushrooms and fruits, leafy plants are considered the most important by the indigenous people. The leaves of 42 wild plants, which have high nutritive value, are regularly consumed during winter and spring. These are gathered mostly by women of all income groups.

The people in the Melendiz Plain, Aksaray province, possess indigenous knowledge of approximately 70 cultivars, of which 20 are vegetables, including 10 plants consumed for their green leaves alone. Some women attempted to grow these wild plants in their home gardens but noticed that the desirable sharp, bitter taste was lost. This may be one of the reasons why so few of the several wild leafy plants were domesticated.

The gathered greens, as well as bulbs, roots, mushrooms and fruits, provide a buffering/risk-management technique against potential hunger. This aspect of plant-gathering is frequently emphasized, but the role of wild plants in the daily diet of farming societies, when they are not under food stress, tends to be forgotten. Further, ethnobotanical studies are required for a better understanding of what determines the domestication of some species as opposed to the gathering of wild plants. This is particularly important from an archaeobotanical point of view.

* * *

Introgression of Durum into Wild Emmer and the Agricultural Origin Question

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Introgression between wild progenitors and their domesticated crop relatives can complicate attempts to locate the regions where agriculture began. Cytogenetics and distribution evidence indicate that most early crops were domesticated only once, i.e. only a small subset of the wild progenitor genepool was involved in domestication. On the one hand, this makes the archaeologist's search for agricultural transition analogous to attempting to find a needle in a haystack. On the other hand, it also means that it should be possible to narrow down the location of domestication by genetic analysis, whereupon archaeological exploration might be more successful. A major difficulty with using genetic analysis to locate the region of domestication, however, is that introgressed individuals may look much like the crop, and hence be mistaken for the progenitor. A necessary first step, therefore, is to recognize introgression where it occurs, and re-create the original genetic composition of the introgressed individuals.

For example, the so-called Upper Jordan Valley (UJV) race of wild emmer (*Triticum dicoccoides*) is sometimes regarded as the progenitor of emmer, durum and bread wheats because it resembles them. UJV plants tend to be robust, large-seeded, and grow in a productive environment, much like domesticates. Genetic research demonstrates that UJV is sharply differentiated from all other wild emmer populations. Some scholars have argued for extensive introgression in UJV, while others have argued for essentially none; but it is known that hybrid swarms do occur in UJV. Approaches to determining the degree of introgression include: (1) morphological comparisons – the progenitor should be more similar to emmer than to durum, since durum evolved from emmer relatively recently; (2) ecological considerations – certain traits are likely to be adaptive in the wild, others in the cultivated field; and, (3) spatial pattern – introgression is more likely in or around former cultivated fields, especially where the cultivated area is (was) large relative to the extent of the wild stands. Morphologically, UJV wild emmer is closer to durum than to emmer; ecologically, UJV traits such as broad spikelets and absence of anthocyanin pigment probably are maladaptive in the wild; and spatially, UJV alleles seem to be distributed in or immediately adjacent to what was once a major wheat-growing area, but in environments that sometimes are radically different from the cultivated areas. Thus, it seems likely that the UJV race of wild emmer is the result of introgression from durum. Some morphological indicators of introgression are presented and discussed.

* * *

Origins of Agriculture: Exploring the History of Harvesting and Threshing Techniques for Wild and Domestic Cereals, Using Data from Experiments and from Analysis of Use-traces on Prehistoric Tools

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The question of the origins of agriculture and the spread of crop plants has been approached in this paper by the use of analysis of characteristic wear traces on flint blades at prehistoric sites, to show that particular harvesting and processing methods are adapted to the wild or domestic morphology of cereals (ripening pattern, rachis fragility), and to particular uses of their products and by-products.

In Syria, over a period of three years, experimental harvest of wild and domestic cereals was carried out by hand and by using reconstructions of prehistoric sickles armed with flint or obsidian blades. These techniques were also tested on a sample of wild einkorn (*Triticum baeoticum*) transported to Jalès, France, from Anatolia, Turkey, and cultivated over a period of eight years, with and without annual harvest, and with and without soil tillage.

Harvesting over various soil types and in both the "wild stand" context in Syria and the simulated cultivation context in southern France, showed a certain degree of stem humidity corresponds to the ideal moment for harvest, when grain is viable but rachises are not completely shattered, and this activity, if plant density is adequate, was best carried out cutting near the ground (influence of soil abrasives). This motion and the above attributes of the plants at this particular stage of maturity, were reflected in traces of use on the experimental sickles. We identified similar traces of harvesting on prehistoric tools using qualitative and quantitative techniques of characterization of wear, for numerous prehistoric sites in the Bear east ranging from 12,500 to 8500 BP (non-calibrated). We interpret these, and other experimental results showing working of soil and annual sowing are unnecessary if fields are not continually moved, as indicating that these activities were probably not involved in the wild-cereal exploitation system practised at these sites. This pattern contrasts with traditional agriculture: isolated events of displacement of cereals from stands may have occurred, but mere harvesting would serve to expand and maintain the areas in which these plants grew annually. No tools related to working of soil or processing other parts of the plant than grain have been identified in this context to date.

The harvesting technique (and, presumably, grain-processing) remains largely the same with the advent of domestic crops, although harvesting appears to occur at a later stage of maturity in some instances. There is no evidence to date for the use use of tools to prepare fields in the Neolithic. However, analysis of traces on tools, tested by experimentation and ethnographic analogy, show they represent new techniques for processing domestic crops, corresponding to the semi-solid and solid nature of the rachis, and the need to process crops on a larger scale to separate grain from the rachis, and to chop straw, for example for temper in mudbrick architecture. A tool similar to the historic threshing sledge, described in Bronze Age texts, was constructed and tested, and appears to have been armed with flint inserts from this period, with characteristic traces of use. Traces indicate an instrument with this function appears in the Near East towards Eastern Europe at the end of the Neolithic, and its inserts have been identified in the Bulgarian Chalcolithic. Documenting origins and spread of such techniques may contribute to understanding of cultural or functional mechanisms of the diffusion of domestic crops.

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Syrian Origins of Safflower Production: New Discoveries in the Agrarian Prehistory of the Habur Basin

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Research into the origins of agricultural crops has tended to focus on the Neolithic period when staple cereals were domesticated and people settled in farming communities, yet numerous other crop plants, *Carthamus tinctorius* (safflower) among them, were arguably domesticated much later in time and under economic and social conditions quite different from those prevalent in the Neolithic. This paper examines the social and economic context of *Carthamus* use in the third millennium BC in Syria. Although archaeological evidence does not unequivocally show *Carthamus* domestication during this period, genetic evidence points to the emergence of the domesticate in Syria. Agricultural practices of the third millennium

BC indicate how the wild plants may first have been used and manipulated, plausibly leading to strong selective pressures and, ultimately, to a secondary human recognition of *Carthamus* products that would leave traces later in the archaeological record.

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Extinction Threat of Wild African *Gossypium* spp. in their Center of Diversity

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Review of the African and Arabian species of *Gossypium* (cotton) in some European and American herbaria and review of nomenclatural, taxonomic, and floristic literature revealed that 12 wild species (including one subspecies) and four cultivated species are found in the region. Keys for their identification are provided. Wild species are confined to the semidesert areas of the tropical belt between latitudes 20°N and 25°S with hiatus in Zaire and the north Zambezian basins.

Cultivated species are grown throughout most of the continent, but perennial escaped species and primitive cultivars were collected mostly within the tropical belt. Distribution maps of the species of genera *Gossypium* and *Gossypioides* are presented, based on data from herbaria and floristic literature.

The distribution of the wild species was compared with the vegetation map of Africa, and remarkable correlation was found between the areas of the distribution and several phytochoria or mapping units. This comparison suggests possible wider distribution of these species than currently recorded. The distribution maps served to identify suitable places for collecting cotton germplasm. The regions with the highest concentration of different species were chosen. The regions where the wild species are endangered by desertification, grazing, agriculture, or other activities, or the areas where the species are very limited in distribution and endemic to them, were designated as the first priority places for collecting. These are mainly: Air Mts, Niger (and the northern Sahel); coastal strip and adjacent mountains of Yemen; central Somalia, and the frontier region of Somalia, Ethiopia and Kenya; Meshra el Zerav, Sudan; Nondwa and Ruaha National Park, Tanzania; and Santo Antao, Cape Verde Islands.

Examination of germplasm collections of the USDA (USA), IRCT (France), and the genebanks of Zimbabwe and Israel revealed that African and Arabian cotton germplasm is very poorly represented, and it is likely that a similar situation exists in other collections. It is concluded that tropical Africa and southern Arabia are the places of first priority for collecting of wild cotton germplasm in the world.

Session VI

Spread of Crops from the Near East to Other Parts of the World

The Spread of Neolithic Agriculture from the Levant to Western Central Asia

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The earliest archaeobotanical evidence for agriculture comes at present from the southern Levant and middle Euphrates Valley where remains of domesticated barley, einkorn and emmer wheat, lentil, pea, chickpea and flax have been recovered from "Pre-Pottery Neolithic A (PPNA)" sites dated between *ca.* 8300 and *ca.* 7600 BC (uncalibrated radiocarbon years). By the 7th millennium BC these "founder crops" of Neolithic agriculture occurred more widely in and beyond the Levant from western Iran to Anatolia, and domesticated goats and sheep also appear for the first time at sites in the Taurus and Zagros mountains. At such sites, outside the Levantine "core area," the domesticated cereals and pulses tend to appear relatively suddenly, often associated with the domesticated caprines, suggesting that they were introduced and later integrated with livestock-raising in what became a highly productive system of agro-pastoralism.

Within Southwest Asia, the spread of agriculture is witnessed archaeologically by a progressive increase in the number and size of villages with rectilinear mud-brick architecture which took place during the "Pre-Pottery Neolithic B" (*ca.* 7600 to 5500 BC). The same process is evident in the spread of Neolithic settlement west across Anatolia into Europe, southeast into South Asia, and northeast into Central Asia.

The question of whether agriculture began independently in western Central Asia or as a result of diffusion from Southwest Asia is examined in the light of new evidence from the Piedmont zone of southern Turkmenistan. There a series of early Neolithic sites attributed to the "Jeitun Culture," named after the site Jeitun where recent excavations have shown that an agro-pastoral economy based on barley and (einkorn) wheat cultivation, and sheep and goat herding was established by 5000 BC. The people of the Jeitun Culture made coarse pottery and lived in small villages of rectilinear mud-brick structures similar to, and suggesting connections with, the PPNB and Pottery Neolithic settlements of Southwest Asia. Consideration of the probable areas of origin of the cereal crops and domesticated caprines found at Jeitun strengthens the inference that agriculture spread there from the west, as does the existence in northeastern Iran of Neolithic sites with Jeitun-type pottery. Overall, the evidence suggests that agro-pastoralism began in western Central Asia as a result of diffusion from Southwest Asia, although whether it did so mainly by a process of Neolithic colonization and/or by the adoption of agriculture by already resident hunter–gatherers remain unknown, and is now being investigated.

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Introduction of Mediterranean Wheat Landraces to Mexico and Their Adaptation

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Wheat was first introduced into the Americas in AD 1519 when it was reported to have been grown in Santo Domingo. The first wheats in Mexico were planted in 1522 around the area now occupied by Mexico City; the Central Plateau of Mexico and the Bajio region were the initial wheat-producing regions. Wheat soon spread outside the Central Plateau with the help of monks: to the Mesa Tarascan, Michoacan in the 1930s by the Franciscans, and to the Altos de Mixteca, Oaxaca around 1540 by Dominican monks. Both bread and durum wheat were introduced into southern Coahuila around 1600 and the Jesuits introduced wheat to the Pacific coast region and to Baja California by 1773. These introductions were grown on residual moisture and often after a maize crop. Later, the wheat was adapted to growing during the end of the rainy season and utilizing some of the winter rain. Later still, after selecting appropriate phenotypes, wheat was also grown during the rainy season which extended the area to the states of Mexico, Puebla and Tlaxcala. Wheat soon became an important crop, and by 1800 wheat flour was exported from Mexico to the USA. In 1995, the wheat area of Mexico was estimated at almost one million hectares, where approximately two-thirds of the area was irrigated and one-third was rain-fed. The original landraces and their selections are still grown in some of the non-irrigated areas and are preferred both for their adaptation to these conditions and for their special qualities for the production of local wheat products.

During the last three years, we have collected a large number of landrace wheats from 16 states in Mexico. During the 1993/94 winter cycle, the accessions were grown in a screen house at El Batan, Mexico, under optimum conditions and evaluated for 19 morphological, agronomic, and quality traits. The collection was classified using a numerical cluster procedure on attribute-standardized data. The method used the incremental sums of squares (Ward's method) strategy with Euclidean distance as the dissimilarity measure. Groups represented agronomic and quality characteristics, and place of collection. Further the accessions were scored for both seedling and adult plant reactions to leaf rust, and both seedling and adult plant leaf rust resistances were identified. The information from clustering and rust reactions were used to form core subsets, which are available for breeder evaluation. Also, our evaluation results show that landraces collected from regions of acid soils are not necessarily more aluminum-tolerant than those collected from regions of basic and neutral soil.

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The Archaeobotanical Record of Wheats in South Asia During Prehistoric and Historic Periods

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The archaeological record of different species of wheat (*Triticum* spp.) recovered from excavations of prehistoric and historic sites in four countries of South Asia, namely Afghanistan, Pakistan, India and Sri Lanka, covering a time period of last 8000 years and spanning Aceramic and Ceramic Neolithic, Harappan, Chalcolithic, Megalithic Iron Age, and Historical cultures is discussed. Although the ancient wheats in South Asian sites have often been diagnosed as hexaploids (*Triticum aestivum*, *T. compactum*, and *T. sphaerococcum*), one cannot totally rule out the possibility of finding tetraploid free-threshing species, such as *T. durum* (hard wheat), which are often difficult to differentiate from dispersed kernels of free-threshing hexaploid species in carbonized condition. This is more so when ancient grains are not associated with finds of spikelet forks, glume bases, and the like.

The present exercise was essentially to understand the changing patterns of cultivation of different wheat species on the Indian subcontinent with reference to the hexaploid species, especially the Indian short wheat (*T. sphaerococcum*) which appears to have had a much wider geographical distribution in antiquity. The solitary historical record of *T. aestivum* (or *Triticum* spp.) in Sri Lanka appears to be due to trade links rather than actual cultivation on that island. The results of archaeobotanical studies on the subcontinental sites are helpful in visualizing a general picture of dispersal of wheat species towards eastern territories away from the core areas of early (primary) domestication in West Asia. The detailed study of early sites from Pakistan and Afghanistan is likely to reveal clues on areas of adoption, secondary domestication, and evolutionary differentiation of hexaploid wheats. This could to be reaffirmed through phytolitherian studies and selective accelerator mass spectrometry (AMS) dating of the grains themselves.

There is some evidence of early cultivation of *T. dicoccum* and *T. durum* from sites in Pakistan (e.g. Mehrgarh, Nausharo in the northern Kutchhi plain). However, they are rarely reported from Indian sites. At present, commercial cultivation of emmer and durum wheat is insignificant in comparison with that of free-threshing bread wheat (*T. aestivum*), which is extensively cultivated in northern and central India. Bread wheat is fast replacing emmer and durum wheats in parts of western India and the Deccan also. The present study, albeit a broad-based one, attempts to search for a historical and factual basis for present distribution of wheat cultivation on the Indian subcontinent.

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Evolution of Cultivated Wheat and Barley in Armenia According to the Archaeological Material

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Geographically, the territory of the Republic of Armenia is a part of a spacious region, conventionally called the Armenian Upland. Armenia was the place of origin of the ancient Armenian nation that encompassed the whole upland. The Armenian Upland is an integral part of the Western Asiatic region which is widely known as one of the primary foci of civilized culture. It is known that primitive communities were established predominantly in areas rich in biodiversity of vegetation including a wide range of edible plants. There is strong evidence to suggest that wheat (*Triticum* L.) and barley (*Hordeum* L.) have been cultivated in Armenia since ancient times. Many scientists assume that the place of wild plant domestication and the conversion to cultivated forms must lie within the area of the plant's natural habitat.

Wheat/barley crop mixtures were grown in Armenia, though the relatively "pure" plantings of wheat and barley were found only during a certain period of history. Both wheat and barley forms with small and round grains prevailed in more ancient samples. Later, the oblong forms appeared and very gradually began to dominate over other forms. This process was connected with the change to a drier climate and genetic changes.

Bakhteyev named the "bottle-shaped" barley in Armenia *Hordeum lagunculiformae*. Tumanyan had also found such forms in archaeobotanical material and named the round-grained forms as *H. antiquorum sphaerococcum* and forms with oblong–elliptical kernels as *H. urartu*. These forms have not been cultivated for a long time, but they can still be found under wild conditions.

The possible origins of "speltoid" tetraploid wheats in the wild and their domestication is assumed as follows: AA × DD = AD, followed by increase of the chromosome number = AADD. They disappeared in the wild because of shattering of the spikes which prevented self-fertilization.

The theory that barley of the Bronze Age was awnless is argued. Ears with well-developed awns have also been found. It is necessary to investigate thoroughly and to conserve the Armenian archaeobotanical material in genebanks for study and more precise taxonomic identification.

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Present-day Distribution of Hulled Wheats (Einkorn, Emmer, and Spelt) in Spain: the Contribution of Ethnobotany

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Hulled wheat species – *Triticum monococcum* (einkorn), *T. dicoccum* (emmer) and *T. spelta* (spelt) – are among the oldest plants cultivated in the Near East. Research based on archaeological studies and literature indicates that the three species were under cultivation during both prehistoric and historic times. In Spain, it is still possible to find the three species under cultivation in isolated mountainous areas of Andalucia (einkorn) and Asturias (emmer and spelt) where traditional farming systems still survive. These are perhaps the last pockets of cultivation on a much larger scale in the past. For millennia farmers have grown various crops which were adapted to different cultivation techniques and grown under diverse cropping systems. This valuable knowledge is an integral part of people's culture and genetic resources. The changes occurring in rural areas have led to the abandonment of traditional farming practices together with these crops that once played an important role within the rural economy. Both germplasm and traditional knowledge are highly threatened in these areas and efforts should be made urgently to safeguard this heritage before it is lost.

Session VII

In Situ Conservation of Wild Relatives of Crop Plants

In Situ Conservation of Wild Relatives of Crop Plants in Relation to Their History

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The important word in the title is "history," which can have several meanings. History can be the current genetic history of the crop, durum wheat for example, which was domesticated via dicoccum wheat from wild tetraploid populations of emmer (*Triticum turgidum* subsp. *dicoccoides*). We need to conserve *in situ* primary wild populations of emmer in southern Syria in the Jebel Druz, in northern Syria possibly at the Der Jamal population near Aleppo, and in northeastern Hasake province if a primary site can be found. Lebanon has several sites worth conserving, such as Rashayya in the southern Beka'a Valley and in the oak-park forest habitats in the central Beka'a. Tetraploid wild emmer (AABB) has an evolutionary history currently interpreted as a wild diploid goatgrass (BB) similar to *Aegilops speltoides* (SS), which was the female parent in a cross with wild diploid *Triticum urartu* (AA) as male parent. Hence, primary populations of all three species should be conserved *in situ*. At such sites, researchers should sample the different soil types in which a species grows, for example, basalt, terra rosa, alluvial or serpentine. Soil types and the extent of soil cracking may aid seed dispersal and discourage seed predation by harvester ants and rodents. History can also be applied to the crop and the agricultural system that still grows landraces such as that near Sabace in Kastamonu province in north-central Anatolia, where einkorn (*Triticum monococcum* subsp. *monococcum*) and emmer are still cultivated. A second system is found in northern Morocco, where landraces of einkorn are also grown. These agricultural systems that still cultivate rare landraces need to be conserved. Chickpea (*Cicer arietinum*) is the fourth most important cultivated legume in world production, with many landraces and cultivars in Eurasia, Africa, the Americas and Australia. Its wild relatives *C. arietinum* subsp. *reticulatum* and *C. echinospermum* have very restricted distributions on different soil types in southeastern Turkey and northern Iraq. There needs to be an international effort to conserve *in situ* these small populations of wild chickpea, even though the regions where they grow are politically unstable.

History may mean an old association with humans, as with the sacred grove at Bsharri in the Lebanon mountains. Conservation of this grove of cedars of Lebanon also protects *in situ* other relatives of crop plants such as *Secale montanum, Vicia* species and the beautiful ornamental *Salvia microstegia*. Archaeological sites often protect relatives of crop plants; thus preserving the ruins may also conserve the wild plants. Many of the dead Byzantine cities of northern Syria shelter rare wild species such as pea, vetches, lathyrus, lentil, wild cereals and a beautiful black iris.

Many crop relatives are associated with recent historical events such as the demarkation of international borders. For example, the border zone between southern Turkey and northern Syria conserves many wild cereals, legumes and other ancestors of crop plants. *In-situ* conservation may also take place on state farms and experimental stations. The Ceylanpinar State Farm in southeastern Turkey is a recent well-known example where the World Bank is funding research on *in-situ* conservation methods. Protected experimental stations may become more important as future *in-situ* conservation sites because of the ease of controlling the system.

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Domestication of Cereal Crop Plants and *In Situ* Conservation of Their Genetic Resources in the Fertile Crescent

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Archaeologists have unearthed evidence of earliest cereal agriculture in the world close to the ancient town of Jericho in the Jordan Valley dating from 10,000 years ago. This early agricultural village supported about 300 people who grew two-row barley (*Hordeum distichum*). Over the next 10 millennia, domesticated cereals provided fresh, reliable food sources, eliminating forever the need for man to rely on wild plant species that had supported human existence for hundreds of thousands of years. Further, unlike before, food grains could be stored for a number of years and consumed at leisure in any season. This led to a growth in human population as well as more complex human societies than those that could develop in hunter–gatherer times. Through the increase of food, after the commencement of the Neolithic revolution, the human species has multiplied its own numbers at the expense of the rest of the world's biota. This manifold increase in human population has threatened habitats of wild species of plants and animals. These habitats need to be conserved *in situ* if the genes which gave rise to modern crops are to be preserved and allowed to evolve in tune with the changing environment for possible future use. Recent archaeological evidence has shown that wild progenitors of crop plants could have been cultivated as a source of food even before being morphologically domesticated for agriculture. Efforts at conserving wild progenitors of wheat and barley, namely *T. baeoticum, T. urartu, T. dicoccoides* and *Hordeum spontaneum*, and their domesticates are underway in the Fertile Crescent which is the center of diversity for these ancient and very important food and feed crops.

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Current Geographical Distribution and Habitat of Wild Wheats and Barley

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Accurate knowledge of the current geographical distribution and habitat of wheat and barley progenitors or ancestors is not only important for plant scientists but also for archaeologists. The maps of wild wheats and barley distribution produced by Harlan and Zohary in 1966 and by Zohary and Hopf in 1988 have been the most comprehensive and frequently cited sources of information. However, recent changes in the taxonomic concept of wild wheats and additional information on wild wheats and barley distribution obtained in numerous collection and survey missions to Near East countries call for the production of updated maps. The following wild wheat species are recognized and treated in the present paper: *Triticum baeoticum* Boiss. emend. E.Schiem. (=*T. monococcum* L. subsp. *aegilopoides* (Link.) Thell.), *Triticum urartu* Tumanian ex Gandilian, *Triticum dicoccoides* Koern. ex Asch. & Graebn. (=*T. turgidum* L. subsp. *dicoccoides* (Koern. ex Asch. & Graebn.) Thell.) and *Triticum araraticum* Jakubz. (=*T. timopheevi* (Zhuk.) Zhuk. subsp. *armeniacum* (Jakubz.) van Slageren). Other species presented in the distribution maps are: *Hordeum spontaneum* C.Koch (=*H. vulgare* subsp. *spontaneum*), *Aegilops speltoides* Tausch, *Ae. searsii* Feldman & Kislev ex Hammer, *Ae. bicornis* (Forssk.) Jaub. & Spach and *Ae. tauschii* Coss. The maps were based on the information in the "Global database of wheat wild relatives" developed by IBPGR in 1990, now upgraded and maintained by the Genetic Resources Unit of ICARDA (18,000 entries, data from 52 genebanks). Additional information was obtained in 50 collection and survey missions conducted by ICARDA in collaboration with the respective national programs to Syria, Jordan, Lebanon, Iraq, Iran, Turkey, Armenia, Cyprus, Egypt, Libya, Tunisia, Algeria, Morocco, Bulgaria, the former USSR, Turkmenistan, Uzbekistan, Pakistan and Tajikistan. The current geographical distribution of the wild wheats and barley has a different pattern from that at the onset of agriculture. The main difference is the present habitat fragmentation and gradual loss in large areas in the Near East. Most of the original habitats in the semi-arid regions of the Near East have been transformed to fields, urban areas or destroyed by other activities of a rapidly growing human population. The remaining potential habitats are degraded by animal overgrazing. On the other hand, the current distribution area may be larger than 10,000 years ago, because the wild species were spread as admixtures with seeds of cultivated species and some of them, like *H. spontaneum, T. baeoticum, T. urartu* and *Ae. tauschii*, developed weedy races, well adapted to growing in cereal fields.

Consequently, diploid wheat species, *T. baeoticum* in particular, occupy a larger geographical area than the tetraploid wheat species, *T. dicoccoides* and *T. araraticum*, which are not weedy. The latter two species and the original, non-weedy populations of *T. urartu* and *T. baeoticum* are threatened by rapid genetic erosion, therefore there is a need for their conservation *ex situ* in genebanks, as well as *in situ* through sustainable habitat management and use.

Remarks on Behalf of Participants

Hala N. Barakat
University of Cairo
Giza, Egypt

I have been requested to say a few words on behalf of all the participants of this Symposium which is about to conclude. It is a great honor for me to do so and I hope I will be able to express correctly the thoughts and feelings of all the participants.

The Symposium has been a great opportunity for all of us to express our appreciation to Prof. Jack R. Harlan for his life-time's work in the study of crop domestication and origins of agriculture. Scientists from about 23 countries, both inside and outside the region, working in several different but inter-linked disciplines such as archaeobotany, archaeology, plant biology, meteorology, plant taxonomy and ethnobotany, as well as scientists working on plant genetics, agronomy and crop breeding, all came together here to discuss the history of crop domestication and the origins of agriculture in the Near East.

It was exciting to exchange ideas and information with scientists from diverse backgrounds, develop contacts, and discuss topics of mutual interest which will no doubt be very useful in one's own research. The discussions during the Symposium have led to important conclusions and recommendations which, we hope, will be followed up.

On behalf of the participants I thank ICARDA, IPGRI and the other co-sponsors of the Symposium. We wish to especially thank the Director General of ICARDA, Prof. Dr Adel El-Beltagy, for his support and generous hospitality. We would also like to thank the International Organizing Committee, especially Dr Jan Valkoun, without whose assistance several regional scientists would perhaps have been unable to attend this important meeting. The participants would like to thank the support staff of ICARDA who have been very informal and efficient and contributed substantially to the success of the Symposium. And last but not the least, we would also like to thank all the research scientists at ICARDA and archaeobotanists from co-sponsoring institutions for showing us their research laboratories and arranging field visits to the archaeological sites, both of which were most interesting to all of us and we hope to meet once again some time in the future. Thank you.

Valedictory Address

Jan Valkoun
Head, Genetic Resources Unit
ICARDA, Aleppo, Syria

Ladies, Gentlemen and Colleagues:

You have spent nearly four and a half days discussing issues related both to archaeology and paleobotany and their relation to present-day plant breeding and plant science. It has been a very interesting meeting and a well balanced forum for exchange of ideas and interaction among groups of scientists which would not have normally got together since they come from disciplines which regularly have their own separate meetings. Over here we could put forward our ideas and exchange view-points while looking at the same scientific facts from different aspects.

I must acknowledge the contribution of George Willcox and his fortunate visit to ICARDA. He met Dr Damania and they visited the stands of wild progenitors of founder crops of the Near East and came up with an idea to have this jointly sponsored meeting. And I would like to take this opportunity to thank Dr Damania who was behind the overall organization of this meeting.

It was a pleasure for ICARDA to host this meeting and we hope you all had a chance to see some of the founder crops and their wild relatives during the field visits. It was also interesting to visit the archaeological sites and for you to observe the wild progenitors in their natural habitats, which provided you with a proper perspective as you trace back the history of farming systems and agriculture in this region. Plant scientists learnt new things from the archaeologists and the archaeologists learnt something fresh from plant biologists and crop breeders.

I would like to thank all of you not only for your participation, but also for your presentations and other contributions to this wonderful event. I would like to make a recommendation that after five or six years we should return to look at the new knowledge in the field of archaeology and plant science with the use of molecular techniques, including the use of DNA markers for carbonized seeds and isozyme analysis, as well as radio-carbon dating by accelerator mass spectrometry (AMS).

We have been through the entire scientific program as per the schedule and it is now my privilege to close the Harlan Symposium. I thank you once again for coming to ICARDA and I wish you all a most pleasant journey back to your homes and hope to meet you once again on the next occasion before too long.

Summary, Conclusions and Recommendations

In the general session at the conclusion of the Symposium good summaries of the major topics were presented. The salient features of a discussion on the future work to be carried out in origins of agriculture and crop evolution are given below.

1. It was proposed and accepted that this Symposium henceforth be called the "Harlan Symposium."

2. The Harlan Symposium achieved its objective by bringing together, for the first time in West Asia, archaeologists, archaeobotanists, ethnobotanists, plant geneticists and crop-improvement experts, to exchange experiences and generate new theories and ideas. It established a linkage between the beginnings of agriculture and present plant-breeding efforts, and brought together archaeology and plant science to meet the challenges of increased food production in the region and the world.

3. A series of recommendations were made and agreed upon by the assembled participants:

   A. Due to the wealth of materials discovered in the West Asia region and that a large proportion of these materials are not adequately curated nor generally accessible, it was **recommended** that an international center be set up for conserving archival archaeobotanical material and disseminating information in West Asia (similar to the Asian Agri-History Foundation established at Secunderabad, India). A start can be made with establishing a world database of relevant publications, maps, information, etc., and making it available freely through the internet and CD-ROM.

   B. It was **recommended** that IPGRI revise and expand its 1980 publication of English–Arabic *A Glossary of Plant Genetic Resources Terms*, to include archaeobotanical terms, and distribute it widely in West Asia and North Africa (WANA) and areas of the Fertile Crescent, so that decision-makers in the region are better informed about the importance of conservation of biodiversity as well as archaeobotanical sites.

   C. The Symposium noted that in recent years there was a tendency for young scientists to move away from traditional taxonomic and diversity studies in favor of molecular biology and genetic engineering. It was **recommended** that in order to better identify and document the rich biodiversity of the region it was necessary to train taxonomists from universities and institutions in the Near East. Special educational support programs, such as the IPGRI-supported "Vavilov–Frankel Fellowships Program," could facilitate these studies and provide encouragement to young enthusiastic scientists in the region to take up plant taxonomy and ecology.

D. It was **recommended** that important works by Russian and Armenian genetic-resources scientists be translated and published in English for a wider audience. Dorofeev's wheat monograph and the one produced by Gandilyan were particularly cited as deserving translation.

E. It was **recommended** that some steps be taken to conserve traditional farming systems and indigenous knowledge as well as crop-land ecology of the region. The wild progenitors of crop plants which have their origins in the Near East and their habitats need to be conserved for future sustainable use in crop-improvement programs.

F. Participants observed that, while a great deal was known about the southern arc and the mid-section of the Fertile Crescent, little recent information was available about the northeastern arc which includes parts of southeastern Turkey and northeastern Iraq and Iran. It was **recommended** that efforts be made to document the biodiversity and archaeobotany of the latter area as soon as possible.

G.The Symposium appreciated the distribution maps of the wild species shown on slides by Jan Valkoun of ICARDA's Genetic Resources Unit and other scientists. It was **recommended** that these maps would be extremely useful if published since they show existence of species from collection sites which have not been reported before.

4. Attention was called to the serious deficiencies in facilities and support for the Vavilov Institute (VIR) in St Petersburg, Russia. An opinion was expressed by the Symposium that greater efforts should be made by IPGRI to rescue VIR's genetic resources and other collections, including historical records of collecting trips, herbarium specimens, etc., and to conserve them in a better shape. It was noted that Spain had volunteered to multiply and rejuvenate some of VIR's germplasm collection free of cost in order to contribute towards this effort.

   Similar apprehensions were expressed about the fate of genetic resources and archaeobotanical material assembled in Armenia and other Central Asian Republics due to total curtailment of funding. It was generally agreed that such "orphaned" collections and archaeobotanical material need to be rescued and their conservation ensured.

5. It was noted that crop-specific papers presented at the Symposium were dominated by those dealing with the cereals. Other crop-specific papers included two on legumes, and one each on safflower, opium poppy, cotton, sesame and olive. In future symposia on this subject, representation of other important crop groups, such as cucurbits, fruit trees, and forest species, should be solicited.

6. It was concluded that ICARDA/IPGRI and others should co-sponsor a follow-up symposium after five or six years to examine the progress in research and to discuss the fresh knowledge on domestication and crop evolution based on modern techniques, such as DNA analysis of carbonized seeds and other materials discovered in the Fertile Crescent.

7. The participants appreciated the efforts of the Organizing Committee in successfully executing the scientific program, which concluded on schedule, and efficiently handling the logistics of the Symposium organization. Special thanks was given to ICARDA for offering its very fine facilities for this Symposium.

Author Index

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