Jack R. Harlan (1917-1998):

Plant Explorer, Archaeobotanist, Geneticist, and Plant Breeder [1]

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Jack Rodney Harlan had a passion for understanding crop plants, their origins, the people who created them, and their use in sustaining the global human population. His career directions were signaled early as he followed the work of his father, Harry V. Harlan, whose research on barley breeding methodologies and plant collection expeditions had a great impact on Jack, and, for that matter, plant breeders throughout the world.

He followed with great interest the long discussions of his father and Nikolay Ivanovich Vavilov, an occasional guest of the Harlan household. Jack had hoped to study with the great Vavilov after completing the Bachelor of Science degree from George Washington University in 1938. He even studied Russian along with other languages during his school days. His hopes were dashed, however, because of the difficult times Vavilov encountered during the latter years of his career. Jack reported in *The Living Fields* (1995) [2], his last book, the following exchange between his father and Vavilov: Harry Harlan was in regular correspondence with Vavilov. 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 was the first graduate student to receive the Ph.D. with the great botanist and evolutionist G. Ledyard Stebbins.

Jack began his professional career as forage and rangeland grass breeder for the U.S. Department of Agriculture in 1942 at Woodward, Oklahoma and in 1951 he transferred to Oklahoma State University, Stillwater. While holding a joint appointment as Professor of Genetics at the University, he began to teach courses and supervised graduate students. He left the USDA in 1961 and joined the faculty of Oklahoma State University as a full-time Professor. In 1966 he moved to the University of Illinois as Professor of Plant Genetics in the Department of Agronomy. A year later, with J.M.J. de Wet, he founded the Crop Evolution Laboratory. In 1984 he became Professor Emeritus as he ended his formal professional career. However, after retirement he continued to write and lecture at many institutions, including two extended periods at the University of California, Davis, where he completed the revision of *Crops and Man* and formulated the basic outline of *The Living Fields: Our Agricultural Heritage.*

He developed a deeper understanding of the domestication of many crops through his extensive plant exploration work and astute observations in some 45 countries on all of the continents over a period of 35 years.[3] Less known is his extensive archeobotanical work which helped shape his views on the origins of agriculture.[4] His plant exploration work is legendary for the large number and diversity of species that he collected. Those collections remain his legacy in gene banks throughout the world, and especially in the U.S., from where samples of many of the accessions he collected were returned to their home country after being lost from local gene banks. A fitting tribute to his plant explorations was made at the Harlan Symposium in Aleppo, Syria in May 1997. He was presented in absentia a mosaic made from seeds of barley, sorghum, rice, and other crops derived from his original collections. The design was done by a local artist at ICARDA in the form of a map of Africa and Asia where he had done so much field work. Jack treasured this token of respect because it symbolized his great interest in crop geography and diversity. This art piece will be placed on display at the University of Illinois and later will be returned to ICARDA for permanent curation.

Jack Harlan was completely committed to the concept that *ex situ* conservation of crops was necessary to capture the products of millennia of crop evolution. These genetic resources may not be used for a long time to come in plant breeding or other studies, but the use of even one of the thousands of accessions he collected justified the whole effort. Jack enjoyed telling of a nondescript wheat he collected in eastern Turkey:

"The potential value of a collection cannot be assessed in the field. Perhaps this statement could best be illustrated by PI 178383, a wheat I collected in a remote part of Eastern Turkey in 1948. It is a miserable looking wheat, tall, thin-stemmed, lodges badly, is susceptible to leaf rust, lacks winter hardiness yet is difficult to vernalize, and has poor baking qualities. Understandably, no one paid any attention to it for some 15 years. Suddenly, stripe rust became serious in the north-western states and PI 178383 turned out to be resistant to four races of stripe rust, 35 races of common bunt, ten races of dwarf bunt and to have good tolerance to flag smut and snow mould. The improved cultivars based on PI 178383 are reducing losses by a matter of some millions of dollars per year." (from "Practical problems in exploration: Seed crops", 1975)

Jack was a very keen student of Vavilov's work, but as he observed crops and wild species throughout the world, he could see, as a few others had also recognized, that the centers of crop origins described by Vavilov were centers of diversity and centers of long-standing agricultural activity, which may or may not represent centers of crop evolution or domestication. He synthesized his observations in a classic paper "Agricultural Origins: Centers and Noncenters," (1971) and introduced the concept of 'noncenters' as a complement and refinement of Vavilovian theories of crop origins and diversity:

"I propose the theory that agriculture originated independently in three different areas and that, in each case, there was a system composed of a center of origin and a noncenter, in which activities of domestication were dispersed over a span of 5,000 to 10,000 kilometers. One system includes a definable Near East center and a noncenter in Africa; another system includes a North Chinese center and a noncenter in Southeast Asia and the South Pacific; the third system includes a Mesoamerican center and a South American noncenter. There are suggestions that, in each case, the center and noncenter interact with each other. Crops did not necessarily originate in centers (in any conventional concept of the term), nor did agriculture necessarily develop in a geographical center."

He revisited this matter almost 25 years later in *The Living Fields* (1995):

"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 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 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."

He readily recognized the great value of wild relatives of crop plants as gene resources for plant breeding. While this concept was not new, he and his colleague, J.M.J. deWet, formalized the concept of gene pools for use in plant breeding in "Towards a Rational Classification of Cultivated Plants" (1971) as primary (for hybridization of cultigens within the same species), secondary (for hybridization of cultigens with closely related compatible species), and tertiary (for hybridization of cultigens with more distantly related species, often requiring unusual steps, such as embryo rescue with artificial media). This classification has been useful in setting priorities for collecting plant genetic resources and as a reference point for use in designing breeding strategies.

He returned to the need for conservation of wild species in a post-Green Revolution paper, "Genetics of Disaster," (1972) in which he formulated many of his concerns about 'genetic vulnerability' and 'genetic wipeout.' This paper also hints at the need for *in situ* conservation, a topic that he held in secondary importance to *ex situ* conservation for practical reasons, as revealed in "Evolution of cultivated plants" (1970):

"For the sake of future generations, we MUST collect and study wild and weedy relatives of our cultivated plants as well as the domesticated races. These sources of germplasm have been dangerously neglected in the past, but the future may not be so tolerant. In the plant breeding programs of tomorrow we cannot afford to ignore *any* source of useable genes."

His views, expressed in several papers in the late 1960s and 1970s, were not unheeded, however. He joined others in landmark meetings with FAO in Rome and in Beltsville, Maryland to set in place the modern era of plant genetic resources conservation as a system of collection, documentation, evaluation, and *ex situ* conservation.. The International Board for Plant Genetic Resources *cum* International Plant Genetic Resources Institute was established in the recently formed Consultative Group for International Agricultural Research as a direct outcome of those jointly expressed concerns . Jack Harlan is prominent among the founders--- Sir Otto Frankel, Erna Bennett, Jack Hawkes, Dieter Bommer, M.S. Swaminathan, John Creech and a few others--- of the modern movement which established plant genetic resources as an interdisciplinary field for scientific study and for biological conservation. This movement began to flourish in the 1980s and is sustained to this time, giving testimony to the wisdom of those early visionaries.

Still, Jack's words in "Our vanishing genetic resources" (1975) ring true today:

"The coevolution of crops and man in subsistence agricultural economies is one of the most fascinating of all subjects for the student of evolution whether he be interested in plant or human cultural evolution. But, as with so many things in this world, the past is being destroyed by the present. Centers of diversity have been wiped out in recent decades. Indigenous tribal cultures and social customs have collapsed as well. Authentic indigenous cultivars and landraces are becoming collector's items as much as Luristan bronzes, African masks and figurines, or precolumbian Indian art. The world of N.I. Vavilov is vanishing and the sources of genetic variability he knew are drying up. The patterns of variation ... may no longer be discernible in a few decades and living traces of the long coevolution of cultivated plants may well disappear forever."

Harlan's philosophy of the origins of agriculture was echoed throughout the Symposium. While many details about the origins of agriculture remain to be discovered, Jack offered this guiding principal in some of his final writings:

"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."(*The Living Fields,* 1995)

We see that his long-standing view of spatial diffuseness and multiple origins of agricultural origins, first expressed in his 1951 paper "Anatomy of gene centers", and elaborated in "Agricultural Origins: Centers and Noncenters" in 1971 have stood over several decades---another of the legacies of Jack Harlan that embody the framework of knowledge about the origins and maintenance of crop genetic diversity that was the theme of his lifetime of research.

Recognitions Received

Jack Harlan received many accolades during his career, most of which are mentioned below. He expressed great appreciation for being remembered at the Symposium dedicated to him, but I believe his greatness satisfaction came in receiving the Vavilov Medal during the Vavilov Centennial Celebration in Moscow and St. Petersburg (Leningrad) in 1987. He was one of the few of the honored guests who actually knew Vavilov personally.

Jack Harlan received numerous 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 Science Award (1971) and the International Service in Agronomy Award (1976). In 1986 he received the Distinguished Botanist Award from the Society for Economic Botany. He served as President of the Crop Science Society of America in 1966. His several elections as Fellow include, the American Association for the Advancement of Science (1956), the American Society of Agronomy (1962), the American Academy for Arts and Sciences (1975), and the Crop Science Society of America (1985). He was elected to membership the prestigious U.S. National Academy of Sciences in 1972. Among his important lectureships were the Wilhelmine E. Key Lecturer in Genetics and the Nilsson-Ehle Lecture for 1984 (Sweden).

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[2] Titles of papers and books and dates are referenced in the accompanying bibliography of Jack R. Harlan.

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[4] 1960: Iran; 1964: Turkey; 1977 and 1979: Jordan; 1983: Russia.

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