

The living fields

our agricultural heritage

JACK R. HARLAN

*Professor Emeritus Plant Genetics,
Agronomy Department
University of Illinois*



CAMBRIDGE
UNIVERSITY PRESS

PUBLISHED BY THE PRESS SYNDICATE OF THE UNIVERSITY OF CAMBRIDGE
The Pitt Building, Trumpington Street, Cambridge CB2 1RP, United Kingdom

CAMBRIDGE UNIVERSITY PRESS
The Edinburgh Building, Cambridge CB2 2RU, UK <http://www/cup.cam.ac.uk>
40 West 20th Street, New York, NY 10011-4211, USA <http://www.cup.org>
10 Stamford Road, Oakleigh, Melbourne 3166, Australia

© Cambridge University Press 1995

This book is copyright. Subject to statutory exception
and to the provisions of relevant collective licensing agreements,
no reproduction of any part may take place without
the written permission of Cambridge University Press.

First published 1995
First paperback edition 1998

Printed in the United Kingdom at the University Press, Cambridge

Typeset in Linotype Meridien 10¹/₂/13 [RO]

A catalogue record for this book is available from the British Library

Library of Congress Cataloguing in Publication data

Harlan, Jack R. (Jack Rodney)

The living fields : our agricultural heritage / Jack R. Harlan.
p. cm.

Includes bibliographical references (p.) and index.

ISBN 0 521 40112 7 (hardback)

1. Agriculture – Origin. 2. Plants, Cultivated – History. 3. Crops – History.

4. Traditional farming – History. 5. Plant remains (Archaeology) I. Title.

GN799.A4H37 1995

630'.9 – dc20 94-42948-CIP

ISBN 0 521 40112 7 hardback

ISBN 0 521 64992 7 paperback

Contents

Preface		xiii
Acknowledgments		xv
CHAPTER ONE	<i>Of pride and prejudice</i>	1
	Agriculture as divine gift	1
	Agriculture as discovery	5
	Agriculture for religious reasons	18
	Agriculture by crowding	21
	Agriculture by fisherfolk	21
	Agriculture by stress	23
	Indigenous perceptions	25
CHAPTER TWO	<i>Evolution and revolution: the processes of domestication</i>	30
	The processes of domestication	30
	Cereal crops	31
	Other seed crops	34
	Weed races	39
	Vegetatively propagated plants	44
	Animal domestication	46
	Geography of plant domestication	49
	Crop origins and evolution	54
CHAPTER THREE	<i>Stones and bones</i>	63
	Nature of archaeology	63
	Dating history	65
	Some generalities from archaeology	80
CHAPTER FOUR	<i>The Near East</i>	86
	The archaeological record	86
	The crops	93
	The animals	106

	Neolithic expansion	111
	Agricultural vulnerability	112
CHAPTER FIVE	<i>Africa</i>	116
	The African pattern	116
	Archaeological background	119
	The crops	123
	Décrue agriculture	134
	The forest zone	138
	East African highlands	139
	The animals	140
	Conclusions	143
CHAPTER SIX	<i>The Far East</i>	144
	Prehistoric record	144
	Recorded history	148
	The crops	150
	The South Pacific	165
	India	169
	The animals	170
CHAPTER SEVEN	<i>The Americas</i>	173
	Archaeological background	173
	Cereals	179
	Roots and tubers	190
	Beans	196
	Tomatoes	200
	Squashes	203
	Peppers	204
	Cottons	205
	Plants: a final note	206
	The animals	206
	Conclusions	209
CHAPTER EIGHT	<i>Some traditional techniques</i>	210
	Bush fallow	210
	Soil preparation	214
	Water management	220
	Sowing and reaping	225
	Preservation of perishables	231

	Processing	233
CHAPTER NINE	<i>Where we stand</i>	236
	Agricultural origins	236
	What in the world does the World eat?	240
	<i>References</i>	251
	<i>Index</i>	264

CHAPTER ONE

*Of pride and prejudice**

Agriculture as divine gift

We find the subject of agricultural origins in the most ancient literatures and the oldest oral traditions. It must have been a subject of interest and speculation long before writing was developed. In the classical mythologies of all civilizations, agriculture came as a divine gift. A god or goddess came not only to instruct the ignorant in the arts of farming and of agriculture but to enlighten them with respect to law, religion, household arts and proper ways of living.

In the Mediterranean region, instruction came from a goddess, Isis in Egypt, Demeter in Greece, Ceres in Rome. According to Diodorus Siculus, agriculture originated in this way: five gods were born to Jupiter and Juno, among them Osiris and Isis. Osiris married his sister, Isis, and

did many things of service to the social life of man. Osiris was the first, they record, to make mankind give up cannibalism; for after Isis had discovered the fruit of both wheat and barley which grew wild all over the land along with other plants but was still unknown to man, and Osiris had also devised the cultivation of these fruits, all men were glad to change their food, both because of the pleasing nature of the newly-discovered grains and because it seemed to their advantage to refrain from their butchery of one another. As proof of the discovery of these fruits they offer the following ancient custom which they still observe: even yet at harvest time the people make a dedication of the first heads of the grain to be cut, and standing beside the sheaf, beat themselves and call upon Isis, by this act rendering honor to the goddess for the fruits which she discovered at the season when she first did this. Moreover in some cities, during the festival of Isis as well, stalks of wheat and barley are carried among the other objects in the procession, as a memorial of what the goddess so ingeniously discovered at the beginning. Isis also established laws, they say, in accordance with which the people regularly dispense justice to one another and are led to refrain through fear of punishment from illegal violence

* From *Pride and Prejudice* by Jane Austen, 1813

and insolence; and it is for this reason also that the early Greeks gave Demeter the name Thesmophorus, that is lawgiver, acknowledging in this way that she had first established their laws.

Translation by C. H. Oldfather, 1946

It was Demeter who taught Tritolemous

. . . to yoke oxen and to till the soil and gave him the first grains to sow. In the rich plains about Eleusis he reaped the first harvest of grain ever grown, and there, too, he built the earliest threshing floor . . . In a car given him by Demeter and drawn by winged dragons he flew from land to land scattering seed for the use of men . . . ?

Fox, 1916

Half a world away, we find a myth containing exactly the same elements: (a) people without agriculture are savages who live like animals and eat each other; (b) through some divine instruction they learn not only how to produce food but also to live by laws and to practice religion and those household arts common to civilized life.

From the Royal Commentaries of the Inca Garcilaso de la Vega (1961) we read:

Know then that, at one time, all the land you see about you was nothing but mountains and desolate cliffs. The people lived like wild beasts, with neither order nor religion, neither villages nor houses, neither fields nor clothing, for they had no knowledge of either wool or cotton. Brought together haphazardly in groups of two or three, they lived in grottoes and caves and like wild game, fed upon grass and roots, wild fruits and even human flesh. They covered their nakedness with the bark and leaves of trees, or with the skins of animals. Some even went unclothed. And as for women, they possessed none who were recognized as their very own.

Seeing the condition they were in, our father the Sun was ashamed for them, and he decided to send one of his sons and one of his daughters from heaven to earth, in order that they might teach men to adore him and acknowledge him as their god; to obey his laws and precepts as every reasonable creature must do; to build houses and assemble together in villages; to till the soil, sow the seed, raise animals, and enjoy the fruits of their labors like human beings.

The Inca king and queen arrived from heaven and were given a sign by which they would know where to establish a capital city. The place was located (Cuzco) and they set out to teach the savages 'how to live, how to clothe and feed themselves like men, instead of like animals.' The epic continues:

While peopling the city, our Inca taught the male Indians the tasks that were to be theirs, such as selecting seeds and tilling the soil. He taught them how to make hoes, how to irrigate their fields by means of canals that connected natural streams, and even to make these same shoes that we wear today. The queen, meanwhile, was teaching the women how to spin and weave wool and cotton, how to make clothing as well as other domestic tasks.

In short, our sovereigns, the Inca king, who was master of men, and Queen Coya, who was mistress of the women taught their subjects everything that had to do with human living.

Garcilaso de la Vega, 1961 edition

From cuneiform tablets, we learn that the source of agriculture for the Babylonians, Chaldeans and Phoenicians was a god named Oannes, who appeared to inhabitants of the Persian Gulf coast and instructed them on growing crops and raising animals (Fiore, 1965). According to Maurice (1795), 'He also taught man to associate in cities and to erect temples to the gods, he initiated them in the principles of legislation and the elements of geometry. He showed them how to practice botany and husbandry and he reformed and civilized the first rude and barbarous race of mortals.'

In Chinese mythology, P'an Ku separated the heavens and the earth, created the sun, moon and stars and produced plants and animals. There followed 12 celestial sovereigns, all brothers, who ruled 18 000 years each, then 11 terrestrial sovereigns, all brothers, who also ruled 18 000 years each. After that came nine human rulers, all brothers, who governed a total of 45 600 years. Among them was Shên-nung who taught the people agriculture and developed medicine. In another version, 16 rulers came after the nine and these were then followed by the 'Three Sovereigns', one of whom was Shên-nung. There are many variations of this particular theme (Latourette, 1941; Fitzgerald, 1950; Christie, 1983) including the following description of Shên-nung by the ancient historian Se-ma-Tsien (first century BC) Shên-nung, he said, had the body of a man and the head of an ox and his element was fire. He taught the people to use the hoe and the plow and initiated the sacrifice at the end of the year. He also found drug plants that cured and made a five-stringed lute (Chavannes, 1967).

The mythologies of the American Indians are enormously varied and complex, but here I shall present themes of only the Aztec and

Maya to compare with the Incan myth already cited. In the Aztec creation literature, Quetzalcoatl was described as

god of the air, a divinity who during his residence on earth instructed the natives in the use of metals, in agriculture and in the arts of government. Under him, the earth teemed with fruits and flowers without the pains of culture. An ear of Indian corn was as much as a single man could carry. Cotton, as it grew, took on of its own accord, the rich dyes of human art. The air was filled with intoxicating perfumes and the sweet melody of birds. In short, these were the halcyon days which find a place in mythic systems of so many nations in the Old World. It was the *Golden Age* of Anahuac.

Prescot, 1936

Interestingly enough both the Aztec and the Maya thought that maize was on earth before mortals. In the Aztec story, Quetzalcoatl disguised himself as a black ant, stole the cereal from Tonacatepel and took it to Tamoachan for the benefit of the people. In the Mayan myth, the flesh of humans was actually formed out of maize meal and snake's blood (Recinos, 1947). It is little wonder that the maize plant is venerated to this day in Mexico and Guatemala. The Mayan epic also contains oblique references to a garden of Eden or Golden Age in which nature yielded abundantly of its own accord.

In this manner they were filled with pleasure because they had discovered a lovely land full of delights, abundant in yellow ears and white ears (of maize) and also abundant in (two kinds of) cacao and innumerable fruits of mamey, chirimoya, jocote, nance, white zopote and honey. The foods of Paxil y Cayalá were abundant and delicious.

Popol Vuh pt. III, as reported in Recinos, 1947; my translation

It is also of interest that the Australian Aborigines who did not practice agriculture had their own mythologies and creation stories in which gods taught the people how to gather foods. An elderly Aborigine woman recited this part of the creation legend as reported by Berndt and Berndt (1970):

Nalgulerg (a mythical woman) gave us women the digging stick and the basket we hang from our foreheads, and Gulubar Kangaroo gave men the spear-thrower. But that Snake that we call Gagag (Mother's mother) taught us how to dig for food and how to eat it, good foods and bitter foods.

In all the myths and tales about the origin of agriculture, knowledge is gratefully received as a blessing from the gods. There is one outstanding exception found in Genesis where agriculture comes as a curse.

. . . cursed is the ground for thy sake; in sorrow shalt thou eat of it all the days of thy life; thorns also and thistles shall it bring forth to thee; and thou shalt eat the herb of the field; in the sweat of thy face shalt thou eat bread, till thou return unto the ground; for out of it wast thou taken: for dust thou art, and unto dust shalt thou return. (3: 17–19)

And the Lord God said, Behold, the man is become as one of us, to know good and evil: and now, lest he put forth his hand, and take also of the tree of life, and eat, and live for ever: therefore the Lord God sent him forth from the garden of Eden, to till the ground from whence he was taken. (3: 22–23)

King James Version

The elements of the traditional mythologies are:

1. There was a time before agriculture when people gathered their food from the wild.
2. Not farming is primitive, wild, uncivilized, lawless, graceless and brutish.
3. Nonfarmers did not farm because of ignorance or lack of intelligence.
4. A god or goddess was required to enlighten humans as to agricultural practices as well as laws, arts, religion and civilized behaviour.
5. Agricultural people knew themselves to be superior to hunter-gatherers.

Agriculture as discovery

It may be that the anthropologists, archaeologists, botanists, philosophers and others who deal with agricultural origins no longer believe that it came from divine revelation, but many have had faith in inspiration. A typically Victorian view was expressed by Charles Darwin:

The savage inhabitants of each land, having found out by many and hard trials what plants were useful, or could be rendered useful by

various cooking processes, would after a time take the first step in cultivation by planting them near their usual abodes . . . The next step in cultivation, and this would require but little forethought, would be to sow the seeds of useful plants; and as the soil near the hovels of natives would often be in some degree manured, improved varieties would sooner or later arise. Or a wild and unusually good variety of a native plant might attract the attention of some wise old savage; and he would transplant it, or sow its seed.

Darwin, 1896

Darwin, among others, was convinced that nomadic people could not develop agriculture:

Nomadic habits, whether over wide plains or through the dense forests of the tropics or along the shores of the sea, have in every case been highly detrimental (to 'progress'). Whilst observing the barbarous inhabitants of Tierra del Fuego, it struck me that the possession of some property, a fixed abode, and the union of many families under a chief, were the indispensable requisites for civilisation. Such habits almost necessitate the cultivation of the ground; and the first steps in cultivation would probably result, as I have shewn elsewhere (above), from some such accident as the seeds of a fruit tree falling on a heap of refuse and producing an unusually fine variety.

Darwin, 1909

Darwin (1909) concluded, however, that 'the problem . . . of the first advance of savages towards civilization is at present much too difficult to be solved.' Genetics was not well developed in Darwin's time and he clearly felt that environment would modify heredity. It does, of course, but through selection of genes favoring fitness to the environment, not in the manner perceived by Darwin. At any rate the mind-set favored the Eureka! or 'lucky accident' school. Agriculture was the result of an idea, a concept that had to be discovered.

A pervasive and pernicious stereotype developed, based, in part, on traditional mythologies but essentially universal among agriculturalists. Europeans applied the term 'civilized tribes' to some eastern North American Indians who cultivated plants and lived in towns. But these same Indians referred to the hunting tribes of the plains as 'wild Indians.' In Africa, farming groups that surround hunter-gatherers 'did not merely assert their political dominance over the hunter-gatherers and ex-hunter-gatherers they encapsulated, they also treated them as inferiors, as people apart, stigmatized and discriminated against them' (Woodburn, 1988, p. 37). Similar attitudes prevail

in Asia, Oceania and tropical America. The stereotype that developed includes the idea that hunting–gathering people were always on the verge of starvation and that the pursuit of food took so much of their time and energy that there was not enough of either one left over to build more ‘advanced’ cultures. Hunters were too nomadic to cultivate plants and too ignorant or unintelligent to understand the life cycles of plants. The idea of sowing and planting had never occurred to them and they lacked the intelligence to conceive of it. Hunters were concerned with animals and they had no interest in plants. In the stereotype that developed it was generally agreed that the life of the hunter–gatherer was ‘nasty, brutish and short’ and that any study of such people would only reveal that they lived like animals, were of low intelligence and were intellectually insensitive and incapable of ‘improvement.’

Aspects of the traditional prejudice still show up in the literature and in current speculations on agricultural origins. One result is the concept that vegetative propagation of crop plants must be earlier than seed agriculture because it is easier to think of. It would not occur to the savage mind that seeds could be sown in order to produce useful plants. The savage had no concept of life cycles of plants and was ignorant of the modes of plant reproduction. Another corollary is the idea that agriculture is so unusual and the conception so difficult that the ‘event’ could only have occurred once or at most two or three times. Some diffusionists have even argued that the concept of agriculture must have diffused across the Pacific or Atlantic oceans thousands of years ago because the idea was too difficult for the American Indian to conceive. But agriculture is obviously so superior and so appealing that it would be accepted readily and gratefully. The idea would diffuse rapidly around the world even if new suites of cultivated plants had to be developed everywhere from the local flora. It also follows that a crop must have a center of origin because the process of domestication is so complex and difficult that domestication could only have occurred once for each species. Fortunately, these ideas are testable by archaeology, studies of patterns of diversity, genetics and by studies of surviving hunter–gatherers.

An alternative view: suppose we were not descended from tribes of idiots; suppose our ancestors had the same genes we do, the same intelligence and powers of observation; suppose plant-using hunter–gatherers knew all about life cycles of plants, about flowering,

fruiting, seed germination and plant growth; suppose they were economic botanists with an extensive knowledge of plant lore; suppose agriculture began on a basis of knowledge and not ignorance; suppose we were willing to admit that hunting and gathering might be a viable alternative to farming, could we look at the problem more objectively? Let us take a closer look at the Victorian 'savage.'

While there have been some perceptive observers in the past, a general turning point in our thinking occurred when, in 1966, Richard B. Lee and Irwin DeVore organized a symposium on 'Man, the Hunter', held at the University of Chicago and published in 1968 (Lee and DeVore, 1968*a*). Lee reported on his studies of the San !Kung of the Dobe area of Botswana. Over a three week study period, Lee (1968) found that the !Kung Bushmen spent 2.3, 1.9 and 3.2 days of the first, second and third week respectively in subsistence activities. He wrote, 'In all, the adults in the Dobe camp worked about 2½ days a week. Since the average working day was about six hours long, the fact emerges that the !Kung Bushmen of Dobe, despite their harsh environment, devote from 12 to 19 hours a week in getting food.'

Among the Bushmen, neither children nor the aged are pressed into service. Children can help if they wish, but they are not expected to contribute regularly to the work force until they are married. The aged are respected for their knowledge, experience and legendary lore, and are cared for even when blind or lame and unable to contribute to the food gathering activities. Neither nonproductive children nor the aged are considered a burden.

Sahlins (1968) recorded almost identical figures for subsistence activities of the Australian Aborigines he studied and elaborated on his term 'original affluent society.' One can be affluent, he said, either by having a great deal or by not wanting much. If one is constantly on the move and must carry all one's possessions, one does not want much. The Aborigines also appeared to be well fed and healthy and enjoyed a great deal of leisure time.

Other reports at the symposium tended to support these general claims. A picture emerged of leisured, if not of affluent, societies, where the food supply was assured even under difficult environmental conditions and could be obtained from the natural productions with little effort. The picture described did seem to fit some sort of Golden Age or Garden of Eden.

The publication was a surprise to many who had some version of

the hunter stereotype. The stimulation was enormous. There have been four international conferences on hunter-gatherers as a direct result, but not all were published. As of this writing, the last one was held in 1986 on the twentieth anniversary of the original symposium and published in 1988 (Ingold, Riches and Woodburn, 1988).

In addition one might cite Dahlburg (1981); Winterhalder and Smith (1981); Koyama and Thomas (1982); Williams and Hunn (1982); Price and Brown (1985); Harris and Hillman (1989) and such regional treatments as Hallam (1975); Silberbauer (1981); Riches (1982); Lee (1984); Akazawa and Aikens (1986); and there are many dozens, if not hundreds, of separate research papers. There is now a vast amount of new material on the subject, but some of the oldest papers are the most useful as observations were made before the hunter-gatherers were so restricted and encapsulated as they are now.

Understanding hunter-gatherers begins with the fact that there is enormous diversity among the many tribes and in their methods of exploiting the environment. To describe this diversity would require volumes. I shall, instead, select a few examples for illustration. Hunter-gatherers can, of course, be classified in various ways. A useful concept of *immediate return* and *delayed return* strategies was introduced by Woodburn (1988 and elsewhere). The Bushmen and Hadza are immediate return foragers. As we have seen, the Bushmen bands forage for a day or two, then stay in camp until the food is consumed, then forage again. The Hadza spend even less time assembling food, in part because they scavenge. They watch the sky for gatherings of vultures in their range, usually a sign of a lion kill. They follow the column of circling birds to the kill site, drive off the lions and help themselves to whatever pieces of freshly killed meat they choose. Needless to say this requires some understanding of lion behaviour. According to studies by O'Connell *et al.* (1988), 15–20% of total animal food obtained by Hadza comes from scavenging and that mostly from lion kills. In immediate return systems people live from hand to mouth, which may appear to be precarious, but they may be perfectly sure the food is always there for the taking.

Delayed return strategies have longer term goals that include: manufacture of boats, weirs, nets, traps and deadfalls; tending bee hives; capture and keeping of animals to be eaten later; managing vegetation with fire; water spreading; irrigation; flooding of forests;

sowing seeds for later harvest; arranged marriages, etc. Delayed return strategists are much closer to agriculturalists than they are to immediate return foragers. There are, as expected, intermediate states and conditions. Many of the Australian Aboriginal tribes were delayed return strategists of great skill.

At the time of European contact, the continent of Australia was inhabited by some 300 000 Aborigines living by hunting, gathering, fishing and shell fishing. They did not exploit any domesticated plants or animals and no true agriculture was practiced. They had however evolved complex delayed return food-procurement systems requiring high levels of skill in managing the flora and fauna and an extensive knowledge of the plants and animals they comprised.

Kangaroo Island lies some 35 km off the coast of southern Australia. It was once inhabited by Aborigines but they either left or died out well before European contact. Presumably it was cut off rather late from the mainland by rising seas. At the time of contact, the woody vegetation had thickened up to form thickets almost impossible to penetrate, while the vegetation on the adjacent mainland, with the same climate and species composition, was covered with an open woodland of well-spaced trees with grasses and other herbaceous vegetation in between. The contrast was quickly noted by Europeans, who could ride horses or drive wagons freely through the mainland countryside, but had to cut their way through Kangaroo Island. It was obvious that the Aborigines had put their stamp on the mainland vegetation. Australians have been entranced and intrigued ever since by the extent of vegetation management by the Aborigines and the skill with which it was practiced. Rhys Jones (1969) has called it 'firestick farming' and Douglas Yen (1989) 'aboriginal agronomy'. The Aborigines had effectively domesticated the landscape but not the plants or animals. Europeans have tended to reduce burning and put out fires once they have started; the results have not always been happy.

The question of burning has recently come up in respect to management of a national park in northern Australia. Should the park rangers burn like Aborigines or prevent fires like Europeans? In a discussion between park rangers and an Aborigine, the subject of a recent (1984) fire in southern Australia, in which 72 people were killed and many millions of dollars of property damage was inflicted, was broached. The Aborigine told the rangers that it was a shame that people lost

their lives, but it was a crime to let the country get so 'dirty.' People should look after their country and keep it 'clean.' Such a fire would not have occurred if the Aborigines had been in control. To underline the point, the Aborigine took out a folder of matches, lit the whole lot and casually tossed the fire into some dry grass. He then got into his pickup and drove off leaving the fire to burn. Before the startled rangers could mobilize, the fire had died out of its own accord. Now that is fire control! Fire is the best defense against fire, but it must be used wisely, skillfully and with experience. The rangers are willing to burn but they do not know how (Lewis, 1989).

Over much of Australia if an area is not managed by fire for some years, the woody vegetation thickens up and Aborigines find the area spiritually unsafe (Chase, 1989). To them, it becomes full of evil and malevolent spirits and should be avoided if possible. The concept of safe and malevolent space is prevalent among hunter-gatherers and traditional farmers around the world and shall be discussed in more detail later.

The Aborigines did more than burn. They diverted water to flood forests in the dry season. 'We like to see plenty water in the jungle all the time, for birds of all kinds gather near it and the food plants that we like grow better' (Campbell, 1965). They constructed water spreading devices for the rainy season (Lourandos, 1980) and they ditched to increase the supply of eels and other fish (Walters, 1989). In the course of digging up wild root crops, they churned up huge areas with digging sticks to the point they resembled plowed fields. Sir George Grey wrote (1841): 'In the province of Victoria . . . I have seen tracts of land several square miles in extent so thickly studded with holes where the natives had been digging up yams (*Dioscorea*) that it was difficult to walk across it.'

Native Australians made considerable use of calendar plants. Some common grasses gave them signals, e.g. when grains of *Chrysopogon setifolius* are ripe, it is time to dig yams or when grains of *Heteropogon triticerus* start to shatter, it is time to dig yams, and when all the grains have fallen, it is time to stop. When *Heteropogon contortus* begins to flower, the rainy season will soon be over, and so on. The reason for being particular about timing the yam harvest is as follows: the yams belong to the genus *Dioscorea*. It is a large pantropical genus of 600 species or more and yams are harvested or cultivated on at least five continents and many Pacific islands. Some of the tropical forest yams

are perennial and woody and not suitable for food. The ones that are utilized tend to be savanna species adapted to long dry seasons, and the tubers behave as annuals. At the end of the rains, tubers are formed below ground and grow very rapidly. Most of the metabolites in the vine are mobilized and pour down into the tuber. The vine then may go dormant as the vegetation turns brown and they can be subject to both drought and natural or man-set fires. However, the tubers are safe below ground. When the rains begin again, the tubers sprout and vines grow very quickly. The process is reversed and metabolites are rushed upward into the vine, in effect emptying out the tuber. Thus, the time of digging yams is critical. If dug too soon, the tuber is immature and will not recover from damage; if dug too late, there will be loss to vine growth. But the end of the digging season can be determined by the rains and vine growth; digging too soon is the main hazard and calendar plants can be very helpful.

Management of vegetation requires an understanding of local ecology, but did the Aborigines understand life cycles of plants? Did they know that flowers lead to seeds and that seeds can be grown to produce more plants? Is this something that must be learned or discovered in order to commence the domestication of plants or is this a part of the general botanical knowledge of gathering peoples?

An early observation by Sir George Grey (1841) is revealing:

The natives have, however, a law that no plant bearing seeds is to be dug up after it has flowered; they then call them (for example) the mother of Bohn, the mother of Mud-ja (*Haemadorum* spp.), etc.; and so strict are they in their observance of this rule that I have never seen a native violate it unless requested by an European, and even then they betray a great dislike to do so.

Confirmation of understanding of plant reproduction comes from Gregory (1886):

The natives on the West Coast of Australia are in the habit amongst other things of digging up yams as a portion of their means of subsistence; the yams are called 'ajuca' in the north and 'wirang' in the south. In digging up these yams they invariably reinsert the head of the yams so as to be sure of a future crop, but beyond this they do absolutely nothing which may be regarded as a tentative in the direction of cultivating plants for their use

The practice of replacing the head of the yam after digging was widespread among hunter-gatherers. Some Aborigines would scold

a yam, no matter how large, perhaps even beat it, replace the head and tell it to do better next time.

To the Andamanese, the goddess Puluga symbolizes the southwest monsoon that brings violent winds and rains from April to October. 'Puluga owned all the wild yams and cicada grubs that the people ate, and all the beeswax that they used in hafting, calking, and cordage. Women who dug yams had to replace the tops to fool Puluga . . .' (Coon, 1971). Indeed, if Puluga caught the people misusing her property she would get angry and send bad weather. Here we see the practice of planting reinforced by a religious belief.

There were many similarities between adaptations adopted by the Aborigines and those of the Great Basin Indians of North America. The Indians were faced with a semiarid to arid environment as were many of the Aborigines in their tribal lands. The Paiute of Owens Valley, California, also diverted water. Using small earth dams and ditches, they irrigated fairly extensive tracts. One block covered 5 km² and another about 13 km². The water spreading was primarily to ensure an increased production of native wild food plants such as *Salvia*, *Chenopodium*, *Helianthus*, *Oryzopsis* and *Eleocharis* as well as a local species of tobacco (*Nicotiana*). But they also sowed seeds to thicken up stands. None of the plants was domesticated (Steward, 1934).

Planting seeds was not uncommon among American Indian hunter-gatherers. Seven of 19 groups studied by Steward in Nevada sowed seeds of wild plants. The most frequently mentioned were *Chenopodium*, *Oryzopsis*, *Mentzelia* and *Sophia*. No tillage was practiced. The usual procedure was to burn a patch of vegetation in the fall and sow the seeds in the following spring.

Klimek (1935) recorded 11 tribes of California Indians that grew a local species of tobacco but no other crop. Some tribes in Oregon, Washington and British Columbia followed the same practice (Drucker, 1963). The tobacco was usually either *Nicotiana attenuata* or *Nicotiana bigelovii*. Harrington (1932) made a very detailed study of tobacco among the Karuk and found the extent of botanical knowledge remarkable. The Karuk burned logs in the forest and sowed seeds in the ashes. A tobacco garden was called 'to plant' or more literally 'to put seed.' The Karuk had terms for cultivated tobacco, wild tobacco, roots, stems, bark, leaves, branches, leaf branches, pith, gum, flowers, buds, seed pods, flower stem, clusters of flowers, sepals

and calyx. No standard word was used for petal but descriptive terms were used: for example, the white-flowered *N. bigelovii* was said to have 'five white ones sticking out.' The stamens and pistil were described as 'sticking out in the middle of every flower where the seeds are going to be.' Stamens are 'flower whiskers,' 'flower threads' or 'flower hairs.' Pollen is 'flower dust'. Nine stages of flowering to seed setting were recognized with descriptive terms. There was a classification of seeds, grains, seeds in the midst of a fruit (pit), seeds inside a shell (nut), etc.

The translation of an informant's description of germinating tobacco seed is botanically accurate and detailed.

Its seeds fall to the ground; the dirt gets over them. Then after awhile when it gets rained on, the seed sprouts. Sometimes all the seeds do not grow up. They say sometimes some of the seeds get rotten. Its sprouts are small white ones, pretty near the size of a hair, whenever it is just peeping out, its seed is on top of it; then they just have two leaves when they first peep out of the ground. They grow quickly when they grow; in a little while, they are tall ones.

The Karuk fertilized with ashes, sowed, weeded, harvested, selected for strength, cured, stored and sold tobacco but grew no other crop. Clearly the concept of planting seeds was in no way revolutionary and did not lead to food production.

It should be noted that tobacco is not the easiest crop to grow. The seeds are very small and the seedlings delicate. The 'rotten' seeds referred to by the Indian informant is what we call 'damping off' and is always a serious problem in tobacco culture. Sowing in ashes provided a sterile medium that probably helped control the disease.

Tobacco was used by western North American Indians not so much for recreation as for religious ceremony, and it was smoked in special pipes on special occasions. It could have simply been harvested from the wild, but these Indians were afraid of wild tobacco as it might have sprouted on the grave of someone with malevolent power and be spiritually dangerous. Death, disease, even injury or bad luck were perceived as being governed by spirits. They therefore grew their ceremonial tobacco in what was perceived as safe space. It is easy to see how such perceptions might lead to gardening and could be readily extended to food crops. The west coast Indians did not follow this practice and it is obvious that the concept of planting seed does not