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THE ADAPTATION OF KUMARA BY THE NEW ZEALAND MAORI

By D. E. YEN

In the December 1960 issue of this Journal (Vol. 69, No. 4) Mr. Yen, of the D.S.I.R. Crop Research Division, Otahuhu, New Zealand, discussed the propagation of the sweet potato in relation to its distribution in the Pacific. In this article, in which he concentrates upon the propagation of the sweet potato by the New Zealand Maori, Mr. Yen makes a further significant contribution to the ethno-botany of Polynesia.

INTRODUCTION

THE KUMARA or sweet potato (*Ipomoea batatas* (L.) Lam.) was the major cultivated crop plant of the New Zealand Maori at the time of early European contacts. Best 1 has reconstructed the system of agricultural procedures associated with the growing of the crop—cultivation, planting, harvesting, storage—at that time. His account, which is given in some detail together with descriptions of the ritual that accompanied each step in the system, emphasizes the high development of Maori agriculture and the contribution of this activity to the aboriginal economic system. 2

The tradition that kumara was introduced to New Zealand from tropical Polynesia in the fourteenth century A.D. is widely accepted. A fact connected with this plant transfer that appears to have been largely overlooked in favour of more spectacular considerations, is that the agricultural procedures established in New Zealand did not have parallels in any putative area of provenance in Polynesia, or over the whole tropic zone of the Pacific. These are the main differences:

(a) *Propagation Method.* In the tropical Pacific Islands, kumara is propagated directly from the growing plant as vegetative stem cuttings. Usually prior to harvest of the edible roots, cuttings are made for immediate planting into ground prepared for the purpose. Handy's account 3 of the Hawaiian method is typical for the region. The New Zealand Maori method utilised the root in the manner of the common potato, 4 whose tubers are planted directly into the soil. Best 5 states that the use of stem cuttings was confined to the more vigorous-growing European introduced varieties and that the sprouting of roots to obtain plants was sometimes adopted. The latter method is that used in temperate climates - 339 where kumaras are grown now as a commercial vegetable commodity, e.g., in U.S.A. and New Zealand. No examples of the use of the root portion of the plant for normal propagation purposes have been found in agricultural settlements in the tropical Pacific, despite the fact that the islanders are well aware of the reproductive function of the root and use it for this purpose when the plant is transferred long distances. That this awareness is of long standing may be attested to by the references to the transfer of roots in Maori legends. 6 In the more usual shifting cultivations the stem-cutting technique suffices.

(b) *Storage.* In a seasonal system of kumara growing that uses the roots for propagation, the storage of the roots is a critical feature: on its efficiency the supply of out-of-season food and the very permanence of the plant species depends. As a character of the Maori kumara growing, this contrasts with the position in the tropics where at most times of the year roots are available for food because of continuous plantings. The kumara root is more difficult to store than true seed of most species. Its requirements in

regard to temperature and humidity for efficient storage have been the subject of considerable study that has resulted in modern commercial techniques. 7 With the use of semi-subterranean stores, the types and occurrence of which have been recorded by Best, 8 the New Zealand Maoris were able, apparently, to supply the conditions of storage which would ensure the survival of kumara stocks. In a recent survey of storage practices, 9 no procedures as highly developed as those of the New Zealand Maori were recorded among primitive peoples. The present writer, in field work among native peoples in Western South America, Thailand, New Guinea, Fiji and on information from the Cook Islands, Tonga and Tahiti, has been unable to find examples of a major storage phase in kumara culture.

The significance of the New Zealand methods of propagation and storage of the kumara lies in the inference of the establishment of a ‘seed’ phase in its culture—that on the basis of a technical invention, a plant grown as a virtual perennial in its region of provenance became an annual plant. This conversion must have been the result of man's response to the new and different environment to conserve his limited vegetable food resources. It has been pointed out that the Maori took the kumara to the highest latitude reached by aboriginal agriculture in the Southern Hemisphere, farther removed from tropical conditions than anywhere in the New World. 10 Thus it is suggested here that the annual process of kumara raising could not have been introduced from the tropics, and that it was an innovation of some magnitude that could - 340 not have been arrived at by a sudden and inspired agricultural deduction immediately on the plant's introduction.

The object of this paper is to examine the introduction of the kumara and its adaptation as a possible logical sequence on a background of current knowledge of the New Zealand climate within the period of purported introduction and European settlement.

THE CLIMATIC BACKGROUND

The seasonal nature of the present-day New Zealand climate imposes the annual cycle of kumara growing since the plant will not survive the winter of even the warmer northern areas. In visits to the Maori kumara growing areas in Northland, Bay of Plenty, East Coast of the North Island no trace of over-wintering in the field or in propagating beds of previous seasons has been found. At the Crop Research Division's Vegetable Station at Otahuhu, no success in overwintering in the fields has been experienced in three years' experiments. 11 This seemingly irrelevant lack of adaptive ability is of some importance in relation to the question of how the kumara could survive if the early Maori introducers did not bring with them the knowledge of the plant as an annual, and if the climate then was as it is now.

A further limit that the climate of today imposes is the southernmost extent of kumara growing. Three years' experimental growing at Crop Research Division, Lincoln, on the Canterbury Plains has shown that while the plant will grow easily there its yields of edible roots are inconsistent and it could not be used as a reliable food source under present day conditions. The shorter growing seasons, with early frosts, interfere seriously with growth. 12

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There is considerable evidence accruing that the climate of New Zealand has changed in a warm-to-cool direction in the post-glacial period, fitting the general theory of synchronous changes in the Northern and Southern hemispheres. 13 Raeside's 14 comparative studies of Canterbury soils and vegetation

indicate that the climate prior to 1200 A.D. was warmer than present day. Summarizing his findings on soil investigations, and other evidence of moa remains in swamps, forestry and pollen studies, and high moraines in the Antarctic, Raeside 15 suggests that a fall in temperature of at least 2° C. occurred.

From ecological studies of South Island forests Holloway 16 presents evidence of recent climatic change which agrees with Raeside's findings. The same author 17 intimates that, because of the greater complexity of the North Island forests, the effects of climatic variation would be less obvious there than in the South. However his prediction that "northern forests can later be interpreted in terms of southern discoveries" appears to have been an accurate one. Forest surveys in the West Taupo area, 18 Taranaki, 19 and the eastern and southern parts of the North Island 20 all invoke the climatic fluctuations described by Holloway in the interpretation of the ecological phenomena recorded.

If the temperature drop between 1200-1600 A.D. postulated by Brooks 21 for Europe may be applied to New Zealand (geological evidence 22 on sea levels in the Firth of Thames shows some correlation with European temperature changes over a 4,000 year period), there was probably a short period, even with a 14th century introduction, when the climate was considerably more suited to the growth of tropical plants than now. When a plant species is introduced to an area close to the border of its ecological adaptation, a small fluctuation of annual mean temperature may have considerable effect on the success - 342 of its introduction. A 5° F. 23 or 2° C. 24 higher temperature in 1200 A.D. than present may have given New Zealand a considerably longer warm growing season or even a number of frost-free areas in which for a time, the 'artificial' storage phase in kumara growing may have been unimportant.

The subsequent deterioration of climate would have provided the stimulus and *time* for the Maori to invent the technical methods to preserve his plants.

KUMARA ADAPTATION IN A CHANGING CLIMATE

When the kumara was first introduced into New Zealand, it is probable that its growing would have been attempted after the same manner as in the tropics. There is sufficient evidence to suggest that in the present climate the plants would be unlikely to survive more than their first growing season, after which frosts would destroy them entirely. Because of the more favourable climate in that early period, however, it is suggested that introduction into the warmer northern parts of the country might need to undergo little modification of the island cultivation methods to survive, particularly if the growing season were of longer duration than at present (November-March). Since the plants in the Otahuhu experiments appeared to survive with little growth till May, the possibly shorter or less severe winters suggested may have allowed the island type of cultivation. Even if this situation did obtain, it would be likely that the cool season growing would be neither as vigorous nor productive as the warm season's. Also if a fourteenth century introduction is correct, the length of the period in which this method could be pursued would not have been long before the perception of the changing climate. The plant's reaction could well have been one of the first indicators of the change.

The response of the Maori agriculturists to the deteriorating conditions would have been horticultural in nature—an attempt to modify the environment to fit the plant's requirements for survival. The modern parallel to this is the use of glasshouses for non-adapted tropical or out-of-season plants. The Maori was more limited in what he could achieve, but the erection of wooden fences for the diversion of cold winds and the use of gravel on growing kumara plants for heat retention are measures of this type recorded. 25

The stone walls which occur in most of New Zealand have been related to Maori kumara growing, 26 and their function may have been partly as permanent shelter for crops. Adherence to fields sheltered by stone walls would have limited the shifting of grounds, which was probably necessary since the Maori knew little of the manuring of crops. 27 This, together with the limit to sources of stones close to fields, the labour involved in wall erections and the decreasing returns for labour under the deteriorating climate, - 343 may account for the spasmodic rather than regular association of the walls with kumara cultivation.

The spreading of gravel around plants seems to be a practice unique to New Zealand, and one which was limited by the same conditions as the stone walls. The provision of fences around crops is common practice in the tropical islands, but their purposes are different, e.g., in the Philippine Islands wooden fences are used by the Hanunóo for the exclusion of livestock; 28 in the New Guinea highlands, stone fences around kumara fields serve the dual purpose of boundary marking and exclusion of pigs. 29

With further cooling of the climate, these protective measures would have proved inadequate to ensure winter survival of crops. The early Maori agriculturists must have known that the roots could survive considerable periods in open storage, but the losses that result by such storage would not ensure a constant supply of food or propagating material. The lack of tradition of storage in the tropics and therefore the ignorance of the conditions necessary for its efficient execution made it imperative for the New Zealander to gain their knowledge for the survival of his crop. What ‘experiments’ must have been carried out may never be known, but the tangible evidence of the success of these has been recorded in the descriptions of the excavated food stores which were capable of being sealed off to provide relatively warm storage and high humidity conditions which are required for kumara root curing and storage. Best 30 has associated four forms of subterranean food stores, including pits and caves, with the storage of kumara. The more recent findings of pits 31 give rise to the possibility that dating of materials associated with such stores may indicate developmental trends in design, e.g., the incidence of drainage and non-drainage of pits in the same area could reflect the rainfall conditions of the time of their construction.

South Island kumara growing is reasonably well established in earlier writings, e.g., in Canterbury, 32 Nelson, 33 Marlborough, 34 and the southern-most limit at Temuka, South Canterbury is set on the discovery of pits construed to have been for storage. 35 The time of establishment of Maori agriculture may be revealed by further archaeological discovery. The transfer of the techniques of storage from the North Island would imply a later establishment of kumara culture, but the possibility of early introduction and technical development in the South owing to the first felt climatic change may not be wholly discounted at present. On Stack's information 36 the Kaiapoi Maoris adopted the protective practices and storage in their kumara culture. The same - 344 writer noted the extinction of the plant by European times, and this may well have been due to the influence of the unfavourable climate which caused the growing of the plant, even as an annual crop, to be uneconomic.

A further and uncontrollable function of deteriorating climate is that of natural selection on the varieties. The loss of varieties was commented on by Colenso in 1880 37 and the names recorded then and in a further list 38 were mainly those remembered by Maori informants. The varieties which required warmer conditions for growth, or which were of poor storage quality, would have been eliminated from cultivation.

By the seventeenth century the system of kumara cultivation and storage must have been formulated, and the limits of its distribution and the varieties grown determined.

OTHER MAORI FOOD PLANTS

The other Maori food plants were also of tropical origin—taro (*Colocasia antiquorum* (L.) Schott), *uhi* or yam (*Dioscorea* spp.), *ti* (*Cordyline terminalis* (L.) Kunth.) and *hue* or gourd (*Lagenaria siceraria* (Molina) Standl.)—and were subject to the same climatic influences as the kumara. The yam and *ti* must have been most uncommonly used by the time of European settlement. Best's account 39 shows definite traditions of yam, but its identification is limited to Banks' on Cook's first voyage 40 and Hooker's surmise of the species in New Zealand as *Dioscorea alata.* 41 *Ti* was rare by the time of Colenso 42 and there is no trace of its cultivation by the Maoris now. While explanations for extinction of these plants involving the competitive effects of European introductions, especially the potato, have been advanced, 43 the climatic influence may have been a major factor. Both plants require long growing seasons in the tropics for the formation of edible roots (the yam 9-12 months), 44 so that by 1769 very few areas in New Zealand would have been suited for their production.

The growing of three unidentified representatives of *Dioscorea* from the Cook Islands was attempted in 1958-59 at Otahuhu. No successful production of edible roots from November planting was achieved before cold weather stopped growth. A further sample collected in South America was grown in an unheated glasshouse in 1959-60 at the Plant Disease Division, Auckland, with the same result. While these species may *not* have been similar to the Maori types, it is suggested that the early introduction must have been in a considerably more favourable climate than present day.

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The taro is still extant in some of the Maori settlements in Northland and the East Coast of the North Island. 45 The probable reason for this species' survival is that there are types which are capable of overwintering in the more favourable areas. Escape plants from cultivation of a vigorous type may be seen in these areas. While these may not be early Maori, they suggest the possibility that the character of hardiness is in the species. Colenso 46 states that the taro tuber was not stored, but Best 47 describes the use of pits for this purpose. East Coast informants of today agree with this and state that the practice was common till quite recently. It seems that with the more delicate varieties at least, this measure could well have developed in like fashion to that suggested for kumara.

The *hue* was exceptional in the Maori food plant complement in that it could be propagated by seed, in contrast to the vegetative reproduction of kumara, taro, yam and *ti*. The *hue* was a dual purpose plant, cultivated for the mature fruit whose hard shell was used as water vessels, and immature for food. Its annual nature—growing in the summer, dormant seeds for over-wintering—made its conservation independent of climatic variation. Seeds of two varieties collected in the East Coast and Northland have been grown successfully at Otahuhu in three successive seasons between 1956 and 1959.

The comparative lack of traditional evidence and association of archaeological findings with these crops makes difficult a more detailed deduction of the influence of climate. However, the introduction of these plants into more favourable climate than present day is a reasonable assumption, and the survival of them indicates success and failure of man's efforts to overcome the effects of climatic change.

DISCUSSION

From the evidence presented, three stages of agricultural development may be postulated in pre-European New Zealand.

1. *Introductory—The introduction of tropical food plants.*

As Buck 48 has stated, such plants as coconut 49 and breadfruit were probably unable to survive the climate of the time. Kumara, taro, yam, *ti, hue* were able to do so, at least for a time, under the growing methods brought with the plants from their provenances.

2. *Experimental—Development of agricultural methods.*

The onset of climatic change in a warm-to-cool direction threatened the survival of most of these crops. Methods were developed for the protection of growing plants in response to the change. The storage phase was evolved as a further step to fit - 346 into the more extreme seasonal differentiation. During this period plants such as yam and *ti* became rare, since no man-made devices could completely overcome their lack of adaptability to the changing conditions.

3. *Systematic—Stable agricultural system.*

By the time of European contact, methods of growing kumara, and perhaps taro, as major contributions to the Maori economy were well established. The ceremonial attached to the growing of kumara is indicative not only of its importance but the degree to which it had been systematised. The agricultural significance is that the potential of the kumara plant as an annual crop in temperate regions was first realised by the New Zealand Maori.

It must be pointed out that this hypothetical sequence is based on *present* knowledge of climate and Maori agriculture. Future contributions to these subjects in the botanical, geological and archaeological fields may well modify the sequence. Its application to such matters as the placing in time of artefacts related to early agriculture may be premature. If Duff's assertion 50 that agriculture was not practised in the Archaic (Moahunter) phase of New Zealand culture is accepted, the suggested agricultural development sequence would fall conveniently into the Classic Maori phase. This may, however, be precipitate in the light of Golson's warning 51 from the archaeological standpoint that “it is on present evidence impossible to say whether agriculture was practised . . . in the Archaic or not”.

Further, Golson 52 in discussing the possibility of agriculture in the Archaic phase has quoted radio-carbon dates (roughly 1300-1350 A.D.) of some significance. These refer to an Archaic site near Mercury Bay circumstantially associated with a number of small pits which he suggests are indicative of kumara cultivation. If further evidence can establish agricultural practice in the pre-Classic phase, the same general developmental sequence based on plant adaptation may still apply. Indeed its application may be rather strengthened, for if kumara *cultivation* as inferred by invented storage practice is dated earlier than 1350, the plant's *introduction* must have been earlier still. The extension of the Introductory stage to begin in a climate that was probably more favourable than 1350, gives a greater period of climatic deterioration for responsive agricultural development to occur.

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1 Best 1925:47-119.
2 Firth 1959:79-83, 293.
3 Handy 1940:145.
4 Best 1925:75-85.
5 Best 1925:91.
6 Best 1925:48-52; Buck 1958:61-2.
7 Lutz and Simons 1958:1-42.
8 Best 1916:71-99.
9 Cooley 1951:383-5.
10 Sauer 1950:510.
11 Experiments on over-wintering of kumara plants outdoors were conducted at Otahuhu in 1957-58, 1958-59, 1959-60. Varieties grown were:—
(a) MAORI (purported to be pre-European varieties): *Rekamaroa, Hutihuti.*
(b) INTRODUCED: *Owairaka Red* and *Tauranga Red* (19th century introductions named by Maori as

Waina); *Porto Rico* (common variety grown in U.S.A.).
In the three years' experiments, plants raised in hot beds in September were planted outdoors in November and December plantings. Growth stopped in April in all cases and plants killed by frosts in mid-May.
In 1960, plants of the five varieties were late planted in January. The same result of May killing was observed. Edible roots recovered from these plants did not store, rotting shortly after digging.
12 Experiments on kumara growing at Lincoln, South Island, in 1956-57, 1957-58, 1959-60, produced the following data:
Yields (in lbs./plant) of edible roots harvested at Lincoln compared with Otahuhu:

LOCATION AND PERIOD OF PLANTING TO HARVEST						
VARIETY	LINCOLN			OTAHUHU		
	1956-57	1957-58	1959-60	1956-57	1957-58	1959-60
	Nov-Mar	Nov-Apr	Dec-Mar	Nov-Apr	Nov-Mar	Dec-Mar
Rekamaroa	2.1	.3	Nil	2.9	2.7	1.9
Hutihuti	2.1	Nil	Nil	2.5	2.0	1.6
Owairaka Red	3.0	.5	Nil	3.1	3.1	2.1
Tauranga Red	2.6	.7	Nil	3.2	3.4	2.3
Porto Rico	1.8	.4	Nil	2.9	2.6	1.5

The later planting of 1959-60 appears to have affected yields even in the Otahuhu experiment. In the Lincoln experiments, the plants were harvested when they were showing the effects of frost damage. The comparable Lincoln and Otahuhu yields of 1956-57 may be accounted for by the better-than-usual growing conditions at Lincoln of that year. The following meteorological records show minimum ground temperatures during March when root formation is in progress. These were higher in 1957 than in the other years of the experiments:

	RAINFALL		MIN. GROUND TEMP. °F.	
Year	Period	Rain (ins.)	February	March
1956-57	Nov.-Apr.	11.87	31.8	31.0
1957-58	Nov.-Mar.	12.17	33.1	28.8
1959-60	Dec.-Mar.	9.75	32.5	24.7

13 Committee on Glaciers 1946:107.
14 Raeside 1948:153-71.
15 Raeside 1948:166-8.
16 Holloway 1954:329-410; Holloway in Golson 1957:273-5.
17 Holloway 1954:333.
18 McKelvey 1960.
19 Nicholls 1956:17-34.
20 Elder 1956:96-103.
21 Brooks 1949:359-78.
22 Schofield 1960:482-3.
23 Holloway 1954:333.
24 Raeside 1948:166-8.
25 Best 1925:16, 89.
26 Best 1925:65-7.

27 Best 1925:70.
28 Conklin 1957:99.
29 Author's field work, Baliem Valley, Netherlands New Guinea, 1958.
30 Best 1916:71-99.
31 Golson 1959:54; Lockerbie 1950:78.
32 Stack 1893:24-6.
33 Best 1925:61-2.
34 Dieffenbach 1843:25.
35 Lockerbie 1950:78.
36 Stack 1893:24-6.
37 Colenso 1880:13, 34-5.
38 Best 1925:55-8.
39 Best 1925:120-2.
40 Banks 1958:126.
41 Hooker, quoted by Best 1925:122.
42 Colenso 1880:16.
43 Best 1925:122.
44 Massal and Barrau 1956:12, 39.
45 A study of Pacific taro, including New Zealand varieties, is being made by Dr. R. C. Cooper.
46 Colenso 1880:15.
47 Best 1925:128.
48 Buck 1958:62.
49 Smith 1898:7.
50 Duff 1956:9, 11.
51 Golson 1959:62.
52 Golson 1959:45.