

# Agricultural origins in the Korean Peninsula

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The authors report the first direct scientific evidence for the beginnings of agriculture in the Korean peninsula.

*Keywords:* Korea, Chulmun, Mumun, archaeobotany, agriculture

## Introduction

The development of agriculture in Korea, as elsewhere, is an important part of landscape evolution and Holocene human adaptation and deserves study in its own right. Furthermore, Korean archaeology can help to clarify the mechanisms and timing of the spread of agriculture through Northeast Asia and the relative independence of developments in East Asia. In particular, Yayoi origins in Japan and the extent to which early crop production in Japan developed independently of mainland processes are open questions and dependent on a critical assessment of events in Korea. However, understanding agricultural origins in Korea has been handicapped by a reliance on circumstantial evidence and inadequate documentation. Whereas archaeobotanical data attest to the development of agriculture in neighbouring China and Japan, such evidence has been rarely collected in the Korean Peninsula (Korea). In consequence, little is known about early Korean agricultural history, except that between 1000 and 500 BC there was intensive crop production focused on crops apparently introduced from China (Choe 1982: 526; Nelson 1991: 106).

We report here the first contextually clear and directly dated sequence of early crop remains recovered from Korea. Our research focuses on the Middle Chulmun through Middle Mumun periods in South Gyeongsang Province, ranging in date from c 3000 to c 1000 BC. The term 'Chulmun' refers to the incised decoration on pottery common at the time, and this period is usually considered the Neolithic of Korea. But in Northeast Asia, 'Neolithic' refers only to the presence of pottery with stone technology and has no necessary connection with agriculture. 'Mumun' refers to the plain ware that appears at the end of the Chulmun: it is a period of significant change in Korea which includes the introduction of metallurgy.

The archaeobotanical data reported here have been recovered from the Tongsamdong shell midden in Busan, the Daundong site in Ulsan, and several localities within a continuous stretch of the Nam River in Jinju (Oun 1, Okbang 1, 2, 4, 6 and 9, Sangchon B) (Figure 1). In the Nam River project, numerous pit-houses, exterior hearths, craft workshops, dolmens, stone-cist burials, and dry fields surrounded by ditches and palisades have been exposed in a

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400 ha area. In addition to documenting early coastal adaptation in Korea and contacts with Jomon cultures in the Japanese archipelago, the Tongsamdong site has played a key role in the development of the South Korean prehistoric chronology (Jeong 1997). Its assemblage includes Chulmun pottery, stone tools, Early to Final Jomon pottery and obsidian from Japan, shell ornaments, and composite bone fish hooks (Sample 1974). Other sites help to continue the sequence. Daundong is an early Middle Mumun occupation and burial site. Okbang is another Mumun community. Sangchon B and Oun 1 have both Chulmun and Mumun settlements. Flotation samples were collected from all the sites, although we were able to take only one sample each from Tongsamdong and Daundong. Crop remains comprise nearly 70 percent or more of the seed assemblage from the Middle Chulmun through Middle Mumun periods (Table 1).

## Dry-field crops

The results show that dry-field crops preceded wet-field production in the Korean Peninsula and continued to be important long after wet-field systems developed. The oldest examples are foxtail millet and broomcorn millet from Tongsamdong (for location see Figure 1), in a stratified sequence with a series of radiocarbon dates spanning the period from about 4800 to 1700 cal. BC (Sample 1974). Hoe-like stone tools appear in the Tудо phase suggesting that agriculture had begun at that time (Sample 1974: 118). The Tудо phase, at one time dated to 1700 cal. BC, is now dated to 3000 cal. BC (Middle Chulmun) (Shin 1997). Until now, plant remains had not been collected by flotation at Tongsamdong to test the hypothesis of Tудо phase agricultural origins. The single flotation sample, from floor fill of a Middle Chulmun semi-subterranean pit-house, has a millet density of six grains per litre. An AMS date of 3360 cal. BC on foxtail millet grains confirms their Middle Chulmun association (Figures 2C and 3).

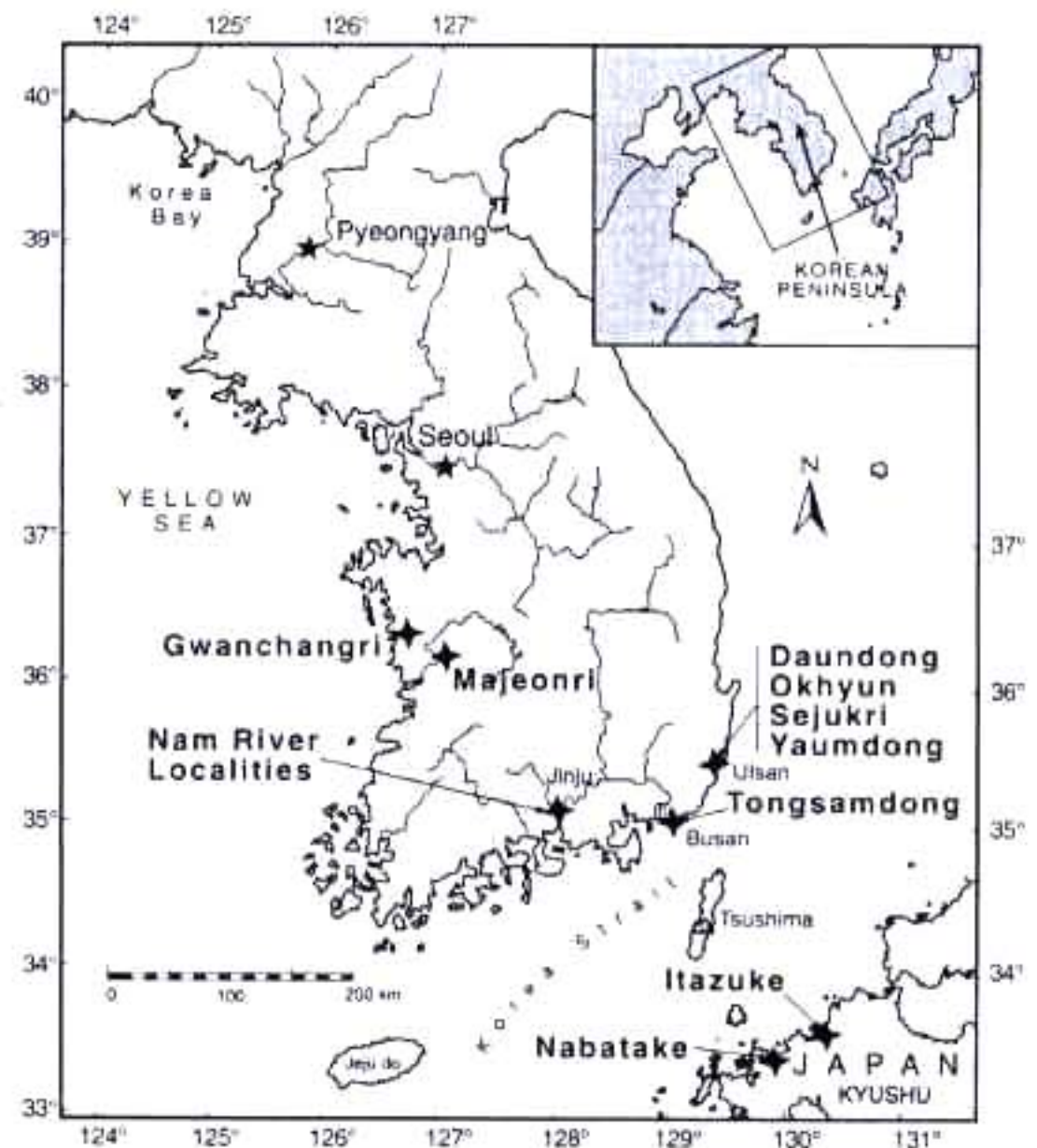


Figure 1. Map of the Korean Peninsula

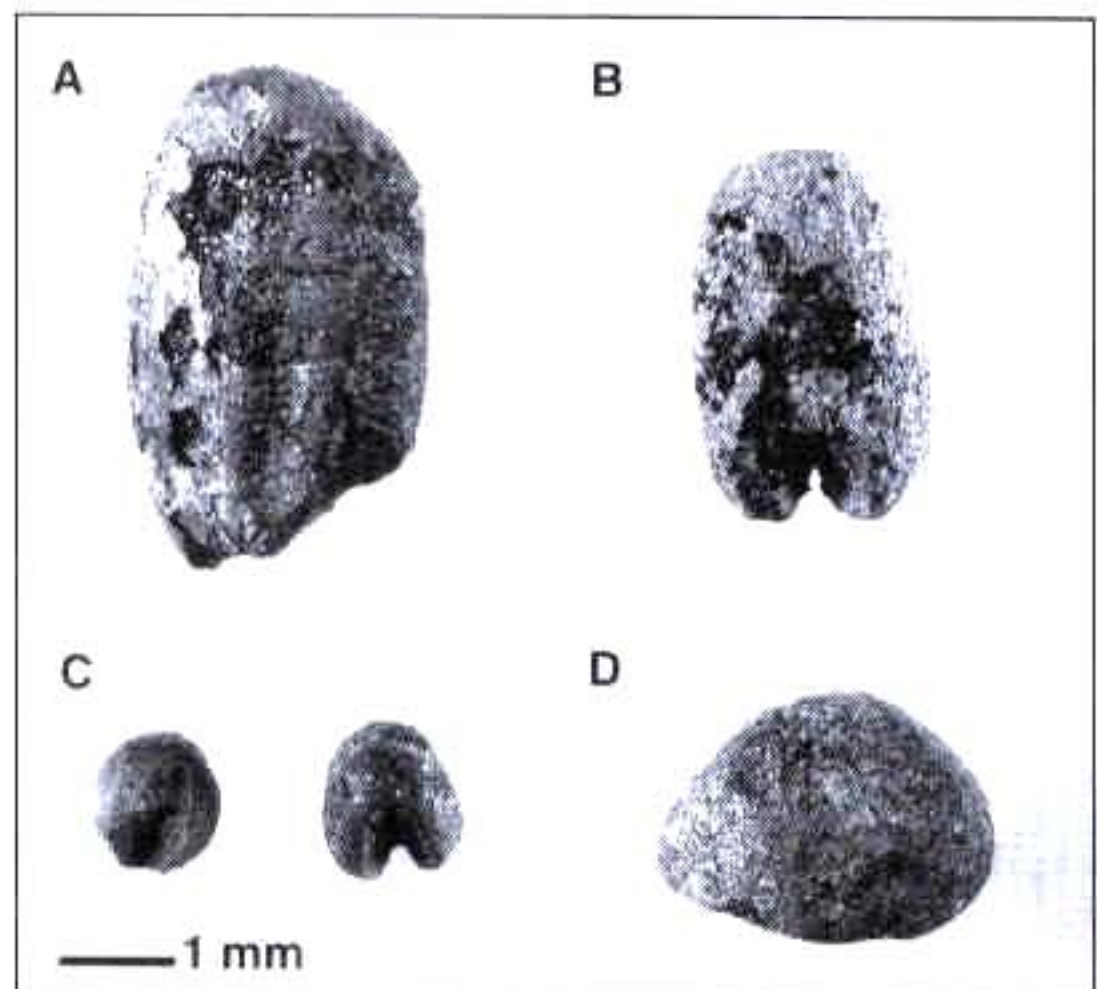


Figure 2. A) Rice from Okbang 1; B) wheat from Oun 1; C) foxtail millet from Tongsamdong and D) beefsteak plant from Okbang 1.



Table 1. Plant Taxa and Percent Representation in South Korean Flotation Samples

COMMON NAME	SCIENTIFIC NAME	CHULMUN	CHULMUN	EARLY	MIDDLE	MIDDLE
		TONGSAM-DONG	NAM R.	NAM R.	DAUNDONG	NAM R.
WILD/WEEDS						
fleshy fruit		0.4	1.9	0.8		0.1
azuki (probably)	<i>Vigna angularis</i> ssp. <i>nipponensis</i>		2.3	0.2		1.2
barnyard grass	<i>Echinochloa crus-galli</i>			A		
chenopod	<i>Chenopodium</i> sp.	36.8	0.9			0.9
foxtail grass	<i>Setaria</i> sp.	3.0	1.9	1.4		2.5
knotweed	<i>Polygonum</i> sp.	0.4	0.5	0.4		0.5
panic grass	<i>Panicum</i> sp.		5.1	1.4		0.7
panicoid grass	<i>Paniceae</i>	4.8	12.6	3.3	0.2	15.0
Other weeds		4.8	0.5	0.4		3.6
EAST ASIAN CROPS						
azuki	<i>Vigna angularis</i>				32.1	1.9
broomcorn millet	<i>Panicum miliaceum</i>	9.1	13.1	9.8	0.8	6.4
foxtail millet	<i>Setaria italica</i> ssp. <i>italica</i>	35.5	46.3	71.5	7.8	48.4
soybean	<i>Glycine max</i>			0.1	46.5	4.6
rice	<i>Oryza sativa</i>		A	5.9	12.7	3.7
shiso/egoma	<i>Perilla frutescens</i>			0.3		0.5
WEST ASIAN CROPS						
barley	<i>Hordeum vulgare</i>			0.4		0.4
bread wheat	<i>Triticum aestivum</i>			1.2	A	2.1
UNKNOWN		5.2	15.0	2.8	0.1	5.6
TOTAL NUMBER		231	214	2239	4616	1072

A: less than 0.1 percent

Lab Number: BP

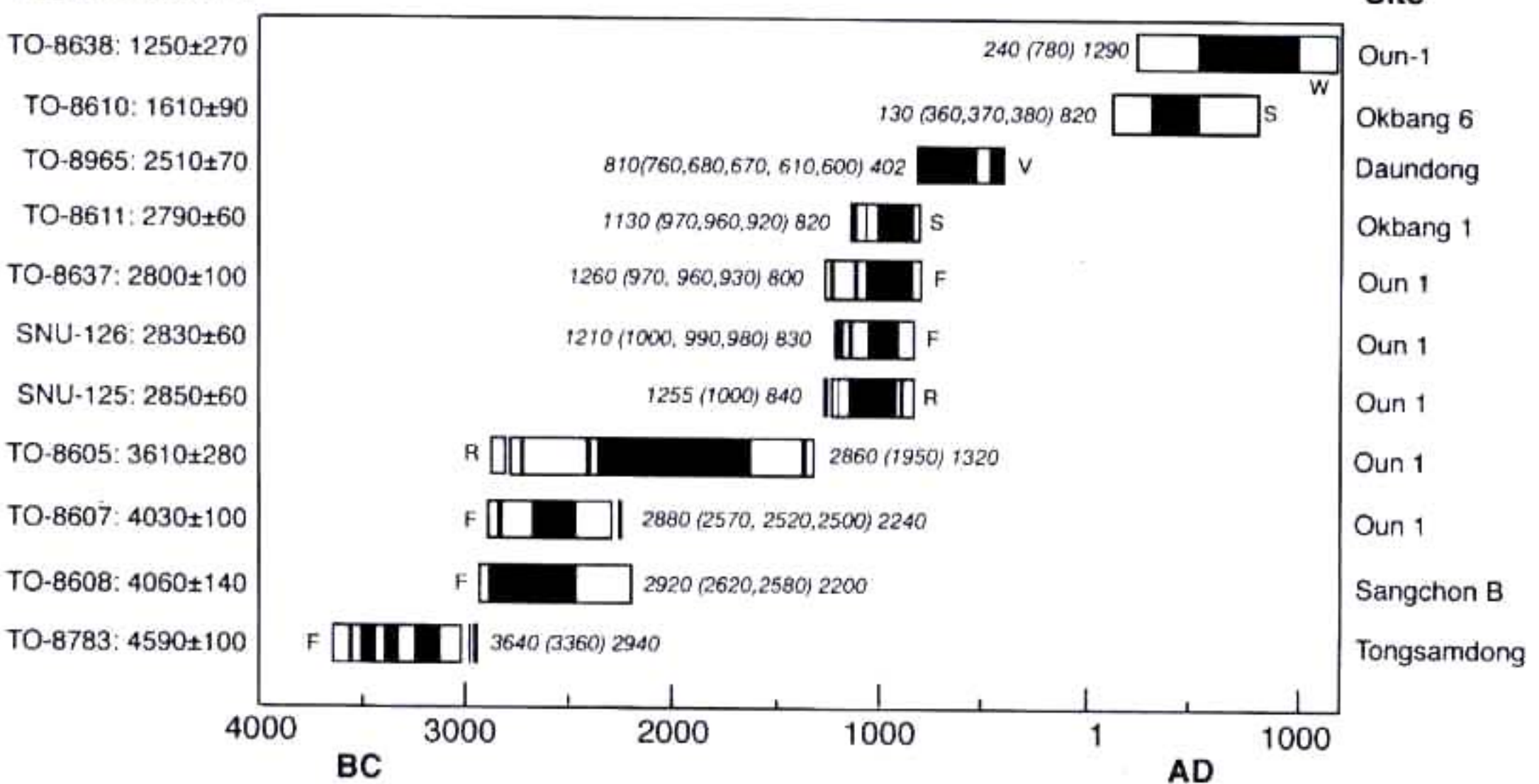


Figure 3. Calibrated AMS dates: white box represents 2 sigma range; grey box represents 1 sigma range. F: foxtail millet, R: rice, S: soybean, V: Vigna, W: wheat.



Daundong and Okbang have produced the earliest substantial archaeological specimens of soybean and *Vigna* sp. from early East Asia (Table 1 and Figure 3). Soybean recovered from Okbang 1 dates to 1000 – 900 cal. BC and *Vigna* from Daundong to 760–600 cal. BC.

Domesticated soybean has high diversity due to the large number of land races (Hymowitz & Singh 1987) so we are unable to link the archaeological remains to a specific soybean type based on seed morphology. The wild ancestor of soybean, *Glycine soja*, is common in northeast China, Korea, and Japan (Hymowitz & Singh 1987) but the Daundong *Glycine* (Figure 4A) is not *G. soja*. Its morphology is within the range of domesticated soybean, *G. max*, and indistinguishable from later soybean from Okbang 6. The soybean revolutionized Late Zhou Chinese agriculture following its introduction from the northeast apparently in 664 BC (Ho 1977: 452). Archaeological soybean appears in Japan during the Yayoi period and post-dates 400 BC (Crawford 1992: 28). The Daundong sample is from floor fill collected from the eastern portion of a pit-house of the Middle Mumun period, with a seed density of 660 per litre. The high density of soybeans from a house floor substantiates the economic importance and utilization of soybean during the Mumun. The AMS dates support Ping-Ti Ho's hypothesis that soybean was domesticated by, and economically important to, peoples in or near the Manchurian Plain (Ho 1977: 452, 454). Our results indicate that the region of early soybean importance includes Korea.

The role of *Vigna* in early Chinese agriculture is not known but it has an archaeological record in Japan starting in the Early Jomon. Originally thought to be mung bean (*V. radiata*

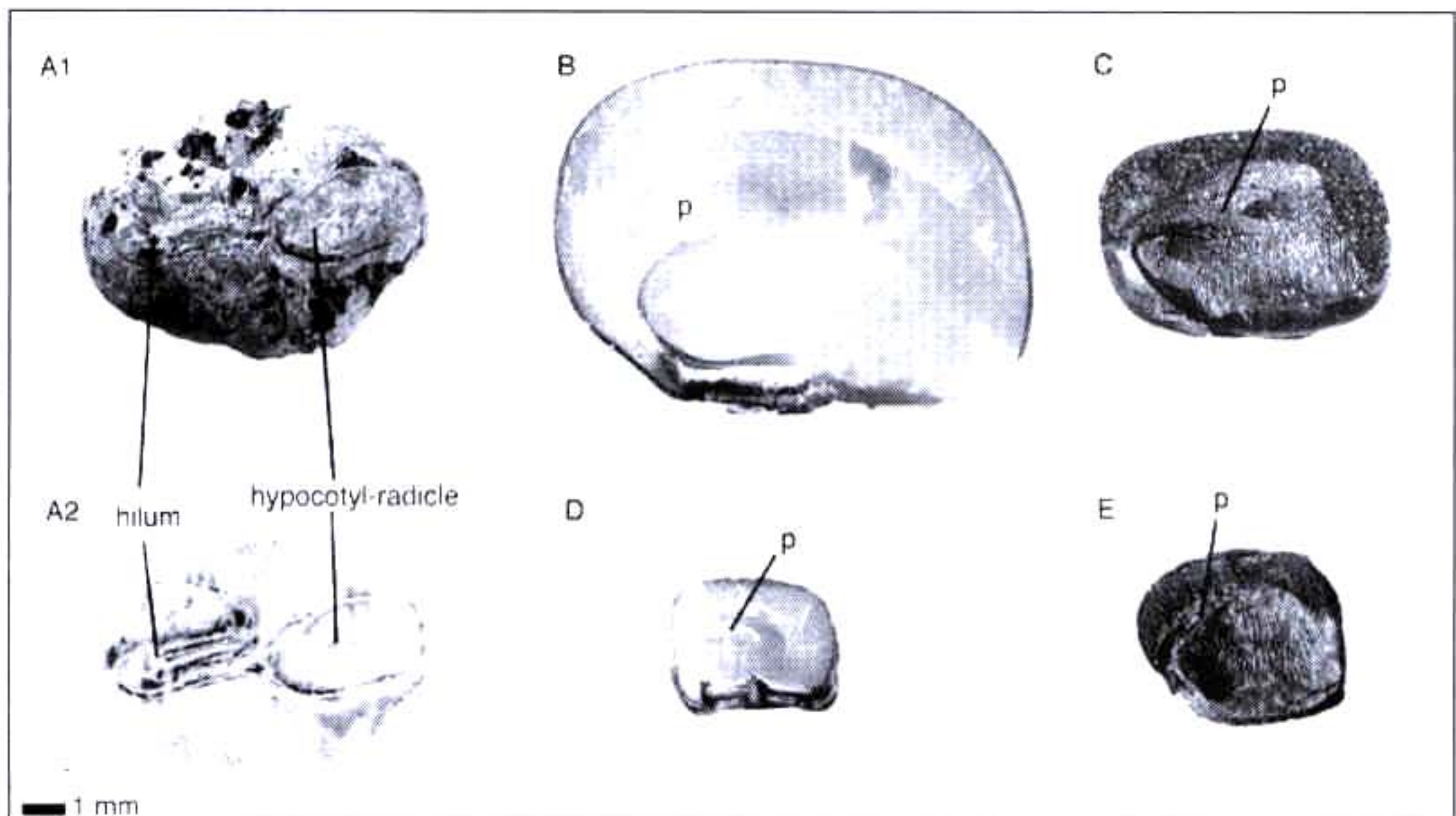


Figure 4. The archaeological soybean specimens, ventral view (A1 and A2), exhibit wide variation from flat-ovate to ovate in cross-section. Clearly visible on many specimens is the hypocotyl-radicle (embryonic stem and root) and hilum. The mean dimensions of the soybeans are 7.3 mm long ( $n=323$ ), 5.2 mm in breadth ( $n=302$ ), and 4.3 mm thick ( $n=186$ ). B) is modern reference azuki; C) is a charred reference mungbean; D) a modern *Vigna radiata* (mung bean) cotyledon E) is a *Vigna* cotyledon from Daundong. The plumule-hypocotyl (embryonic leaves and stem) shape and size relative to the cotyledon appear to distinguish East Asian azuki from the South Asian mung bean (*Vigna radiata*) (Yoshizaki 1992). The morphology of the archaeological *Vigna* specimens resembles that of azuki rather than that of the mung bean.



var. *radiata*), the Jomon period *Vigna* is more likely azuki or wild azuki (*Vigna angularis*) (Crawford 1992: 26, 30). The specific identification of the archaeological *Vigna* specimens is not clear (Figures 4D and E) but they seem to be azuki whose ancestor (*Vigna angularis* ssp. *nipponensis*) is indigenous to East Asia (Yamaguchi 1992). Domesticated azuki, like soybean, has larger seeds than its wild ancestor. We hypothesize that selection for the large azuki beans common among cultivars today had not yet occurred. The Daundong beans show a wide range of size between specimens of wild and domesticated azuki (Figure 5) consistent with being an early domesticated variety.

A form of dwarf bread wheat with seeds smaller than those from any other compact variety is present in archaeological collections in Japan and early historic Korea (Crawford 1992: 26). Wheat is present no earlier than the Yayoi period in Japan (Crawford 1992). The oldest Korean wheat is associated with millet and rice AMS dated to ca.

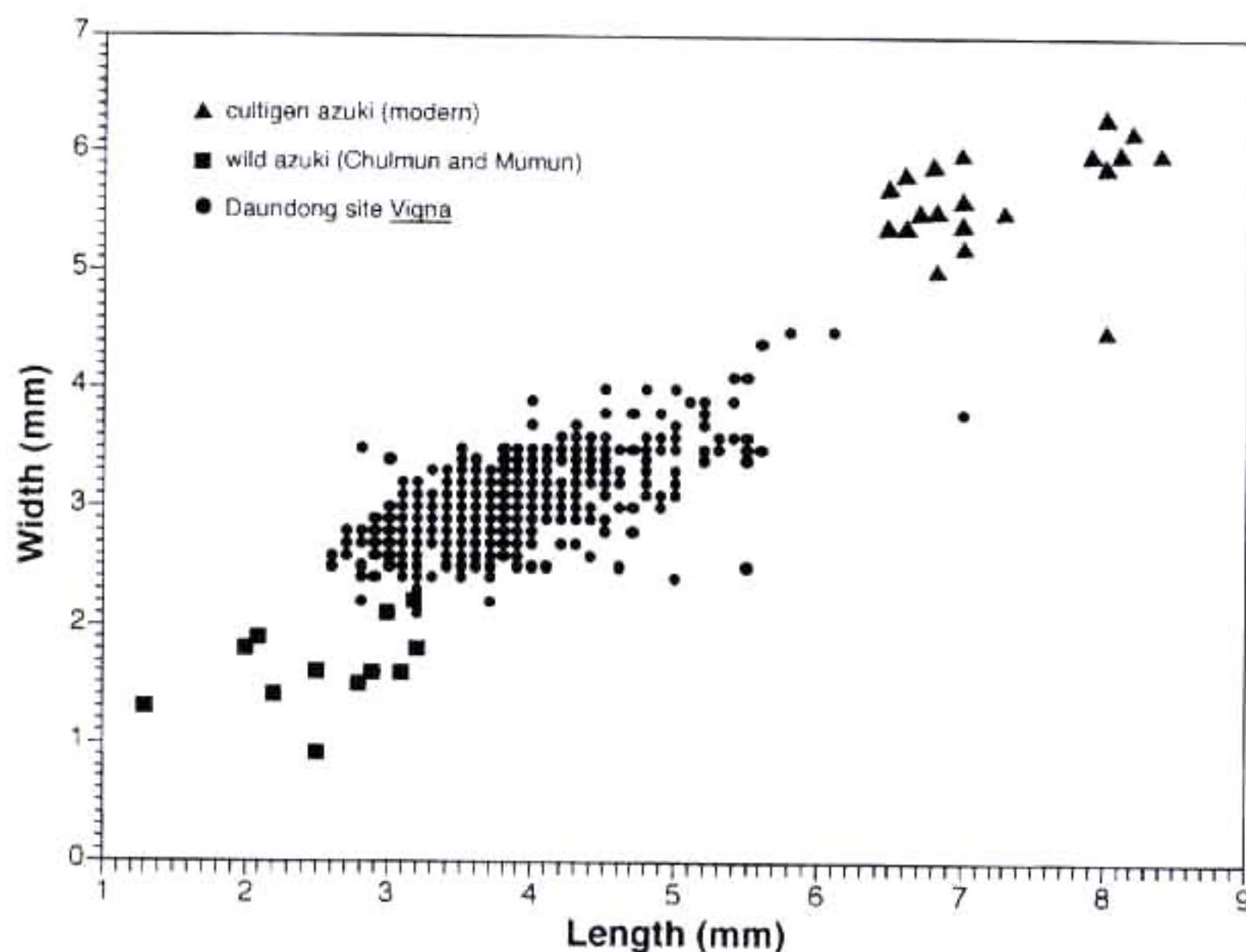


Figure 5. Plot of length vs. width of *Vigna* from Daundong. The size of the Daundong *Vigna* specimens is extremely variable. None are as large as modern domesticated azuki. The *Vigna* appears to be one species with highly variable cotyledon size. Mean length is 3.8 mm ( $n=653$ ) and mean width is 3.0 mm ( $n=652$ ).

1000 cal. BC in Mumun contexts at Oun 1 and Okbang 1 (Table 1 and Figure 2). The wheat grains in the Nam River project samples, averaging 3.9 by 2.5 by 1.9 mm, are the same extremely compact bread wheat reported in Japanese assemblages (Crawford 1992).

Beefsteak plant (Table 1 and Figure 2) is another potential member of the Early/Middle Mumun crop complex in the Nam River. Beefsteak plant is grown today for its aromatic leaves, oil seeds and its medicinal properties in China, Japan, and Korea (Crawford 1992: 28). Although the main area of the plant's diversity is China, no evidence for it has been recovered from Chinese archaeological sites (Crawford 1992). In Japan, seeds of beefsteak plant have been reported from Early through Final Jomon sites (Kasahara 1983; Matsutani 1983: 183).

Excavations in the Nam River research area have exposed 1.8 ha of dry fields. The fields date to the Early and Middle Mumun as well as the Three Kingdom period based on associated artefacts, structures, and stratigraphy. The fields consist of pairs of ridges and furrows 20 to 80 cm wide. Dry fields were located in the floodplains along the large rivers (Lee & Lee 2001). Foxtail and broomcorn millet, legumes, barley, wheat, and beefsteak plant remains



have all been recovered from Early and Middle Mumun houses and hearths near the dry fields.

## Wet-field agriculture

Rice remains are reported from over 50 sites in Korea (Ahn 1996) and occur in many of the sites in this study. Undated rice caryopses from non-cultural layers in peat in central Korea, large Poaceae pollen grains, and *Oryza*-type phytoliths in archaeological contexts suggest rice cultivation in Korea as early as 1500 to 3000 cal. BC (Im 1990; Kim & Lee 1997; Kim 1980; Kwak *et al.* 1994; Lee & Park 1997). Pollen is weaker evidence than charred grain for the presence of domesticated rice because all grass pollen is morphologically similar (monoporate), pollen is not yet directly dateable, and wild rice may have a long history in Korea (Crawford & Shen 1998). Domesticated rice phytoliths are distinguishable from wild or weedy rice only on the basis of statistical analysis of substantial samples of specific types of phytoliths (Zhao *et al.* 1998); phytoliths cannot yet be directly dated. Rice (kernels and separate husks) has been reported together with foxtail millet, barley, wheat, hemp, and a legume from a pit house floor at the Middle Chulmun site at Daecheonri, North Chungcheong province in central Korea (Han *et al.* 2002). The specimens were carbonized except for the rice husks. Radiocarbon dates of  $4240 \pm 110$  BP,  $4400 \pm 60$  BP,  $4490 \pm 40$ , and  $4590 \pm 70$  BP (ie c 2500–2200 BC) have been obtained from associated charcoal, but direct AMS dating of individual grains would be advisable and published photographs of the specimens suggest that the identification of hemp and legume is problematic. The uncarbonized rice hulls suggest these plant remains are more recent than the Middle Chulmun.

Two AMS dates of 1950 and 1000 cal. BC on rice grains from Oun 1 are the first direct evidence for the antiquity of rice in Korea (Table 1 and Figure 3). The 1000 cal. BC date is contextually consistent with the Early Mumun context in which it was found. The older date is also from an Early Mumun pit-house but the date is consistent with Late Chulmun. Oun 1 is intensively occupied and rice grains found in Mumun pit-houses may be residual from the earlier Chulmun contexts they were cut through. Indeed, Late Chulmun pottery has also been found in this Early Mumun house. However, no rice has been recovered from unequivocal Chulmun contexts at Oun 1.

Early and Middle Mumun rice appears to have been grown in paddy fields. Among the ten archaeologically identified paddy fields found in Korea, the two oldest are the Early Mumun Okhyun and Yaumdong sites in Ulsan (Figure 1; Lee & Lee 2001). The sites are in narrow valley flats at the base of low hills (Kwak 2000). The Mumun inhabitants took advantage of the high ground-water level in the valleys and running water from higher elevations. Artificial reservoirs and irrigation canals appear during the Middle Mumun (Lee 2000). At the Majeonri site, a reservoir was created near the bottom of a hill, but elevated higher than the field to facilitate a gravity-fed irrigation system (Lee 2000). At the Gwanchangri site, five reservoirs were constructed along small streams. None of these are associated with large floodplains. Later historic rice fields have been found not only in the narrow valley flats but also in back-swamp areas and floodplains along large rivers, requiring advanced water control techniques (Lee 2000).



## Nuts

A prevailing view is that nuts were the mainstay of Korean Chulmun, as well as the Japanese Jomon diets. However, during the Jomon in south-western Hokkaido, Japan, nuts are common in the archaeological record until about 4000 cal. BC and subsequently became less common, while annual grasses and weedy grain plants including a probable local domesticate, barnyard millet (*Echinochloa utilis*), came into use (Crawford 1983). Few nut remains have been recovered in our Chulmun samples. With the exception of one sample at Obkang 4, Mumun assemblages have not produced nut remains either. In contrast, charred nuts in addition to small seeds are common at the waterlogged Early Chulmun Sejukri shell midden (5400 to 4600 cal. BC) (Kim, Yoon & Ahn 2002) currently undergoing study. The sequence is thus similar to that in north-eastern Japan and may indicate the onset of agricultural production.

## Discussion

The directly dated examples of early cultigens from Korea can be placed in context by briefly noting their occurrence in the neighbouring territories of China and Japan. Foxtail and broomcorn millet, and rice, all domesticated in China, were of some significance there by 7000–6000 cal. BC (Early Neolithic) (Crawford 1992; Crawford & Shen 1998). Late Neolithic compact wheat from Donghuishan, Gansu Province has been directly dated to 2880 calendar years BC (BA92101: Gansu Provincial Institute of Cultural Relics 1998: 190), and barley may appear at about the same time in China (Crawford 1992) although actual remains have not yet been found. Rice was domesticated in south-central China (Crawford & Shen 1998) while millets originated in the north (Crawford 1992).

Rice, foxtail and broomcorn millet are present in north-eastern Japan by 900 cal. BC (D'Andrea *et al.* 1995), so connections with the mainland were occurring sometime before that. Less is known about the sequence of events in Kyushu, but at least two sites, Nabatake and Itazuke (Figure 1) have produced evidence of relatively intensive agriculture by 300 cal. BC. Millets appear to have been present at Nabatake between 1000 and 400 BC (Crawford 1992).

The new Korean data are consistent with a time-transgressive model with the earliest barley, broomcorn and foxtail millet, rice, barley, and wheat appearing first in China, then in Korea and then in Japan. The Korean Middle Chulmun period is roughly contemporaneous with the Chinese Late Neolithic so crops were certainly available to Korean populations at that time. Beginning in the Middle Chulmun complex diffusion processes probably resulted in the introduction of these Chinese and West Asian crops to the Korean Peninsula. Our study confirms that the two varieties of millet were established no later than 3400 cal. BC (Middle Chulmun) in the southern Korean Peninsula. Millets were probably available throughout Korea before then because Tongsamdong is at the south-eastern extreme of the Korean Peninsula, over 700 km overland from the likely source of the crop in north-eastern China. Furthermore, at least ten weed taxa including grasses appear in samples from the Middle Chulmun and later (Table 1). The new data indicate that Middle Chulmun people had a mixed economy that included gathering plants, fishing, and hunting. This appears to have changed little through the Late Chulmun as evidenced by the Nam River data. We suggest rice as well as millet was grown during the Late Chulmun, but the evidence needs



strengthening. Middle and Late Chulmun cultures exhibit little, if any, significant alterations suggesting crops helped maintain Chulmun lifeways rather than alter them. The earliest crops in Archaic period North America and Jomon period Japan also seem to have helped maintain existing economic systems while imparting no obvious immediate changes.

Significant culture change did not occur until the Mumun period when azuki, barley, beefsteak plant, millet, soybean, wet-rice production, and wheat appear. Azuki and soybean may have been secondary domesticates after the introduction of millet production, or they may have been introduced from as yet unidentified locations. For now, the only substantial archaeological evidence for early soybean and azuki is from Japan and South Gyeongsang Province, South Korea. The Early Mumun, like the Yayoi in Japan, represents agricultural intensification rather than origins.

The evidence from Tongsamdong shows that obsidian and pottery were exchanged between Korea and Japan throughout the life of the settlement, so crops may have been included in the exchange system as well. But we do not rule out indigenous plant management leading to domestication of indigenous crops in either Korea or Japan. The case for barnyard millet has already been made (Crawford 1983). Flotation samples from earlier Jomon contexts in Kyushu are needed, and the contexts of azuki, beefsteak plant, and soybean need further study.

How agriculture developed in Korea and Japan is still an open question, but it certainly involved diffusion from mainland East Asia. Korea is thus a secondary region of agricultural origins. The best examples of this process outside Asia are in northern Europe, the southwestern U.S. and north-eastern North America where agriculture developed at different rates and in cultural settings with varying degrees of mobility (Smith 1998). In Korea and Japan, factors underlying primary agricultural origins such as association with resource-richness, proximity to aquatic resources and low residential mobility were all operating when crops were first in use.

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