Ninevite 5 Period Agriculture at Tell Leilan: Preliminary Results*

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Introduction

The Ninevite 5 period was a time of dramatic change at Tell Leilan in northeastern Syria (see Calderone and Weiss, this volume). The archaeological record documents exponential growth; starting with a community of approximately 15 hectares in the early 4th millennium B.C., Tell Leilan expanded to 90 hectares by the mid 3rd millennium B.C. This massive growth was undoubtedly accompanied by far reaching alterations in nearly all aspects of Leilan life, particularly food production. Provisioning an ever expanding population may have been accomplished by casting the food net farther and wider (Weiss 1986: 95; Stein and Wattenmaker, this volume), as well as intensifying dry-farming in order to produce larger harvests.

Leilan's agriculture and its transformation during the 3rd millennium is the focus of an on going study involving plant remains from the site. This paper details preliminary results of work on materials recovered during the 1987 excavations of the Tell Leilan Acropolis where Ninevite 5, Leilan period III, deposits have been studied (see Mayo and Weiss; Calderone and Weiss, this volume). Archaeological plants, consisting of the remains of fruits, seeds, and other structures, provide direct evidence of crops and their accompanying field weeds, as well as wild flora used for fuel, food, dyes, medicine, construction, and matting. When properly "read" these "documents" of ancient agricultural practices can provide information about the crops that were raised and how the fields were managed.

At this point, however, the samples are too small and the contexts too few to give us more than a tantalizing glimpse of Leilan farming from which we can formulate hypotheses for future testing. They hint at changes during Leilan period III, which may have entailed intensifying agriculture by expanding the acreage under cultivation. They also suggest that Leilan's farming strategies may have been quite different from those in southern Mesopotamia although basically the same crops were grown in both areas. Such might be expected as dry-farming in the north and irrigation agriculture in the south were fundamentally different in a number of respects (Weiss 1986: 72). In the south limited areas were irrigated and farmed, producing very high yields per unit area. In the north extensive areas were put under cultivation; high aggregate yields were possible but there was also a high risk of loss. Rainfall levels are, on average, adequate to sustain crops over much of the Habur Plains but because of the high inter-annual variability dry years and lost crops are common (Weiss 1986: 97). Leilan farmers would have needed to cover themselves for these uncertainties. Their goal would have been to minimize risk while maximizing yields (*ibid.*), which probably became increasingly important as the community expanded. It appears that Leilan farmers may have tried to hedge by planting three different cereals, emmer wheat, durum, and hulled 2-row barley, possibly selecting the most appropriate one for the different soils they faced in their extensive fields. Each would have had a different range of tolerances which would have increased the chances that some crop would have survived no matter what the weather. In southern Mesopotamia, on the other hand, the focus was primarily on a single highly reliable, productive crop, 6-row barley, while wheats played a minor role (Powell 1985: 19).

Archaeological plant remains and recovery techniques

The only plant remains that were recovered from Leilan during 1987 and previous field seasons were carbonized specimens. Unless charred, seeds and fruits usually decompose in moist environments, such as northeastern Syria. Partially burned, however, plant materials do not support microbial growth, but they do retain many of the original anatomical and morphological features, making genus and often species identification possible.

Charring takes place in a number of ways. The most common is in household hearths during heating, cooking, and other food processing activities such as parching grains. Occasionally bulk stores of crops are

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charred in a conflagration. Much of this burned material finds its way into middens, while some is scattered on house floors or dispersed through other deposits.

In order to recover charred seeds and fruits, more than troweling and hand-picking are called for. Most of the remains are too small to be noticed, let alone picked out during excavation. Nowadays samples of the deposits are first removed; then charred plants are recovered from these sediments by means of flotation, a water separation process.

At Tell Leilan a simple bucket technique was used for flotation in 1987. Samples of sediment, ranging from one to 10 liters, were systematically collected during excavations in Operation 1. The sediment was poured into a bucket of water and after a minute or two, the flotate, consisting of charred plant fragments and other porous material, was poured off the surface onto cheese cloth set over a strainer. After drying in the cloth, the sample was transferred to bags or boxes for shipment and storage.

The samples were examined at the Harvard Botanical Museum using a low power dissecting microscope. After all identifiable material was separated from the flotation samples, they were identified by comparing their morphological and anatomical features, noted earlier, with modern reference specimens and published descriptions of archaeobotanical remains (van Zeist 1970, 1972; van Zeist and Heeres 1973; van Zeist and Bakker-Heeres 1975, 1982, 1985).

Content and context of the Tell Leilan samples

Sixteen flotation samples, representing about 43 liters of sediment, were processed for this study and produced roughly 2,500 identifiable items, as shown in Table 1.

Chronologically, these samples represent: 1) the early part of the Ninevite 5 period: Leilan period IIIa, strata 39 and 37, and Leilan period IIIb, strata 25-28, and 2) the terminal Ninevite 5 period, Leilan period IIId, strata 15f-d and 15b (see Calderone and Weiss, this volume).

The samples derive from three different contexts:

1) The strata 39 and 25-28 samples, which consist mainly of cereal spike fragments and weed seeds, are all from ash deposits associated with ovens.
2) The period IIId materials, also consisting mainly of cereal debris, are from two middens:
   a) stratum 15b samples from trash dumped on a courtyard, and
   b) stratum 15f-d samples from trash of a roughly similar composition discarded on room floors in an adjacent structure, Building 1.
3) The other early Ninevite 5 samples, from stratum 37, consisting primarily of cereal grains, were taken from thick lenses of ash containing carbonized grains and littered with sherds.

All of the samples, with their preponderance of cereal debris or grains, were probably related to processing and storing of cereal crops. To gain some insight into what stages of cereal processing they might represent, they were compared with a detailed model of grain processing developed by Gordon Hillman (1981a, 1984a, 1984b, 1985). Working in Turkish villages where wheat and barley were still cultivated and processed by archaic methods, Hillman carefully followed the crop from harvest to food preparation, recording the products and by-products of each operation, noting particularly how an archaeobotanical record might be generated. He found that the "principal components of each product are sufficiently different (both in type and in their relative abundance) for charred remains of different products to be readily distinguished" (1984a: 12).

The first two groups of Leilan materials (strata 39, 25-28, 15f-d, and 15b) closely match the by-products of fine sieving and hand cleaning in Hillman's model. Fine sieving, which follows threshing and winnowing, removes, by means of a sieve, quantities of glume bases, rachis segments, and some spikelet forks, as well as tail (under-sized) grains and a large number of small weed seeds. Hand sorting, the final picking over before the grain is ground or cooked, removes the last remaining spikelet forks, glume bases, and weeds, most of which consist of seeds the same size as the grains. These final stages of cleaning are often done in the household and the resulting by-products, the "cleanings", are used as fodder or thrown into domestic fires (Hillman 1984a: 4 f., 1984b: 133, 145).

The first two groups of Leilan samples, like "cleanings", consist largely of glume bases and rachis segments; the ratio of grain to chaff is 1:17 in both stratum 15 samples, 1:15 in stratum 39, and 1:7.4 in strata 25-28, as shown in Table 2. Most of the wild seeds fall easily within the category of fine-sieving by-products since they are small; that is, they have a dimension less than 1.5 mm which would allow them to slip through a fine sieve (Jones 1981: 107). The remaining weed seeds match the criteria for by-products of the final cleaning done by hand sorting. They are grain-sized or slightly larger, such that they would probably not have been removed either with the large mesh coarse sieves or with fine sieves.

The pulses in these samples may have also been hand sort discards or possibly the dregs or spills of legume processing. Pulses are not uncommon contaminants of cereal grains since they may sprout in wheat or barley fields if they had previously served as a rotation crop (Keen 1946: 63). Because of their size lentil seeds would remain with the crop until final cleaning.

The dregs from grain processing represented in these samples may have been used as fuel or discarded in hearths. In the stratum 39 samples, ash associated with ovens, the "cleanings" may have served as fodder, which was in turn burned as fuel. The samples from this stratum appear to have been at least partially derived from dung fuel. They were rich in *Prosopis* (see Table 1), an important fodder for sheep and goats during the summer when this spiny legume covers great tracts of land (Townsend and Guest 1974: 41). The large seeds, which pass through the digestive system undamaged (*ibid.*), are usually brought into villages only through animal dung (Hillman n.d.). Since the plant flowers and fruits after the winter crops are harvested it would not occur as a grain contaminant.

The third group of Leilan materials, the stratum 37 samples, are strikingly different as they have almost no rachis segments or glume bases, except for some of emmer; the grain to chaff ratio is only 1:0.1. The samples, consisting mainly of whole and fragmented grains and pulses with some weeds, appear to be semi-clean grain from bulk storage. According to Hillman (1981a: 131 f., 1984a: 8, 1984b: 130-33, 1985: 10) cereal grains are stored in Near Eastern villages after having been threshed, winnowed, coarse-sieved, and lightly fine-sieved. This semi-clean grain is still contaminated by a few emmer spikelet forks, dense chaff fragments, and small and grain-sized weed seeds (Hillman 1984b: 133 f.). Hillman (1984a: 34) found there is generally "well *over* one weed seed to 20 grains" in semi-clean bulk stored cereals. The stratum 37 samples were still quite weedy with a grain to weed seed ratio of 1:1, as shown in Table 3.

The pulses in the stratum 37 samples provide further evidence that this material is from a burned storage facility. They are exceptionally abundant here, with a pulse to grain ratio of 1:3, which is more than twice as frequent as in the other strata. In archaeological deposits legumes are usually scarce because they have little chance of being charred. They require relatively little processing, generate scant waste, and rarely come in contact with fire. Most often pulses are simply cooked in water to a soft mass. They are charred only under special circumstances: for example, if dry pulses were spilled in cooking or prepared by parching, or went up in flames in a room or house fire. Small quantities might end up in a household fire if they had been contaminants of cereal crops, as noted above.

Tell Leilan farming

The two types of deposits, food stores and by-products of hand sorting and fine sieving, should offer complementary information about Leilan's crops. The bulk food remains, as actual food products, once destined for consumption, should provide data about the crops directly, while the "cleanings" are an indirect source of information on not only grain processing methods but also on husbandry techniques applied in the field. Although the sample is small we can cautiously explore 1) the crops and farming strategies and 2) changes in agriculture during the Ninevite 5 period as reflected in the weed flora.

The view of Leilan's economy that emerges from the stratum 37 food store samples is at odds with what is known of approximately contemporary Mesopotamian agriculture from the south. Barley, the major cereal of irrigation farming in southern Mesopotamia (Powell 1985: 19) was outnumbered by emmer and free-threshing wheat, with a ratio of barley to wheats of 1:1.6 (see Table 2). Free-threshing wheat, scarce in the south (Powell 1984: 56), was more abundant than emmer in the stratum 37 samples, with an emmer to free-threshing wheat ratio of 1:1.7. It should be noted, however, that distortions in the grains caused by charring make it difficult to distinguish the two wheats. Nonetheless, even if 20% of the grains identified as free-threshing wheat were actually emmer, this wheat would still be as abundant as emmer. Only with a very large error in identifications could it be considered scarce in the stratum 37 sample. We do not know, however, how representative this sample is of Leilan agriculture since it comes from probably no more than two fire episodes in a storeroom.

The other Leilan Ninevite 5 samples, unfortunately, offer no additional evidence. Their wheat and barley ratios show no consistent pattern, while traces of free-threshing wheat are scarce. It is not particularly surprising, however, that the proportions in these samples are so different from stratum 37. As grain processing debris, these materials reflect the amount of chaff on the cereal head and how it is processed, but they are not necessarily a good indication of its role in the economy.

The hulled wheats have a higher probability of leaving an archaeological record than the free-threshing wheats for several reasons. The grains are separated from the glumes only after a long, laborious process involving pounding, and repeated winnowing and sieving (Hillman 1984a: 5). Large quantities of glumes, tough glume bases, and rachis segments are discarded through all stages of processing and sometimes burned (Hillman 1984b: 131, 128). In contrast, free-threshing wheat separates freely from its chaff which is removed along with the light straw in the first round of primary winnowing (Hillman 1984b: 128). Thus it may be grossly underrepresented in comparison to emmer.

Barley is probably underrepresented, as well, in some kinds of archaeological deposits for similar reasons. Barley has less rachis debris than emmer, most of which is separated in the early stages of grain cleaning. In addition, the hulls, which are chemically fused to the grains, are not removed during cereal processing, although they may later be stripped using a mortar and pestle (Hillman 1985: 20). As a result barley rachis segments are usually far less abundant than emmer chaff, as is the case in the Leilan samples. Even in the samples where barley grains outnumber emmer, barley rachis segments are still in the minority. In short, the archaeological record from the grain processing debris cannot be taken at face value. Grain stores, however, should provide some handle on the relative importance of the cereals, if the samples are large and representative. In the future we hope to increase the size of the sample to resolve these issues. For now we can only raise the possibility that rainfall farming in northern Mesopotamia was distinctly different from irrigation agriculture in the south; the wheats, especially free-threshing wheat, may have played a more important role in the Leilan economy than they did in southern Mesopotamia.

Another difference between Leilan and southern Mesopotamian agriculture is in the barley varieties grown. While 6-row barley dominated the irrigated plains of the south (Charles 1984: 27, 30), Leilan appears to have cultivated the 2-row variety. The dominant barley of the dry-farmed upland regions of Iraq, 2-row barley may have been better adapted to the rigors of rain-fall agriculture (*ibid.*). Very few of the Leilan grains show any evidence of twisting, a diagnostic of 6-row barley grains. In the 6-row form about two-thirds of the grains in a head are asymmetrical as the two lateral grains must twist to conform to the spikelet while the central one can grow straight. In 2-row barley, on the other hand, only the central floret develops, resulting in a head made up entirely of symmetrical grains. Nearly all the Leilan barley grains appear to be more or less symmetrical while the few that are twisted appear to have been distorted by charring rather than growth.

The type of free-threshing wheat grown at Leilan appears to have been durum (*Triticum durum*), but we do not know if this is the same wheat that was grown in southern Mesopotamia. Durum, adapted to the Mediterranean climate with its mild, rainy winters and hot, dry summers, was purported to be, until recently, the most important wheat cultivated in the Mediterranean basin (van Zeist and Bakker-Heeres 1982: 199). Another naked form, bread wheat (*T. aestivum*), was also raised in the ancient world and is often identified among archaeobotanical remains, including southern Mesopotamian materials. These identifications, however, may not necessarily be correct as bread wheat and durum are difficult to distinguish; they cannot be separated on the basis of grain morphology. Their rachises cannot be sorted out either unless they belong to one of the extreme forms which have highly distinctive characteristics (Hillman 1981b: 509). The Tell Leilan free-threshing wheat apparently fall into this category as their rachises have three features that Hillman (n.d.) has found are distinctive of tetraploid wheats: 1) The rachis internode is trapezoidal. 2) Portions of the glume bases have survived attached to the rachis node. 3) The rachis internode shows no evidence of longitudinal lines on its convex face which is characteristic of *T. aestivum*.

Raising both durum wheat and emmer at Tell Leilan was probably a wise strategy for insuring a successful wheat harvest. Although we do not know the specific tolerances of the ancient wheat varieties grown in northern Mesopotamia, it is inevitable that they would have been different in view of the vast range of genotypes present in varieties of a single species of cereal. Two wheats would have offered farmers different agronomic advantages and disadvantages, although we cannot be sure what they were. Emmer probably survived bird damage better than durum because of the tough glumes, while durum required far less labor to process (Charles 1984: 27). The two wheats also, might have tolerated different soil conditions, allowing farmers to use a greater range of lands. Or they could have ripened at different times easing the pressure on labor at harvest time. Two wheat crops might have been a hedge against the vagaries of nature as well, such as drought or excess rain, which would have been especially important in the high-risk environment of the Habur Plains (Weiss 1986: 97). When one crop did poorly perhaps the other produced. Jasny (1944: 110, 118) found that two wheats complemented each other in this way for the farmers of ancient Rome. On the basis of the writings of Columella, Pliny, and Virgil, he concluded that the Romans' variety of durum was more productive than their emmer variety but was less tolerant of cold, drought, and heavy wet soils.

As for the other Leilan crops, the pulses, lentil far outnumbers chickpeas and field peas in the stratum 37 samples, suggesting that it was the major legume.

Weeds and farming practices

Weeds in cultivated fields are often one of the best sources of indirect information about agricultural practices. Defined as plants adapted to disturbed habitats, weeds include a wide range of types. Segetals are weeds of tilled, arable soil, while ruderals grow in other disturbed environments such as roadsides, canal banks, and trash heaps (Holzner 1982: 6). Some weeds, which have very broad ecological tolerances, grow under a wide range of conditions: on cultivated ground and in other disturbed habitats as well as in primary, or undisturbed, environments (Zohary 1973: 634). Other weeds have very specific requirements; the most exacting are those of "satellite weeds", plants which are adapted to grow with one particular crop under specific cultural conditions (Baker 1974: 14; Barrett 1983: 256).

The communities of weeds that grow in cultivated fields adapt over time to particular crops and soil conditions and maintain fairly stable floristic compositions (Barrett 1983: 255 f.). If the local environment, however, is altered, as a result of, say, soil depletion or changes in tillage practice or crops the weed composition changes (Wasylikowa 1981: 11).

Shifts in weed communities have been documented in a number of studies. Salisbury (1961 cited in Radosevich and Holt 1984: 21 f.) observed that some of the most common and pernicious weeds 400 years ago in England were rare by the middle of the 20th century. He attributed this partly to changes in planting methods. Prior to the invention of the seed drill, crops were broadcast, a method which made weeding impossible. With the seed drill crops were set out in rows allowing farmers to hand hoe weeds between the crop rows.

Baas and Streibig (1982) found that pineapple weed (*Matricaria matricariodes*) has increased in cereal fields in Denmark during the 20th century. They attribute its success to combine harvesting; the plant tolerates compacted soils which are associated with the combine. In alfalfa fields in California a prostrate form of yellow foxtail (*Setaria lutescens*) now predominates in contrast to other areas where the upright form is more common. Apparently cutting alfalfa every 21 to 28 days, an unusually short cycle, has encouraged the low growing form of foxtail (Schoner et al. 1978), while eliminating the other variety.

Archaeological weed seeds also document changes in farming practice, although they are a selective record (Wasylikowa 1981). The weed seeds that end up with a harvest do not encompass all the wild flora in a field, but are primarily those that ride on the "coat tails" of the crop by dispersing their seeds at the same time as the cereals. This sample, however, can be considered a good reflection of the weed community; Kornas (1972, cited in Wasylikowa 1981: 12 f.) demonstrated good consistency between weeds in the fields and disseminules in the harvest.

Wasylikowa (1981), working with large collections of burned grain stores from Medieval deposits in southeastern Poland, has shown that archaeological weed flora can be very informative. She found that seeds now considered segetals represented less than 50% of the weed seeds, while in modern Polish wheat and rye samples they account for over half the weeds. On the other hand, weeds which now grow among rootcrops and meadow species were relatively more abundant in these deposits than in the modern samples. Wasylikowa concluded that the early Medieval fields were less specialized habitats than modern ones, possibly as a result of long fallowing or lower crop densities. In a set of samples from Cracow, Poland, Wasylikowa (1981: 20 f.) observed changes in the composition of the weed flora between the 11th and mid 13th centuries: the weeds of acid soils increased while those of calcareous soils declined. She suggested that this could indicate the spread of cultivation on lighter soils.

Tell Leilan weed flora

Most of the Leilan weeds that have been identified are not particularly useful guides to field conditions as they grow in a wide range of disturbed habitats (Davis 1970: 457-79; Zohary 1968: 54-82; 1973: 483, 583, 636-43). But *Melilotus* sp., *Rumex* sp., and *Scirpus maritimus* grow on the well-watered soils of valley bottoms (Hillman n.d.; Davis 1985: 63), making them good indicators of moist land. As components of the Leilan flotation samples they offer some intriguing clues to land-use and farming strategies. Their distribution suggests that early in the Ninevite 5 period the people of Leilan may have been cultivating primarily well-watered soils, while by the end of this time they had extended their fields out to drier soils as well.

The evidence from the late Ninevite 5 period samples for use of both well-watered and drier lands is striking. The three moist soil indicator weeds outnumbered other weeds in stratum 15f-d samples in a ratio of 1:0.4, suggesting that the crop represented here was raised on well-watered land. By contrast, these weeds are in the minority in the stratum 15b sample, with a ratio of only 1:16 (see Table 3), reflecting drier soil conditions.

These differences in weed flora cannot easily be attributed to other causes. The plant remains in the two sets of samples appear to be products of the same stages in cereal crop processing; their grain to chaff ratio is identical, 1:17 (see Table 2).

The stratum 15b samples, however, are weedier, with a grain to weed ratio of 1:7.6 in contrast to stratum 15f-d's ratio of 1:4.4. But this does not account for the difference in moist soil indicator weeds either.

The larger share of weeds in 15b probably comes from dung fuel mixed in the sample. *Prosopis* seeds, an indicator of dung (Hillman n.d.), are more abundant in stratum 15b, occurring in a ratio of *Prosopis* to weeds of 1:44, compared with 1:182 in stratum 15f-d (see Table 3). But we can correct for this difference by excluding from our calculations the weeds which may have been introduced by dung alone, the steppe plants that occur only in 15b. These may have been consumed by livestock grazing beyond the fields, although they grow on cultivated land as well (Davis 1970: 457-479; Townsend and Guest 1974: 450, 452 f.; Zohary 1968: 54-82). When these weeds, *Trigonella, Astragalus*, and *Scorpiurus*, are excluded from the calculation, the ratio of "wet weeds" to others for stratum 15b changes only slightly to 1:15. It appears that the crops represented here were raised on drier soils than the stratum 15f-d samples.

In contrast to stratum 15, the limited evidence from the early Ninevite 5 period points only to well-watered soils. Moist soil indicator weeds were abundant in the two stratum 37 samples, the single lot of material suitable for comparison, as explained below. The ratio of moist soil weeds to others for the combined samples is 1:1.3 and for the richest sample, 1:0.9 (116 "wet weeds", 104 others). The other sample suggests slightly drier field conditions with a ratio of "wet weeds" to others of 1:5 (10 "wet weeds", 51 others) but it is unfortunately too small to be significant. The other early Ninevite 5 period samples, from strata 39 and 25-28, shed no light on soil conditions either. The latter sample is too small, with a total of only 35 weed seeds, while the former appears to have derived a large share of its weeds from dung fuel. The stratum 39 sample has a very high proportion of *Prosopis* seeds (a weed seeds to *Prosopis* ratio of 1:14, see Table 3), but only about 60% to 70% as many weed types as the other samples, although a comparable number of seeds.

The stratum 37 samples would also seem to be a poor choice of materials to compare with the terminal Ninevite 5 samples, as the two come from different contexts. Yet there are several reasons that the stratum 37 bulk food store weeds can be considered comparable to the "cleanings" from stratum 15. The assemblages from the two strata are very similar, although that of stratum 15 is larger with 22 weed types; all but 2 of the 14 identified seed types in stratum 37 occur in stratum 15, while stratum 37 lacks only 5 types that are found in both strata 15f-d and 15b (see Table 1). Furthermore, the stratum 37 weed seeds are roughly equivalent to the stratum 15 "cleanings" as they include grain-size and smaller weeds which would have been removed by additional fine sieving and hand-sorting had the bulk stores not burned.

One other aspect of the stratum 15 weed assemblage deserves mention. An unknown seed type or possibly two very similar ones, designated *Gramineae* type A, (see Table 1 and Fig. 1) proliferated in period IIId. Over 2,000 specimens were found in the stratum 15b sample, whereas almost none were recovered in the earlier samples. The appearance of this thin, needle-like grass caryopsis, approximately 1.5 to 2 mm long, in period IIId suggests a change between early and late Ninevite 5 times, possibly in farming practices, harvesting methods, or grazing patterns. Since 89% of the Period IIId *Gramineae* type A specimens came from stratum 15b, it is possible that this grass is a weed of drier soils and it may thus be another indication that Leilan farmers were extending cultivation onto drier soils. Unfortunately we can do no more than speculate until it is identified. Nor can we include it in any of the calculations of ratios until we know if it was a field weed, fodder, or fuel.

Leilan agricultural strategies

With this limited sample of plant remains from the Ninevite 5 period we can tentatively outline Leilan's agricultural strategies during the 3rd millennium B.C. Early in the Ninevite 5 period the people of Leilan were using a range of soils and all of these may have been well-watered, if the stratum 37 samples are representative of this time. By the end of this period they were cultivating both well-watered and drier soils. They had apparently extended their fields out beyond the wadi valley bottoms to more marginal lands in order to boost food production.

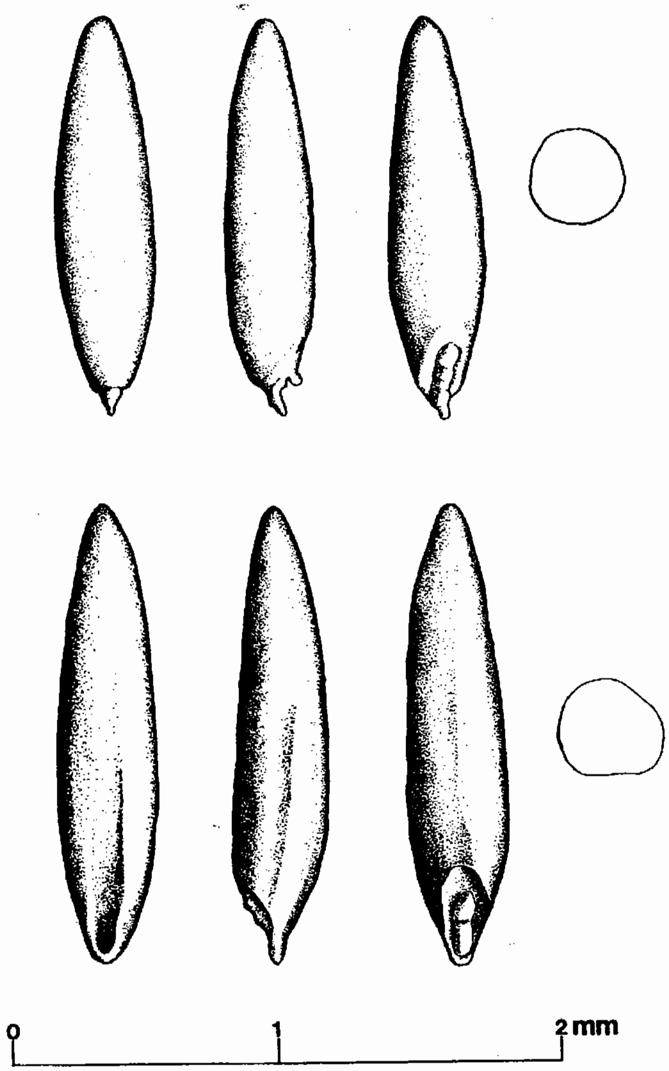
Part of their strategy may have been to plant the drier soils in barley, a highly reliable crop (Powell 1985: 18), while sowing a mixture of durum, emmer, and barley on the well-watered valley bottom lands. The evidence from the stratum 15 flotation samples is suggestive of such a pattern. Barley predominated in the stratum 15b sample with a barley to emmer wheat ratio of 1:0.2, while it was mixed with emmer and durum in the other samples from the moist soils, 15f-d, in a barley to combined wheat ratio of 1:1.5 (see Table 2). Stratum 15b had no durum, while the other set of samples had a small quantity of durum grains and rachis segments. Although we do not know the tolerances of the ancient cereal varieties grown at Leilan, it is likely that barley was hardier than the wheats as it has been shown to be more reliable on average, weathering drought and disease better than emmer (Powell 1985: 16 f.). Barley would, therefore, have been a wiser choice than the wheats for the more drought-prone soils. It is also possible, however, that as Leilan expanded cereal cultivation onto more marginal soils, barley was selected for the increased acreage because it was already well-established in Mesopotamia as the standard palace payment for ration labor (Powell 1985: 19).

There is some evidence that the Leilan palace oversaw the production and distribution of these two sets of crops. The stratum 15 flotation samples came from deposits which contained, in addition to plant remains, abundant sealings which had been used to seal jars and doors and as door stoppers (see Calderone and Weiss; Parayre, this volume). These deposits were apparently the remains of food stuffs processed and redistributed by the palace.

Conclusions

Weiss (1986: 98) has suggested that agricultural strategies played a role in Leilan's growth and prosperity, pointing to "the competitive or adaptive advantage of absorbing climatic uncertainty through a variety of land-use strategies." The plant remains here suggest that by Leilan period IIId various land-use strategies were indeed practiced that may have reduced the uncertainties of high-risk dry-farming while possibly maximizing yields. By planting two different wheat species, each with different tolerances to drought and cold, Leilan farmers would have increased their chances of reaping a wheat harvest. By extending their fields out beyond the valley bottoms to drier land they would not only have augmented their crop but they would also have had a hedge in the event of flooding during wet years. By planting this additional acreage in barley they may have reduced the possibility of loss to drought in dry years. How this farming strategy was orchestrated is not clear except that the palace apparently had a hand in it.

These preliminary results, presently no more than hypotheses, will soon be tested and refined with a large collection of recently excavated Leilan period II and III plant remains, which are presently being analyzed. Collected during the 1989 field season at Tell Leilan, these samples were extracted with a flotation machine from massive volumes of sediment in order to avoid the problems of small sample size that plagued this study; altogether more than 1700 liters, or a 40 fold increase over the 1987 sample, were floated. The Acropolis samples should help resolve questions of land-use strategies and crop selection. We can also look forward to insights into other aspects of the Leilan economy. Samples taken from the excavations in a Lower Town domestic area will offer evidence of how the crops were redistributed and used among Leilan's worker households.



- Fig. 1: Two examples of Graminae type A.

Plant Type		Str. 37	Str. 39	Str. 25-28
		Number of seeds or other plant parts		
		Early Ninevite 5		
		Period IIIa		Period IIIb
Cultivars				
Barley	grains (*Hordeum vulgare*)	105	12	14
	rachis fragments	-	18	22
Emmer	grains (*Triticum dicoccum*)	64	13	6
	rachis fragments and glume bases	27	388	121
Durum wheat	(*Triticum* cf. *durum*)			
	grains	105	3	-
	rachis fragments	-	2	5
Lentil (*Lens culinaris*)		85	2	1
Chick pea (*Cicer arietinum*)		2	2	1
Field pea (*Pisum sativum*)		-	-	-
Bitter vetch (*Vicia ervilia*)		-	-	-
Grass pea (*Lathyrus sativus* type)		8	-	-
Wild Flora				
Galium spp.		5	21	4
Coronilla sp.		-	-	-
Trigonella sp.		3	13	-
Astragalus sp.		2	76	2
Scorpiurus sp.		-	-	-
Adonis sp.		-	3	-
Silene sp.		1	-	-
Plantago cf. *squarosa*		1	-	-
Centaurea spp.		-	6	-
Melilotus sp.		25	-	1
cf. *Lepidium* sp.		48	-	-
cf. *Brassica* sp.		57	-	-
Propopis farcta		-	19	-
Aegilops sp.		1	1	-
Rumex spp.		-	10	-
Malva sp.		-	1	-
Lolium spp. (excluding *L. temulentum*)		-	8	-
cf. *Bromus* sp.		-	2	-
cf. *Agrostis* sp.		17	126	24
cf. *Hordeum* spp.		4	-	-
Chenopodium sp.		-	-	2
Avena sp.		-	-	
Androsace sp.		-	-	-
cf. *Lens* sp.		9	-	-
Scirpus maritimus		101	-	-
cf. *Carex* spp.		7	-	-
Gramineae type A		7	-	1

- Table 1: Plant Remains from Tell Leilan (continued overleaf).

Plant Type		Number of seeds or other plant parts Terminal Ninevite 5 Period IIId Str. 15f-d	Str. 15b
Cultivars			
Barley	grains (*Hordeum vulgare*)	33	24
	rachis fragments	204	180
Emmer	grains (*Triticum dicoccum*)	45	5
	rachis fragments and glume bases	1231	248
Durum wheat (*Triticum durum*)			
	grains	5	-
	rachis fragments	4	-
Lentil (*Lens culinaris*)		8	5
Chick pea (*Cicer arietinum*)		-	-
Field pea (*Pisum sativum*)		-	2
Bitter vetch (*Vicia ervilia*)		2	2
Grass pea (*Lathyrus sativus* type)		-	-
Wild Flora			
Galium spp.		29	76
Coronilla sp.		4	58
Trigonella sp.		-	9
Astragalus sp.		-	7
Scorpiurus sp.		-	2
Adonis sp.		1	7
Silene sp.		3	-
Plantago cf. *squarosa*		-	-
Centaurea spp.		1	-
Melilotus sp.		65	4
cf. *Lepidium* sp.		-	3
cf. *Brassica* sp.		-	-
Propopis farcta		2	5
Aegilops sp.		27	23
Rumex spp.		188	1
Malva sp.		14	5
Lolium spp. (excluding *L. temulentum*)		8	-
cf. *Bromus* sp.		1	1
cf. *Agrostis* sp.		-	-
cf. *Hordeum* spp.		-	5
Chenopodium sp.		5	-
Avena sp.		2	-
Androsace sp.		1	-
cf. *Lens* sp.		1	3
Scirpus maritimus		12	7
cf. *Carex* spp.		1	9
Graminae type A		277	2167

A number of unidentified seeds and fruits are not included on the table.

- Table 1: Plant Remains from Tell Leilan.

	Early Ninevite 5			Late Ninevite 5	
	Period IIIa Strata		Period IIIb Stratum	Period IIId Strata	
	37	39	25-28	15f-d	15b
<u>Grains</u>					
Barley	105	12	14	33	24
Emmer	64	13	6	45	5
Durum	105	3	-	5	-
All wheats	169	16	6	50	5
Total cereals	274	28	20	83	29
<u>Rachis Segments, Glumes, Glume-Bases</u>					
Barley	-	18	22	204	180
Emmer	27	388	121	1231	248
Durum	-	3	5	4	-
Total no.	27	408	148	1439	482
<u>Ratios</u>					
Grain : Rachis	1:0.1	1:15	1:7.4	1:17	1:17
Barley : Wheat	1:1.6	1:1.3	1:0.4	1:1.5	1:0.2
Emmer : Durum	1:1.6	1:0.2	-	1:0.1	-

- Table 2: Cereal Remains from Tell Leilan.

	Early Ninevite 5			Late Ninevite 5	
	Period IIIa Strata		Period IIIb Stratum	Period IIId Strata	
	37	39	25-28	15f-d	15b
Total cereals	274	28	20	83	29
Total weeds	281	267	35	363	221
Grains : weeds	1:1	1:9.5	1:1.8	1:4.4	1:7.6
Weeds of moist soils (wet weeds)	126	10	2	265	13
Other weeds	155	257	33	98	208
Wet weeds : other weeds	1:1.2	1:2.6	1:16.5	1:0.4	1:16
Prosopis seeds	-	19	-	2	5
Prosopis : total weeds	-	1:14	-	1:182	1:44

- Table 3: Grain and Weed Ratios Among Tell Leilan Plant Remains.

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