THE VALLUS: THE FIRST REAPING MACHINE

There is little doubt that during the first century A.D. the typical cereals under cultivation were as in the preceding century, namely Emmer *(Triticum dicoccum),* Spelt *(Triticum spelta),* Bread Wheat (*Triticum aestivum),* Club wheat (*Triticum compactum),* Barley *(Hordeum vulgare)* and probably oats (*Avena sativa).* From the extant representations of both vallus and carpentum, it is unclear which cereal is depicted. However, it is the belief of this writer that the invention of the reaping machine is specifically associated with Emmer wheat.

One of the core research programmes at the Ancient Farm examines the yield potential under varying treatments and soil and climatological conditions of all the prehistoric cereal types evidenced in Britain for the late Iron Age. Within that programme a major focus has been upon Emmer wheat (Reynolds, 1992). Consequently all the potential agricultural processes so far considered concerning Emmer wheat, for which there is little documentary or archaeological evidence, have been examined. The key to understanding how the plant may be treated lies in its very nature. Because it is a primitive species rather than a modern genetically engineered variety, the fruiting heads or ears often reach quite disparate stand heights. For example, an autumn sown plant might have in excess of six tillers which range from 300mm to 1500mm in height, each tiller bearing a perfectly harvestable spike. Spring sown plants with but three tillers can demonstrate the same disparity in stand height. In addressing the method of harvest the problem is immediately apparent. The popular idea of grasping a handful of ears in one hand and neatly cutting the stalks with a sickle becomes impossible. Strabo exacerbates the problem by referring to the collecting of cereal heads as a Celtic primary harvesting technique. But in practical trials using a sickle at least forty per cent of the harvest would be missed. Of course, all the harvest would be collected by cutting the straw at ground level but this in turn would also harvest all the arable weeds present in the crop and would necessitate a major processing treatment within the farmstead after the harvest for which there is virtually no evidence at all. In fact, from the evidence of carbonised seed from closed features like storage pits, the contaminating arable weeds are generally restricted to those which fruit at the same fruiting height of the cereals, in particular, bindweed (*Polygonum bilderdykia)* and fat hen (*Chenopodium album)* (Reynolds, 1981). This type of evidence rather supports the principle of a primary harvest of the cereal ears followed by a secondary harvest of the straw.

The major revelation during the harvesting programme was the ease and speed with which the ears of Emmer could be picked by hand. In fact, no matter how the reapers were persuaded, replica sickles were regularly set aside for the primary harvest and only employed for gathering the straw harvest. The ears are so easy to pick because when the cereal is ripe the culm internode becomes extremely brittle and readily snaps. Reverting to the image of grasping cereal heads in one hand and wielding a sickle in the other, the normal practical result is that the ears break off more or less on contact rendering the sickle totally redundant. This undoubtedly gave rise to the reaping comb or pecten, a tool which in comparison to picking by hand is cumbersome and difficult to manoeuvre, but which mimics running splayed fingers up the straw of the crop and grasping the ears in the palm of the hand. With very little

experience it is possible to become extremely efficient and gather well over ninety-five percent of the harvest.

The splayed fingers in a very real sense represent the tines of both the vallus and carpentum and further emphasise the lack of need for any kind of cutting edge. However, it is only Emmer which has an extremely brittle culm internode. All the other cereals referred to above have a much more powerful culm internode and do not readily shed their ears. A minor experiment to demonstrate this point was carried out by the writer in 1988. Two small plots, 5m x 5m square, of Emmer and Spelt wheat respectively were left standing after the main harvest had been completed. Within the space of twenty-one days, eighty percent of Emmer spikes had been shed naturally while less than ten percent of the Spelt spikes had fallen. Examination of the latter showed that they shattered within the spike, breaking at a spikelet internode often leaving two or more spikelets still attached to the calm. Similarly, during harvesting the crops by hand, the bottom spikelet or two is left attached to the calm. Barley on the other hand tends to shed its seed in the fingers of the harvester frequently resulting in a proportion being spilled to the ground. If left in the field the seed naturally falls out of the spike. One of the major difficulties of identifying which cereal is represented in the sculptural evidence is the broad visual similarity between Emmer and barley since both are bearded and have dense spikes. Regularly Emmer is mistaken for barley by modern agriculturists until it is reduced to seed form.

The vallus and carpentum, therefore, would seem to be designed specifically to harvest Emmer on the one hand, on the other could well strip seeds from barley spikes with equal facility but probably greater wastage. The other cereals represent greater challenges though the trials were confined only to Emmer and Spelt. In the case of the latter, the spikes tended to be broken along their length leaving a high proportion, some twenty-five percent, still attached to the waste straw.

Given the nature of Emmer wheat, the vallus has all the qualities to deal with this crop in particular. The angle and level of presentation of the tines into the crop can be altered by the operator at the rear of the machine simply by raising or lowering the handle. The forward motion of the machine catches the stems of straw between the pointed tines moving along their length until the spike or head is broken off between the narrowing spaces between the tines. The operator walking beside the tines cleans off the harvested spikes into the collecting box.

During the summer of 1985, the construct of the vallus was used on the experimental fields at the Ancient Farm. Of necessity the trials were to a degree limited because the field areas in question were laid out in such a way as to accommodate statistically random plots for four different cereals, respectively Emmer, Spelt, modern wheat and Einkorn *(Triticum monococcum)*. Each random plot measured 6m x 6m. By chance this particular year two plots of Emmer and two plots of Spelt abutted which meant the trials had a total area of 12m x 6m for each of the two cereals. The land was relatively flat with a minor slope of 1 in 20 across the line of the plots.

Two types of traction were used in the trials. Most usefully human power was utilised with two people pushing against a leather strap set across the shafts. Initially one of the cows from the trained team used for ploughing at the Ancient Farm was employed. Unfortunately it proved impossible at the time to find a trained pony or mule. The cow, although perfectly happy to work as one of a

yoked pair, was extremely reluctant to work alone especially set between the shafts of the vallus instead of having the normal plough beam on her left side. It was also difficult to attach the pulling ropes in a useful way mimicking the yoke to which she was accustomed. After several abortive training sessions and one trial in a separate plot from those designated, it was decided to use human power. The most obvious result from using animal traction was the devastating trampling effect upon the straw. After passage of vallus, cow and operator as well as the tine attendant, the straw was rendered quite useless. One interesting and amusing side effect observed was that once the cow settled down, her one major anxiety was to reach the wholesome snack of wheat and straw on the surface of the tines immediately in front of her. As she inched forward so the object of her desire maintained its distance. In the case of the pony or mule, the vallus clearly offers all the qualities of a carrot on a stick. Ironically the first pass of this trial through a plot of Emmer wheat proved to be the most successful. Nearly all the spikes of wheat were collected between the tines and snapped off easily, while the tine operator brushed the heads into the collecting box. Analysis of the remaining straw showed only fifteen percent of the spikes was lost. The second pass raised huge difficulties, primarily with the cow who refused to walk in a straight line. At this point it was decided to dispense with the idea of animal traction for the next set of trials and simply use human power. For the reaper to work, very little effort was needed and certainly by no more than two people.

The second set of trials comprised a series of passes through the two plots of Emmer and Spelt wheat in order to study further the question of the machine itself but also to examine the differences in efficiency of reaping these two particular cereals. Passes through the Emmer continued to be relatively successful and the vallus was perfectly able to cope with the disparate stand heights of the spikes provided the lowest spikes were large enough to become trapped in the tines. The angle at which the vallus operator needed to raise the handle was easily advised by the tine attendant. Occasionally whole plants were uprooted in this series of trials which always caused a complete disruption to the process until all the tines were cleared and the spikes rescued. For Spelt wheat the vallus was considerably less efficient, succeeding primarily in breaking the spike along its length rather than at the culm internode. In fact as soon as the tines were engaged into the straw, uprooting became a considerable problem. So much so that it proved virtually impossible to effect a complete pass through the cereal stand of twelve meters. The initial response was to revert to the Emmer crop when again the vallus operated more efficiently. The problem of uprooting is dealt with more fully below but the immediate conclusion was to isolate the strength of the spike internode as the major difference and to toy with the idea that the vallus might be restricted specifically to Emmer wheat. Logically this seems to be most unlikely though it would be of value to examine the carbonised seed evidence from the zone where the vallus is attested to determine cereal types and their relative abundance provided such a conclusion might be drawn.

These tests carried out at the Ancient Farm cannot be regarded either as exhaustive or statistically acceptable. At best they were pilot trials which merely explored the potential of the device. There is little doubt that the reaper could work and its design can elegantly cope with the disparate stand heights of the cereals.

During the trials with the reaping machine which in general terms were successful with all the recorded *caveats,* one major shortcoming became apparent which might well account for the failure of this technological innovation to spread beyond its limited zone of origin. The soil type of the fields of the Ancient Farm is a puffy black rendzina on one site, on the other the typical mix of rendzina, clay with flints and chalk granules to be found on the chalk downs of southern England. In the latter case the quantity of clay derived from adjacent hill tops is relatively minimal. Thus the soil of both sites can be generally described as very friable and difficult to compact. This leads to difficulties particularly with autumn sown cereals should there happen to, be extended periods of sub-zero temperatures during the winter when frost penetration can destroy a crop completely. With regard to the vallus and its operation on these sites however, the friable nature of the soil severely affected its efficiency. In order that the pick-up comb can work efficiently and break off the heads of the cereal, the roots of the plants must have a sufficient hold within the structure of the soil to be stronger than the culm internode. In effect the culm internode must be the weakest link in the chain in order for it to snap under the pressure/force exerted by the forward motion of the reaper. In the case of hand reaping described above, the ear is snapped off the culm by bending at a slight angle which in itself puts pressure on a precise point where the laws of compression and extension clearly apply. The vallus in direct contrast catches the ear between the teeth of the comb and applies virtually a straight pull between the ear and the root but off the perpendicular given the forward motion of the machine. It is always easier to pull out or uproot a plant at an angle to its natural growth. In practice one uproots the plant by degrees, loosening and breaking only a few roots at a time. Pulling vertically is to compete against the combined strength of all the root stock.

During the trials the vallus occasionally worked extremely well and proved its value, more frequently the wheat plants were uprooted. In fact it only required one or two plants to be uprooted to cause a ripple effect along the seed drills leading to immediate clogging of the comb or tines. In the extant representations a man is shown attending to the tines. It of may well be that he is dealing with this problem rather than the usual 'clearing of chaff'. Provided it is an occasional problem, such an attendant could easily keep the machine in steady motion. On the Ancient Farm soils this proved impossible. Once uprooting began the whole operation had to be halted, the tines cleaned out, ears hand picked off the straws and put into the collecting box. Generally the exercise was counter productive.

The overall conclusion reached from this experience is that the success or failure of the vallus to perform its designed function depends specifically upon the nature of the soil and the rooting ability of the cereal. The obvious criteria, therefore, would seem to be a soil with sufficient clay content to allow compaction and increased retention of the rootstock as well as an increased diurnal average temperature in the latter part of the growing season to bake a solid crust on the soil surface. These conditions generally apply in the zone of its origin. The problem could have been easily surmounted by the insertion of a sharp blade or knife across the tines which would cut through the individual straws on contact. The alternative of having metal tines with sharpened edges, an option adopted by other researchers but rejected by this writer initially in terms of cost, can equally well be rejected in terms of efficiency since the offered cutting edges are in line of travel rather than opposed to it. In a minor trial

with three wooden tines being replaced by metal one with sharpened edges, no appreciable differences were observed. The speed of forward travel was too slow to cut the straws and the same clogging and uprooting occurred. Even with the attendant in position pushing straws against the cuttings edges of the tines failed to improve the situation. One single trial with an extremely sharp blade set across the tines at right angles to the line of travel worked extremely well but only with constant attention. In simple terms, the attendant carried out the role of the sails used on the re-invented harvester of the eighteenth century which push the straws against the knife or cutting edge, the spikes then tumbling into the collecting box.

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