Report on the CRL Mk II SRC harvester.

by Raffaele Spinelli

Introduction

The CRL Mk II harvester is a purpose-built header designed for application to Claas foragers. The machine has been developed by Coppice Resource Limited, a joint-venture of four enterprises.

CRL

Coppice resource Limited is a joint-venture of four English enterprises, which after co-operating as an informal group at an earlier stage, eventually decided to constitute a society for liability reasons. The enterprises are:

Fred Walter and Sons Ltd. Fred is a large farmer and contractor, and he has been growing SRC since 1996. He directly farms over 800 ha of land - own, rented or borrowed. Fred Walter and Sons Ltd controls 40 % of CRL.

Shuldham Calverley. Rural practice chartered surveyors - a big firm in Retford. Tim Shuldham is the author of the ETSU report on the Mk I harvester.

H. Mell and Son. Agricultural engineers and specialist fabricators of equipment for the oil industry. They manage a large workshop and employ a number of staff. Chris Mell is the ingenious designer of the harvester.

Pharmacy Plc. Agronomy advisers and agrochemical specialists. Mark Paulson is their lead man inside CRL, where he is one of the four directors, together with Fred, Tim and Chris.

CRL roots are firmly set in agriculture rather than in the industrial sector, and CRL can reflect the farmers' viewpoints. CRL manage app. 400 ha of SRC and have established most of the SRC stands in the area. For this purpose, they have bought a 4-rows (double-rows, of course) step planter. They also developed a single-row (again, double rows) cut-back machine that Chris Mell is now enlarging into a 3-row version. Finally, CRL designed and built a sludge irrigator for special use in SRC.

SRC in England

SRC in England has a few characteristics that make it stand apart from its Swedish prototype.

First of all, the English regularly use clone mixes, so that each stand resembles a puzzle of small mono-clone blocks planted as 10-20 m row-segments. This is done in order to limit the spreading of pests inside the plantation. However, such an intimate mixing of clones somewhat complicates harvesting, because the crop density continuously varies along the rows and the machine ends up working in hick-ups. Certainly, the English SRC does not suffer much from disease. Insect attacks are also very limited - the most common insects found in SRC being occasional leatherjackets and red aphids.

A second characteristic of the English SRC is the type of marginal land normally available for the crop. Sites are often wet - like in Sweden - but lack the redeeming frost period that would allow effective harvesting. Moreover, the Retford area is riddled with quarries, and reclaimed quarries constitute a very common substrate for SRC. The reclamation method involves filling the quarry with industrial ash and covering all with a layer of soil 20 to 40 cm deep. These sites do not offer the best conditions for vigorous crop growth and easy machine traffic.

An additional complicating factor is represented by the poor accuracy of row-spacing found on many sites. Probably, this is the result of bad access conditions at the time of establishment, which affected the driving of the planter.

For the rest, the English use a number of Swedish willow clones, selected after extensive clone trials conducted in the 90s. Under English conditions, willows achieve substantially higher yields than poplars, which therefore account for a minimal proportion of the total area grown with SRC.

Cuttings are routinely planted with Step-planters. An English firm, John Turton Engineering, have developed their own version of the Step, which is more advanced but also more complicated than Salix Maskiner's original. So far, John Turton's machine has not obtained much success.

ETSU also carried out some trials with the "lay-flat" system, inviting two Scandinavian contractors to England: Gunnar Henriksson from Sweden and Johannes Falk from Denmark. These first trials gave negative results and it is not likely that the tests will be repeated. According to Fred Walter, the main reason for the failure was that both planters were adjusted to open their furrows exactly on the wheel tracks. Fred believes that the soil on the test site was too sensitive for this treatment: the wheel passage would generate a compaction sole that the furrow opener was not able to loosen up all the way down. Swedish soils may be lighter and forgive that, which may explain the discrepancy between the results of the ETSU trials and those of similar trials carried out in Sweden. Fred agrees that the cuttings used for the trials were very poor, yet he thinks that they were enough good cuttings to allow for a better result than was obtained: the cuttings were not the primary cause for the failure, although they contributed to it.

Weeding is essential. The climate and the terrain conditions of most English SRC sites are extremely favourable to rapid weed growth. Weeds are the main cause of establishment failure in English SRC. Both pre-emergence and post-emergence herbicides are applied - the latter with standard shielded sprayers. This is a field where Pharmacy Plc plays a major role.

Cut-back is performed regularly, and Fred recommends it. The uncontroversial advantage of cut-back is that it offers a second chance to weed-control. CRL had developed a cut-back implement for standard farm tractors. This uses a modified German-made Cut-Pro® sickle-bar and is claimed to be very effective. Chris is now building a wider 3-row version.

Digested sewage sludge is often applied as a fertiliser - either as a solid (cake) or as a liquid. Sludge application will substantially increase nitrogen availability and boost plant growth. In general, suppliers prefer to deliver sludge as cake, because this is more concentrated and is cheaper to transport. The disadvantage of cake sludge is that it can only be spread in pre-emergence or during establishment. Liquid sludge allows for more flexibility and it also contributes some water to plant growth. CRL have developed a liquid sludge irrigator, especially designed for SRC. In short, suppliers prefer cake sludge, whereas farmers prefer liquid sludge. In England, sewage treatment plants deliver and apply the sludge at their own cost, but they do not pay to the farmers any fees for the disposal service.

Harvesting is done in winter, during the dormant season. Unfortunately, during this period most English sites offer the worst access conditions, being at their wettest. Contrary to Sweden, England cannot count on any serious winter frost to make terrain accessible. Tracks and wide tyres seem to be the only resorts. In fact, it seems that one may extend the harvesting season from late September to early July - well outside the dormant season. An authoritative ETSU study has shown that the regenerating capacity of willow stools may not be affected by summer harvesting. Farmers are obviously interested and they would like to catch this opportunity. Unfortunately, conversion plants based on high temperature processes such as gasification prefer not to accept wood harvested when in leaf. Leaves contain a high proportion of the chlorine in a tree - which during conversion might generate harmful dioxins. To avoid potential problems, the leaves could be separated from wood destined for combustion or gasification.

ARBRE requires that farmers plant a minimum field size of app. 8 ha. Below that, machine moving cost will constitute a disproportionate share of the overall harvesting cost and make the operation unprofitable.

The SRC harvester

At the end of 1999, CRL set out to build a dedicated SRC harvester. The first prototype was conceived as a tractor-powered implement that would enable most farmers to harvest their crops themselves. The machine was built around a modified corn chopper and used two overlapping circular saws as a cutting device. It underwent a number of tests and harvested app. 40 ha. However, it appeared that the productivity of a tractor-based SRC harvester was too limited for industrial chip production. Therefore, CRL stripped their first prototype and built a second larger unit, designed to be mounted on a forage harvester. This is the current version that I observed in action.

The machine is very sturdy and comparably simple. The frame is made of generously dimensioned box steel that may defy any punishment. The frame is mounted on the face plate of a 400-hp Claas 860 forager and supports two overlapping disc saws, a horizontal feed roller and an adjustable push bar ending in a second horizontal roller.

The disc saws have a diameter of 150 cm and rotate at 1100 rpm. High rotating speed and wide diameter combine to give an extremely high peripheral speed to the saw edges. The saws are made of solid steel and have steel teeth that can be re-sharpened in the field, as does the Austoft. Each saw is mounted at the end of a long vertical shaft, which also bears a vertical feed roller. This rotates with the saw at 1100 rpm. The upper end of each shaft is fitted with a sprocket, which is engaged by a wide transmission chain. Chain and sprockets are housed in steel box placed on the top of the header's frame. In fact, the chain is supported by a number of sprockets, so that it can better mould to the header's shape. The chain is force-lubricated before it engages any single sprocket, using return oil from the hydraulic system. Since they overlap, the saws are able to cut on the whole front, which makes the CRL harvester less dependent on accurate/regular row-spacing than is the Claas header.

Power is obtained from a converter box mounted on the right side of the header. This channels mechanical power upwards to the drive gear that moves the chain transmission, and downwards to a hydraulic pump. The pump feeds the two hydraulic motors that power the horizontal feed-roller and the roller at the end of the push bar. Hydraulic power is also supplied to the cylinders that provide force to the horizontal feed roller and control the position of the push-bar.

The converter box receives power from a belt transmission flanged to the right end of the chopper drum shaft. An hydraulically-activated belt tensioner is used to engage the transmission, which can only run when the chopper's feed-rollers are moving. The transmission uses five V-belts. Ideally, Chris would like to build a new transmission using a single belt and a hydraulic clutch for safer and smoother operation. The tensioner system currently in use is somewhat difficult to operate and needs accurate adjustment.

The roller on the push-bar looks very much like that mounted on the Austoft. Chris thinks that this arrangement is better than that on Claas headers. He believes that the Claas push-bar is unable to effectively handle tall trees. Indeed, if the tree is so tall that the push-bar engages it below its center of gravity, pushing will result in moving the butt away from the feed-rollers. On the other hand, a roller eventually mounted on the push-bar will somewhat pull the tree downwards, even if it is very tall. The push-bar can be fitted with two steel "horns" that act as static crop gatherers.

The head is very massive and weights app. 2500 kg: the forage harvester must be equipped with counterweights to maintain enough traction on the steering wheels. Chris said that he could have made it some 500 kg lighter, but that he wanted an over-dimensioned prototype where he could make all needed adjustments without having to mind the risk of structural failure. The next version will certainly be lighter. Projected cost for producing a new header is about 40,000 GBP.

Besides building the header, Chris also reinforced the threads on the chopper's horizontal feed-rollers, as he felt that the original threads were neither sturdy nor aggressive enough. Some users of HS2 Claas headers may think the same, and the reason why HS1 users may not agree is simply that the earlier Claas header has 4 horizontal rollers of its own, whereas the CRL header uses only one roller and the HS2 none at all. In their cases, the chopper's horizontal feed-rollers take the main strain of feeding the crop through the head and into the chopper.

Overall, the machine looks extremely sturdy and very well designed. It is definitely sturdier than the Claas HS2 and simpler than the HS1. In particular, the throat is wide and totally free from obstructions, for a smooth and sustained flow.

Tree size may be less limiting for the CRL header than for any Claas version, but to date there are no experimental data that can corroborate this assumption. The saws certainly will have no trouble cutting through large diameters trees, and the CRL Mk I header has already proved capable of cutting through a 110 mm poplar stem (personally measured at Chris' workshop). However, the chopper may constitute the weak link here, and effective operation on large trees may require a reinforced comminuting device.

In fact, one may need to modify the chopper in any case, as the ARBRE plant requires a bigger chip than is produced by the Claas forage chopper. In particular, the blades hit the stems at a right angle and shatter the chip into small fragments, generating a lot of fines. The production of excessively small chip is a common drawback of Claas harvesters, and even the Swedes complain about it. Chris is working at obtaining a larger chip, which he may achieve by modifying the existing chopper. He is also exploring the possibility of replacing the forage chopper with a different device, as was done by Bruks with the Mengele foragers.

Chris and Fred would rather stay with larger chip than go with billets, as they think that billets do not flow well and cannot be handled efficiently.

The trial

A trial was conducted with the CRL Mk II header on April 24th, 2001. The machine harvested 1.2 ha of willow SRC on a young reclaimed ash-field around Retford. The weather was not bad, with scattered showers now and then – certainly not enough to make the ground impracticable.

The crop was three year old and not too bad. The average stocking was 42 gt/ha, which at a measured m.c. of 57 % make 18 odt/ha. Dominant diameter was 42 mm, and dominant height app. 600 cm. The crop was planted in double-rows spaced 140/75 cm. There were some weeds on the field, but not too many.

Before this trial, the machine had harvested app. 8 ha. Most of the work scheduled for this harvesting season had to be cancelled due to the Foot-and-Mouth disease epidemics that hit the UK and limited the moving of farming equipment both inside and outside the Country.

Chips were blown into a silage trailer towed by a tractor alongside the harvester. Three tractor-and-trailer units were used, as the chip was being transported directly to a storage area at the farm, a few kilometres away.

I conducted a detailed time-motion study, stopwatching all phases of the work cycle and measuring the length of row harvested with each run. All trailers were taken to Fred Walter's farm and scaled on a weighbridge.

Recorded productivity was 26 green tonnes/Productive Machine Hour. Productivity could have been higher if one had cut on the turn-around times. These amounted to about 2 minutes per turn, which is definitely excessive. Better co-ordination between the harvester and the tractor may allow halving this figure, to obtain higher productivity.

The potential of the machine was better expressed by its average harvesting speed, slightly higher than 4 kph. In the table below, the speed recorded in the trial is compared to those calculated for other SRC harvesters under the same crop density conditions.

Tab.1 – *Harvesting speed calculated for a crop density of 3.9 od kg/m*

Harvester	**m/min**
CRL	69,8
Austoft	60,9
Claas HS1	90,8
Bender MkIII	62,1

The CRL compares favourably to the other machines. Readers must be aware that harvesting speed decreases with increasing crop density, at different rates for different machines. The test in Retford was conducted on a small-size, high-density crop that would have been ideal for a standard Claas harvester. Machine ranking would substantially change with a larger stem size: this would favour the Austoft and penalise both the Claas and the Bender, as their curves drop more quickly. Considering its massive structure, one can guess that the CRL would also be favoured in the comparison by a larger stem size – but this assumption should be corroborated by experimental tests.

The most striking thing about the CRL was its smooth operation. During all the time of the trial, no header jams were recorded – not even micro-jams (i.e. jams that only last a few seconds and are recovered by the operator without dismounting from the cab). The test was too short for drawing any conclusive statement on this point, but certainly the machine seems very promising. The wide, unobstructed throat must have a major role in preventing header jams.

Cut quality was good. Stools were cut low and even. However, the steel blades would get blunted very quickly and this would result in a rougher cut – similar to that obtained with an Austoft. Several options are offered to the operator in this respect: he may grind his saws more often, he may cut a bit higher or he may replace the steel saws with TCT discs. Probably, a combination of the first two alternatives will work fine. Certainly, one must find a way to automate in-field saw sharpening: the saws are too big and they have too many teeth for speedy manual grinding. Chris took over one hour to grind them during the trial and that is too much. A small jig is likely to work, and may be set to run during the lunch break.

The machine also left behind occasional long stubs. This happened for two reasons. First of all, some clones produce very expansive stools (cow-horns), with stems running semi-horizontal for almost a metre. These stems are easy to miss. Secondly, the inter-row spacing was too narrow for easy harvesting, as it fell 10 cm below the prescribed 150 cm. Therefore, the harvester occasionally ran on some stems from the adjacent uncut row and bent them to the ground. At any rate, the percentage of long stubs appeared very limited and I would not consider that a problem.

Fred and Chris were also concerned about double cutting, as they feared that it would generate excessive harvesting losses. For this reason, Chris welded a small triangular shield before the overlapping section of the saws, as the overlap was deemed to cause most of the double cuts. During the trial I did not notice any more double cuts than I had in other SRC harvesting operations.

Attached: Excel file with trial results