INFORMATION NOTE ODW 12.04

Forest Research
The Research Agency of the Forestry Commission
TECHNICAL DEVELOPMENT

SMALL SCALE THINNING PROCESSORS FOR USE WITH AGRICULTURAL TRACTORS

Introduction

This Information Note is one of a series produced for a Technical Development Branch (TDB) Outdoor Workshop (ODW) and is produced as a guide to part of a harvesting system suitable for use in small-scale woodlands. ODWs are a TDB initiative designed to offer practical advice to practical people through presentation, demonstration and user guidance. The ODW programme will involve repeating trials and introducing new systems around Great Britain so that a wide range of sites, systems and practitioners can be included.

Machine Descriptions

The processors described in this Report can be mounted on the 3-point linkage of suitable agricultural tractors. For the majority this is the only mounting option but some can be used as bed processors mounted on the rear carrier of small forwarders. Most loader fed 3-point linkage processors are designed so that the processor can be quickly detached, enabling a forestry trailer to be connected for produce extraction.

They are best considered in categories relating to their loading and tree feeding methods:

- Loading: by winch or grapple.
- Tree feeding: by rollers or reciprocating boom (stroke).

These factors have a bigger impact on machine application than the size of the processor.

The base machine, the agricultural tractor, supplies the power demands of the processor. It must be modified to meet terrain, machine protection, safety and ergonomic requirements. While terrain and machine protection modifications vary according to site severity, the safety and ergonomic requirements will remain constant across sites. Normal requirements are for between 40 and 60 hp at the standard PTO speed of 540 rpm, although some stroke delimbers have a lower demand. Some models also require a hydraulic supply from the tractor. This usually amounts to only 35 litres/minute at 130 bar.

Plate 1

Niab winch-fed stroke processor

Niab N-1501: This 3-point mounted processor (Plate 1) is a stroke delimber and has been on the market for over 5 years. Although a stroke delimber, the delimbing ram operates the sliding boom via a mechanical linkage, similar too much larger purpose built processors. This system increases the speed of stroke but reduces the direct power of the operating ram, although it is still adequate.

The machine is very robust, which probably accounts for its high weight (1030 kg). In common with most stroke delimbers, construction is simple and servicing straightforward. The machine seems to have been designed with a long service life in mind. Most moving joints are equipped with 'expanda-bolts' that can be adjusted to take up wear. The sliding boom is well equipped with wear pads and, on later models the delimbing ram is equipped with hydraulic cushion ends.

The latest model has many improvements over the earlier models. For example, and particularly relevant to UK conditions, the knives have an improved profile and are double-edged. The original "Sepson" winch is now a "Star" and is radio controlled. Many parts of the machine have been strengthened and the crosscut saw guarding improved.

Table 1

Summary of Niab Specification

Processor Model	
Winch Fed Stroke Delimber	
Niab N1501	
Control Position	Ground
Weight kg	1030
Winch power (Tonnes)	2.5
Max Delimb Diam cm	45
Max Crosscut Diam cm	40
Remote winch control	yes
Power Required hp	40
Delimb Speed: m/sec	1.0
Delimb Power: kN	19
Delimb Stroke: m	1.5
Knives	
Movable Double edged	2
Single edged	–
Fixed Double edged	–
Single edged	2
Slew angle°	65
Length Measurement	Electronic
Length Accuracy ± cm	3
Computer Control	No
Preselect Length No	No
Preselect Diameter	No
Calculate volume	No
Felling head cm	No
Other base unit	No
Mountings	No

Tractor Protection

Essential work consists of protective guarding to:

- Vulnerable engine components (filters, alternators, injection pipes and hoses).
- Radiator.
- Lights, indicators and mirrors.
- Tyre valves.
- Exhaust and air intake pipes.
- Underside (belly guard for sump and gearbox).
- Windows (front branch deflector and side window guards). The rear window may need special protection for the operator as described later.

A suitable fire extinguisher will need to be fitted and attention given to the cab mounting step to prevent damage in forest conditions. The integrity of the Safety Cab must be maintained when carrying out such modifications (i.e. no drilling or welding).

Terrain considerations

The ability of the complete tractor and processor unit, to effectively work over soft, rough and sloping terrain is dependent on the following tractor attributes:

- Four-wheel drive.
- Equal sized wheels front and rear (or nearly so).
- Large tyre footprint (large diameter wheels and wide tyres).
- Equal weight distribution over front and rear axles.
- Low tyre pressures.
- Tyre chains, in certain conditions (on all driving wheels).
- A low centre of gravity. This can be achieved by finding the optimum wheel spacing setting for the thinning conditions.
- Adequate ground clearance. The ideal of 50 cm is difficult to achieve with farm tractors. Removing the draw bar hitch will help.
- A good power to weight ratio. Being able to carefully carry the processor over rough and sloping terrain will require about 10 to 20 horsepower more than that usually needed to drive it.
- Adequate gearing. For slow, careful movement over difficult ground "creeper" gears are an advantage. However, the torque converter options offered with some tractors reduce the amount of engine braking available. Descending sloping terrain can then place more strain on the brakes and the driver's ability to use them without locking the wheels.

Special attributes may be needed for **difficult terrain:**

Winch Fed

- A powerful winch with a reliable, responsive control system. Otherwise rope damage will quickly result, or damage to the processor and 3-point linkage will eventually occur.

- A skidding cone to enable trees to be winched over rough terrain without the risk of snagging.

Loader Fed

- A long loader reach to collect the thinnings in rough terrain and enable tractor routes to wind through the crop in the most suitable positions. A long reach will also promote the processing of sufficient trees to ensure that the brash mat is adequate for flotation on soft ground.

- A powerful loader slew mechanism to bring trees in over sloping ground.

Operator Safety

There are more safety considerations with winch fed processors than with other types, so greater vigilance is needed to maintain safe work systems. Winch fed processors have been designed for systems using both one and two people, hence the winch radio control option. With two people, the second man is usually used to assist with winching for part of the time.

Apart from the fact that winch fed processors are designed to winch from 1 side, the remainder of the winch and rope safety points are discussed in the Arboricultural and Forestry Advisory Group (AFAG) Guide 502 *Extraction by Skidder.*

If the winch is occasionally used to take down a hung up tree the situation must be properly assessed and carried out without endangering anyone on the machine. AFAG Guide 310, Use of winches in directional felling and takedown refers to this.

- Prime safety points with 3 point linkage processors concern:

- The adequate guarding and good maintenance of the crosscut saw.

- The use of good techniques to ensure stability of the machine when winching or loading.

- The maintenance of guarding between operator and processor.

- The correct choice of base machinery and its equipment.

- An ergonomically sound operator environment.

AFAG Guide 603 Mechanical Harvesting applies to all 3 point linkage mounted processors. Problems have arisen over inadequate provision for guarding against **chain-shot** (chain breakage), especially with some older models.

Loader fed processors must have a 12 mm polycarbonate rear window guard for this purpose. Operators of winch fed processors are potentially more vulnerable than those of loader fed processors. The latest models of winch fed processors have improved guarding, especially for the vulnerable cutter bar nose and heel areas. Earlier models can be brought up to these specifications. Sensible chain-shot precautions also include using the stronger purpose-made **18H cutting chain** designed for the larger machines, instead of cutting chain intended for hand-held petrol driven saws.

Working Systems

Getting to know the work site before starting and making good plans are essential with any forest machine work. With small-scale machinery this aspect is probably more important than with larger machinery as smaller machines do not usually have the reserves of strength and power to overcome poor planning. With good planning high outputs are easier to achieve and breakdowns, which affect profitability, are kept to a minimum.

Winch fed systems are generally more suited to less dense crops, for ease of winching and also lower removal intensities, as racks can be more widely spaced.

Loader fed systems require closer rack spacing and can involve a relatively high percent of stems removed.

Winch Fed Processors

Work systems with winch fed processors involve 2 people for felling, winching and processing.

Chainsaw felling and takedown usually progress at a faster rate than processing. Felling must not get ahead to the extent that people become isolated but it must be far enough ahead for adequate safety.

It is always difficult to balance felling with winching and processing. Assistance with winching seldom enhances outputs to cover the cost of the second person.

Useful extra work can be to bunch small, easily handled trees for subsequent easier winch chokering and separating forked stems etc.

Felling is done in a direction away from the tractor route and is best carried out from the furthest point of intended winching, working a square area in a zigzag fashion back towards the rack. In this way trees will stand the best chance of falling into the gaps already created.

One side of the chosen tractor route is worked first, due to the processor only being able to be fed from one side, usually the left. If necessary, the bottom 1.5 m of the stem should be sned (delimbed) to aid subsequent processing.

Hung up trees should be taken down safely. AFAG Guides 302, 307, 310 describes the correct procedures. Most winch fed processors cannot create a **new tractor rackway** at the same time as working the side thinnings. The method of making tractor racks is either to turn the tractor sideways to winch and process trees from a new rack section or to clear the rack by chainsaw alone.

Chainsaw rack clearance can be either of 2 methods:

- If the gaps created by the proceeding thinning in the crop matrix are sufficient, the rack trees can be felled sideways into the crop. In this way, only the first product or two has to be delimbed, crosscut and stacked opposite. The part of the tree remaining inside the rack edge can be left for the processor provided that the lower part has the branches removed.

- If the crop matrix is closely spaced the rack trees must be felled in the rack, fully converted by chainsaw and stacked by hand.

Large trees are **winched** individually. Small trees can be winched in bunches to save time. Loads can be winched from further distances than are accessible to loader fed machinery. Maximum distances will depend on conditions such as crop density and ground roughness but are usually 10 m to 15 m. In favourable circumstances greater distances can be worked, although outputs will be lower.

When a single person is both winching and processing, the radio control is used. This eliminates unnecessary walking and winching snags can be better anticipated. If the second person assists winching by pulling the rope out and chokering during processing, 'winching in' is still done by the processor operator. This eliminates any sudden unexpected movements of the processor caused by the winched load snagging on stumps etc.

If terrain is rough, a winching cone can be used to reduce snagging. If ploughed rows are a problem, one solution is for the tractor routes to cross rows (depending on terrain slope and furrow depth) at a steep angle. Winching along furrows is far easier than across.

Stroke delimber winch processors can usually **pick up** from the ground. Feed roller winch fed processors are usually tilted up to accept the tree. If bunched trees are winched, these can be dropped in front of the machine and one selected for processing. Alternatively where trees are small, the bunch can be dropped into the processor and then all but one winched up and out of the way. The applicability of this technique depends on the height of the winch fairlead.

Once the tree stem is at the processor, the winch rope is detached and the knives are clamped round for **processing**.

Different **product assortments** can be cut with the processor slewing to stack them separately but a high stacking quality or degree of separation cannot be achieved.

No more than two or three products should be cut. Even three products can become hopelessly mixed unless one (such as a sawlog) is markedly longer than the others. The situation can be made worse by processing many trees at the same stance.

Short products (<2 m) can give problems by falling at an angle on the stack, especially if they are of small diameter.

The ability to stack separately is governed by the slewing ability and the height from which the product is dropped, together with tree and product length and diameter. The height of the processor bed is fixed and at present there are no small 3 point linkage processors where the processing height can be varied under operational control. However, this can be overcome by tilting the processor. With larger and longer products, this is necessary to avoid splitting when sawing.

Removing the **treetop** after processing is usually achieved by reversing the feed rollers quickly. The top may catch on the back of the knives and then require manual removal. Winch fed processors with stroke delimbing (such as the Niab) have the knives facing downwards, so releasing the top is easy. However, in this case the top may still require handling because it can easily fall upon the support leg for the control panel. One way of reducing the problem is for the chainsaw operator to cut the top off after felling and takedown.

Branch **residue** (brash) build-up can be a problem if many trees are processed at one place. Brash requires moving if it hinders further winching and processing. With winch fed feed roller processors this has to be done by hand. Some stroke delimber processors can handle brash mechanically.

Obtaining brash for machine flotation can be difficult for winch fed processors. This is because, for the first machine pass down the tractor route, the branches are left on one side only. It is exhausting work to distribute it by hand and it is also difficult to reverse over one-sided branch heaps.

Some stroke delimber winch fed processors can distribute branches behind them, with varying degrees of success but this work reduces time for processing. Therefore, although winch fed processors have the potential to gather more branches; most cannot make good brash mats for flotation. Where they are able to build good brash mats behind themselves, it is only after they have passed twice along the tractor route.

Loader fed processors do not suffer the same problem providing removal intensities ensure adequate brash.

Loader Fed Processors

Work systems with loader fed processors centre upon the effective reach of the loader and (as with winch feed processing) appropriate felling and presentation is very important. The **loader** should be able to reach the tree butt for processor loading, which limits maximum rackway spacings.

Common loader reach for agricultural tractor base units are usually only 5.0 m to 6.5 m, although some are available with a reach up to 7.0 m.

Felling the furthest thinnings towards the rack can extend rack spacing (normally twice the loader reach). However, this involves more work for the loader and correspondingly more “idle” time for the processor when turning and positioning the tip first tree. Only lightly branched trees can be properly delimbed tip first.

The thinning technique for loader fed processors is similar to that for winch fed processors. **Thinning** starts furthest away from the rackway. Trees are felled away from the rack over a square area in a zigzag fashion back towards the tractor rack. However, felling is not limited to one side because loader fed processors can work both sides of the rack alternately.

Rack trees are best felled sideways into gaps already created in the crop matrix. There is no need to clear the rack by chainsaw work as the loader can lift stems over the processor. However, new rackways in tight crops may still need to be cleared manually if trees cannot be felled sideways.

Loader fed processors to date are all of the ‘bed’ type, that is the knives open upwards. Therefore, produce is dropped from quite a height leading to similar **stacking** problems as occur with some winch fed machines. However, tilting mechanisms are incorporated into most models and the loader can also assist in stacking, although this reduces time for processing.

The ability to stack on both sides of the rack increases the space available but produce specifications are still best kept to two or three types. The closer rack spacings of loader fed systems over winch fed systems also reduces the amount of produce to be stacked at each stop.

The **loader** can be used to distribute a good brash mat in front of the processor as it progresses, which it does in reverse. The loader is also commonly used to clear treetops from the processor that has not been ejected, although care must be taken to avoid knife-edge damage.

Other Methods

Loader fed machines can be used for roadside processing with extraction of thinnings to the processor being either by high lead (cable crane) or whole tree skidding. Residue disposal can be a problem as can ground disturbance in the absence of brash mats if extraction is by skidding. Logistics can become complicated if processor output is greater than one cableway. This is dependent upon whether whole poles (for subsequent conversion) or shortwood is produced.

Outputs with shortwood roadside processing are lower and stacking can be a big problem. Producing whole poles for subsequent conversion is faster, but this 3 stage process involves more machinery and planning.

Outputs

A summary of the site descriptions and the outputs obtained from 2 case studies of the Niab N1501 a winch fed, stroke delimbing processor is given in Table 2 and Table 3.

Table 2

Site Descriptions

Case Study	Thinning Type	Species	Age (years)	Yield Class	Produce	Mean Winching Distance (m)	Terrain	Comments
1	Selective (33% volume removal)	Grand fir	37	22	1.7 m stakewood (72%) and 2 m bars (28%)	18	Ground firm, slightly uneven, 20% slope	Rack edge previously thinned up to 10 m to 12 m
2	Selective (delayed, 18% volume removal)	Western hemlock	37	20	1.7 m stakewood (83%), 1.9 m palllet (28%) and 3.8 m sawlogs (2%)	17	Ground firm, even, 25% to 30% slope	Maximum winching distance 31 m

Table 3

Outputs

Case Study	Average Tree Size (m^3)	Standard Output (m^3/shr*)
1	0.16	1.8
2	0.20	1.9

shr: Standard output per hour includes allowances of 20% for Rest and 16% for Other Work.

Case Study 1: Although the processor handled trees up to 0.3 m^3 without difficulty the outputs were affected by winching across 10 m to 12 m "dead" ground.

The length measurement accuracy was remarkably good at +/- 3 cm. A 2 cm under measurement for 2 m lengths was consistent and could be taken into account.

Case Study 2: Successful winching was made possible by winching downhill along the planting rows.

The outputs were affected by the low thinning volume removed and the long winching distances encountered. The largest tree handled was 0.56 m^3, which gave some difficulty when crosscutting the sawlog element.

Case Study Element Distribution: The average breakdown of the cyclic elements is given in Table 4.

Table 4

Distribution of Cyclic Elements

Cyclic Element	Total Cyclic Time (%)
Processing (debranched and crosscut)	58
Winching and Loading into processor	24
Moving Branches (by machine) and Moving the tree top aside	10
Moving the tractor	7
Adjusting the stack by hand	1

An additional short study in the same crop highlighted the effect of takedown difficulties. Some 20% of the trees needing takedown by winch in a small-thinned area where the site adjoined existing hardwoods. For a mean tree size of 0.21 m^3 outputs were reduced to 1.4 m^3/shr.

Factors affecting output include:

- Tree size. This is the major overriding factor. Output increases with volume, providing that trees are within the optimum working limits of the processor.

- Species. Heavy-branched species require more time.
- Tree form. Bent twisted trees and multiple stems reduce output.
- Product. Longer products normally give higher outputs.
- Type of feed. Feed rollers are quicker than stroke delimbers.
- Presentation. Good manual felling of trees prior to processing is essential for optimum outputs.

Machine and System Choices

There is a wide choice of 3 point linkage mounting processors on the UK market. The ideal choice will inevitably be influenced by costs but there are many factors that should be taken into account. The best choice will be tailored to individual circumstances.

Suppliers & Costs

The supplier of the Niab N1501 is as follows:

Brian Thomas
Graig Wen Fach
Llansilin
Oswestry
Salop
SY10 9BN

The cost (1994) of the Niab N1501 winch processor is £15 500 (excluding VAT) and a basic 4 wheel drive agricultural tractor, up to 67 hp and forestry protected (e.g. Valmet 455) is estimated (1994) to be £21 500. This would give a total cost of £37 000 for the unit.

Based on this cost the estimated operational hourly working cost is calculated to be £17.06 (Table 5).

Table 5

Machine Costing

Item		Value
Capital cost (£)	C	37 000
Residual value (£)	RV	3 700
Life of machine (hrs)	L	10 000
Productive (hrs/year)	PH	2 000
Life in years-	n	5
Interest rate (%)	R*	6
Discount factor-	$Dn = \frac{1}{(1+r)n}$	0.7473
Equivalent annual cost	$An = \frac{r}{1-Dn}$	0.2374
Capital cost (£/hr) =	$\frac{[C-(RV \times Dn)]An}{PH}$	4.06
Operating cost (£/hr)		
Repair & maintenance		1.50
Fuel & oil		1.50
Operator (including oncost)		10.00
Total cost (£/hr)		17.06

*$r = \frac{R}{100}$

Cost Example: A cost example is given for felling and process a thinning site with a tractor complete with a Niab N1501. The mean tree size of 0.11 m³ gave a processing output of 1.9 m³/shr. The costs are summarised in Table 6.

Table 6

Costs

Mean Tree Size (m^3)	Cost (£/m^3)		
	Fell	Process	Fell and Process
0.11	3.65	8.98	12.63

Thinning Specification

Maximum winching distances are normally between 10 m and 15 m and crop removal intensities usually between 33% to 50%, dependent on circumstances. Most winch fed processors can work rack spacings, and thus a brash mat, suitable for subsequent extraction without risk of ground disturbance and root damage but they may not profit from it themselves.

Loader fed processors do not usually have long reach abilities, so rack spacings may need to be closer than desirable. However, such machines are narrow and fairly manoeuvrable. On easy to moderate terrain where the crop spacing is wide enough for the machine, they can work within the remaining crop between the racks. Produce is concentrated towards the wider spaced extraction routes. However, such stand-mobile methods run a risk of inadequate rack brash mats for subsequent extraction operations.

Conclusions

Tractor mounted, 3 point linkage thinning processors can be cost-effective for small-scale operations due to a low capital cost. Higher output, loader fed, feed roller processors can be competitive with compact excavator grapple harvesters in thinnings of tree sizes up to 0.1 m^3.

The efficient use of 3 point linkage processors requires good site planning and job organisation. Training is essential.

Most modern 3 point linkage processors are sufficiently reliable and easily maintained for use in full-time small-scale operations.

Winch fed processor operators face a greater safety hazard than those of other types. Effective attention to guarding and operational procedures is crucial.

Where tight specification high value products are to be cut an accurate length measurement device is required. Some processor models do not have this.

Forest Research
Technical Development Branch
Ae Village
Dumfries

Tel: 01387 860264
Fax: 01387 860386
Email: tdb.ae@forestry.gsi.gov.uk

Aggressive metal peg feed rollers, which cause damage, can be unsuitable for some high value products.

Most modern 3 point linkage processors are fitted with profiled double-edged knives sufficient for adequate spruce delimbing.

Good machine choice (processor **and** tractor) plays a large part in ensuring an efficient unit. This is a critical prerequisite for consistent high outputs.

There has been a steady increase in models on the UK market and manufacturers have made improvements to the most popular older models. There is now a far wider choice than ever before.

More systems development relevant to the UK is required.

Tractor cab controlled, loader fed types have the highest output potential in small scale operations and can give the operator a comfortable and safe working environment.

Winch fed systems are generally more suited to less dense crops.

Wider rack spacing can lead to lower removal intensities and improved rack thatching, as racks can be more widely spaced.

Loader fed systems require closer rack spacing and can involve a relatively high percent of stems removed.

Technical Development Branch

Develops, evaluates and publicises safe and efficient equipment and methods of work, maintains output information and provides advice on forest operations.

500S/13/03 ODW 12.04