SHORTFOR WP3: Economical sustainability of SRF

Markets and Values

Stand Volume / Biomass

Supply Chain Costs

Characterisation of SRF supply chains

SRF Supply Chains

Harvest Method	Products	Machine system	Haulage
Cut to length	Roundwood	Harvester, Forwarder	Timber trucks
Integrated		Harvester, Forwarder,	Timber trucks,
(loose residues)	Roundwood, Wood fuel	Chipper	Walking Floors
Intergrated		Harvester, Forwarder x 2,	
(bundled residues)	Roundwood, Wood fuel	Shredder	Timber trucks
		Feller buncher, terrain	Chip Vans /
Whole tree	Wood fuel	chipper, chips forwarder	walking floors

Machine Productivity models

Machine	Country	Operation	Method	Species	Productivity	Covariate	Covariate Range	Model	Parameters	Machine specifications	Reference
Harvester	Ireland	Clearfell	CTL	not stated	13.5 m ³ -60.5 m ³ / PMH	Tree size	0.1 m ³ - 1.0 m ³	$Y = 60.711x^{0.6545}$, R ² = 0.9219	Y = productivity (m ³ / PMH), x – average tree size (m ³)	Global model for numerous machines	Jiroušek et al. (2007)
Feller Buncher (shears)	Italy	Clearfell	WT	Poplar SRF	173 trees / PMH, 18.6 ODT / PMH, 45.1 m³ / PMH	n/a	Mean dbh of 20 cm	Average	n/a	Biasi Shear head on Hitachi EX 165	Schweier et al. (2015)
Feller Buncher (chainsaw)	Ireland	Clearfell	WT	Birch	5.24 m ³ solid/PMH	n/a	Mean dbh of 9 cm	Average		Silvatec 656TH feller- buncher	Kent & Kofman (2007)
Forwarder	Ireland	Clearfell	CTL	notstated	10 m ³ – 35 m ³ / PMH	Distance, machine size	Distance 80 m - 1400 m. Three machine size classes; Class 1: < 80 kW, payload < 10 tonnes Class 2: 80 kW to 120 kW, payload 10 - 12 tonnes Class 3: > 120 kW, payload > 12 tonnes	$\begin{aligned} &Class 1, Y = 10.5193x^{(24.9181/x)}, R^2 = \\ &0.5221 \\ &Class 2, Y = 17.0068x^{(13.2533/x)}, R^2 = \\ &0.6263 \\ &Class 3, Y = 10.5193x^{(24.9181/x)} + 10, R^2 \\ &\text{not stated} \end{aligned}$	Y = productivity (m³/PMH),x = average hauling distance (m)	Global model for numerous machines	Jiroušek et al. (2007)
Tractor mounted terrain chipper	Ireland	Clearfell	WT	Birch	5.5 m³ solid volume / PMH	n/a	Mean dbh of 9 cm	Average	n/a	TP280 tractor- mounted terrain chipper on a Valtra tractor and trailer	Kent & Kofman (2007)
Residue Bundler	Spain	Clearfell	CTL	Eucalyptus (E. globulus)	4.94 ODT / PMH	n/a	n/a	Average	n/a	Woodpac ENFO 2000	Garcia et al. (2011)
Feller buncher (circular saw)	USA, Pacific Northwest	Clearfell	WT	Poplar SRF	430 trees / PMH, 21.96 ODT / PMH	n/a	Mean dbh 17	Average	n/a	Quadco56-cmhotsaw mouted on an excavator Timbco TE820	Spinelliand Hartsough (2006)
DDC Chipper (Delimb, Debark, Chip)	USA Pacific Northwest	Clearfell	WT	Hybrid poplar	26.1 ODT of clean chip / PMH	n/a	Mean dbh 16.5 cm	Average	n/a	Peterson Pacific DDC 5000	Hartsough et al. (2002)
DDC Chipper (Delimb, Debark, Chip)	Australia, sunshine coast	Clearfell	WT	Eucalyptus globulus	25.61 ODT / PMH	n/a	Mean dbh of 17.8	Average	n/a	Peterson Pacific DDC 5000	Ghaffariyan and M. Brown (2013)
Chipper	Ireland	Roadside during thinning	WT	Ash	22.5 m ³ solid vol. / PMH	n/a	Mean dbh 8 cm	Average	n/a	Jenz Hem700 mounted on a truck	Kent and Kofman 2007
Chipper (roadside and terrain, global model)	Italy	Various	Various: whole tree, tops, residues	Various	see models	Engine size, piece size	22 – 440 kW, 0.001 – 1.000 green tonnes	Chip (mintonne ⁻¹) = $0.02 + \frac{13.1}{Piece Size \times Power}$ + 566/(Power) R ² = 0.79 Reposition (mintonne ⁻¹) = 0.584 + $0.00744(\frac{(n Stand Dummy)}{Piece Size}) -$ 0.385(Self Prop.Dummy) R ² = 0.48 Other (mintonne ⁻¹) = $0.2 + \frac{0.0157}{Piece Sieze}$ + 4.72(Small Chipper Forwarder Dummy) R ² =0.73	Piece size = as received weight per piece (tonnes) Power = chipper engine size / PTO power In Stand Dummy = 1 if in stand chipping, 0 if at the roadside Self Prop. Dummy = 1 if chipper is self propelled, 0 otherwise Small chipper Forwarder Dummy = 1 if chipper is a small chipper- forwarder, 0	Global model for numerous machines	Spinelliand Hartsough (2001)

Machine Rate

				Net Cost PMH Gross Costs PMH	€ €	120.34 131.42	72.97 79.20	85.61 93.81	65.17 70.60	208.24 228.50	39.28 42.22
				Normal operating profit (%)		5 ^[h]	5 ^[h]	5 ^[h]	5 ^[h]	5 ^[h]	5 ^[h]
						-	-	-	-	-	
		Total Rate per PMH	Euro/pmh	Overhead Costs (%)	%	5 ^[h]	5 ^[h]	5 ^[h]	5 ^[h]	5 ^[h]	5 ^[h]
		Total Rate per SMH	Euro/smh	Machine Utilisation (%)	%	65 ^[g]	65 ^[g]	69 ^[g]	65 ^[g]	75 ^[g]	75 ^[g]
		_		Hours per shift		10	10	10	10	10	10
		Operating Profit Per SMH	Euro/smh	Shifts per day		1	1	1	1	1	1
Total Rate per PMH	Euro/pmh	Overheads per SMH	Euro/smh	Work Days per year		250	250	250	250	250	250
Fotal Rate per SMH	Euro/smh			Productivity and Operations							
	- / .	, per entri									
Operating Profit Per SMH	Euro/smh	Operating cost per SMH	Euro/smh	Costs	€	23.82	23.82	22.43	23.82	20.64	20.64
Overheads per SMH	Euro/smh	Operating cost per PMH	Euro/pmh	Total Operator Direct							
			care, print	Operator Insurance (€/a)	€	1,200 141	1,200 ^[e]	1,200	1,200	1,200	1,200 ^[e]
		Ownership cost per PMH	Euro/pmh	(€)	€	15 ^[e]	15 ^[e]	15 ^[e] 1.200 ^[e]	15 ^[e]	15 ^[e] 1.200 ^[e]	15 ^[e]
Operating cost per SMH	Euro/smh	Ownership cost per SMH	Euro/smh	Cost/ Hour (incl. Benefits)	-	1.6		[s]	[a]	1 a fal	1 - [a]
Operating cost per PMH	Euro/pmh	operating Front //	70	Number of Shifts		1	1	1	1	1	1
		Operating Profit %	%	Operator Costs							
Ownership cost per PMH	Euro/pmh	Overheads %	Euro/pmh %	Total Variable Costs	€	55.41	23.94	31.94	21.28	131.03	9.58
Ownership cost per SMH	Euro/smh	Labour cost per PMH	Euro/omb				-		-		-
operating Front /0	/0	Annual cost	Euro per ann	Consumables	€/PMH	saw chain, bundler twine)	-	et al 2004)	-	(Hammers, Knives)	-
Overheads % Operating Profit %	%	Benefits Rate				21 ^[a] (Saw bar, saw chain,		(saw bar and chain) (Karha		24.06 ^[b] (Hammers,	
Labour Cost per PMH	Euro/pmh	Labour, wages per hour	Euro / SMH	. ,				1.30 / PMH			
				(PMH)	PMH	18000 ^[e]	6000 ^[e]	18,000	6000 ^[e]	-	-
Annual cost	Euro per annum	Lubrication	Euro/pmh	Cost per track set (€) Estimated track set life	€	5500 ^[e]	5500 ^[e]	5,500	5500 ^[e]	-	-
Benefits Rate		Lubrication Consumption Rate		sets		1	2	2	2	-	-
Labour, wages per hour	Euro / SMH	Fuel	Euro/pmh	Number of additional track							
		Cost of litre of fuel (ex vat)		of replacement value)	%	100% ^[h]	80% ^[h]	100%	80% ^[h]	100% ^[h]	80% ^[h]
Lubrication	Euro/pmh	Fuel Consumption Rate	Litres / pmh	costs per PMH) Maintenance and Repair (%	%	15% ^[h]	15% ^[h]	15%	15% ^[h]	15% ^[h]	15% ^[h]
Lubrication Consumption Rate		Maintenance and Repair	Euro/pmh	Lubrication cost (% of fuel		t so (h)	t no (lb)		t no (b)	t may [b]	1 may 1941
Fuel	Euro/pmh			Fuel cost per hour (€)	€	9.13	9.18	8.80	6.48	51.15	4.46
Cost of litre of fuel (ex vat)				Average Fuel Consumption (I/PMH)	litre	10.4 ^[h]	10.4 ^[h]	10.0	7.4 ^[h]	(50%)	5.1 ^[h]
Fuel Consumption Rate	Litres / pmh			Fuel Cost (€/I)	€/litre	0.88 ***	0.88	0.88	0.88 ***	0.88 ^[4] 58.13 ^[h]	0.88 [4]
Maintenance and Repair	Euro/pmh		,	Variable Costs	0.5	0.88 [*]	0.88 ^[e]	0.00	0.88 [*]	0.88 ^[e]	0.88 [*]
		Insurance and Tax	Euro/year								
		Interest	Euro/year	Total Fixed Costs	€	41.11	25.21	31.24	20.08	56.57	9.06
		Average Yearly Investment	Euro/year	Insurance cost (€) Machine power kW	€/year kW	7,746	4,830 **	6061	3,645 **	6,676	1,823
Insurance and Tax	Euro/year	Depreciation	Euro/year	Annual Depreciation (€) Insurance cost (€)	€/year	36,153 ^[i] 7,746 ^[i]	22,543 ^[i] 4,830 ^[i]	27,681 6061	17,013 ^[i] 3,645 ^[i]	72,185 ^[i] 6,676 ^[i]	8,507 ^[i] 1,823 ^[i]
Interest	Euro/year	Repair an Maintenance		Economic Life (PMH) Annual Depreciation (€)	PMH	18,000 ^[f]	18,000 ^[f]	18,000	18,000 ^[f]	7,000 ^[e]	18,000 ^[f]
Average Yearly Investment	Euro/year	Interest Rate Insurance and tax rate	%	Salvage Value (€)	€	55,250	34,450	43,160	26,000	42,900	13,000
Depreciation	Euro/year	Interest Data	%	Purchase Price (€)	€	425,000 ^[a]	265,000 ^[a]	332,000	200,000	330,000 ^[b]	100,000 [
Repair an Maintenance	% of depreciation	Productive Machine Hours	hrs/year	Fixed Costs							
Insurance and tax rate	%	Utilisation Percentage	%	масшие	Unit		TITOL		SIUL		(loader)
Interest Rate	%	Scheduled Operating hours	hrs/year	Machine	Unit	Brash Bundler	Forwarder 1110E	Harvester	Forwarder 810E	Shredder	Excavate
		Economic Life	years	6.9 0	Coillte						
Productive Machine Hours	hrs/year	Salvage Value	Euro	47000	20%						
Utilisation Percentage	%	Machine Power	kw	86	20%						
Scheduled Operating hours	hrs/year	Initial Investment	Euro		ohn Deere						
Economic Life	years	Forwarder 810D E	-								
arrage value	Euro										
Machine Power Salvage Value	kw	136									

August 2008 Version 1.10

IRISH TRUCK PRODUCTIVITY AND COSTING MODEL

W

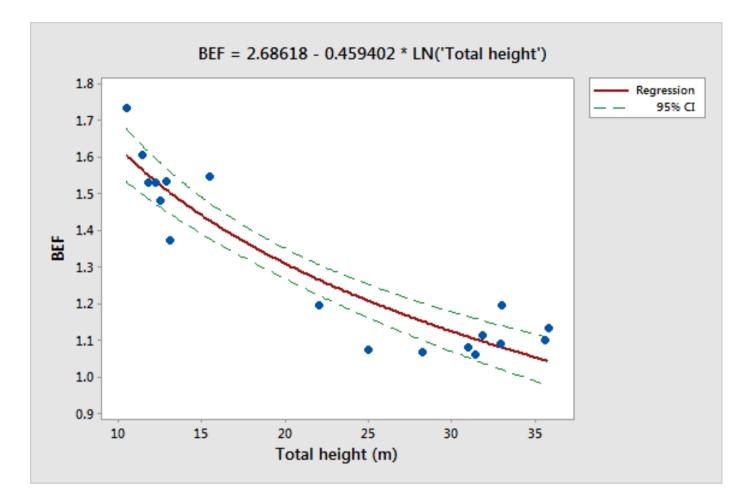
Glen Murphy

Route Number	Truck Configuration			– Load Type (Select thi	s First)	Extras to be Included	Work Sheets
Date	Articulated C Rigid + T		With Crane	C Logs Only	C Logs + Other	LabourOverheads	Labour
Outputs	Axles 0 3 • 4 • 5 • 0	C 6	LOAD TYPE FIRST	C Slash: Loose	O Slash: Bundle	 Pickup Separate Loader 	Overheads
Clear Print	Current Fuel Costs (€/	(litre)	0.00	C Chips: Clean	C Boiler fuel	Calculate Costs	Pickup
Annual Costs (€ per annum)			Trucking Rate				Compared 1
Labour		0	Prod'n est	imate (tonne-km	n per annum)	0	Separate Loader
Overheads		0	Trucking ra	ate (€/tonne-km))	0.000	Truck and Trailer
Pickup		0	Trucking ra	ate (€/tonne-km	rounded)	0.00	Routes
Separate Loader		0	Trip Cost (€/tonne) for	0 km (or	ne-way) is: 0.00	
Truck and Trailer		0	Energy Profile				Speeds and Loads
Other Equipment Costs (i	fany)	0	Fuel Cons	umption for Rou	ute: Per Day (lit	res) 0	Conversion Factors
Sub-total		0	Fuel Cons	umption for Rou	ute: Per Year (li		
Profit 0 (% of C	osts)	0	Fuel Cons	umption for Trip	: (litres)	0	Instructions
Total Costs (€ per ann	um)	0					Raw Data
Acknowledgement: Parts of this model	are based on the Truck Costing M	lodel originall	lly developed by th	e New Zealand Loggin;	g Industry Research 0)rganisation in the mid-1990's.	Exit

Yield Model

Select yield tab Species Shining gum Mapped Specie Poplar	le T	Initial spacing		Thinning treatm	ient			
Shining gum	•	-Initial spacing-		Thinning treatm	ient			
Mapped Specie	<u> </u>					yield		
Poplar	s	2.7m						volume assortment
J. op.a.				No Thinning				
							? 🖘	values for age
Weeld deep	12 🔺							
Yield class	12 💌	0.14						clear
🔺 Display yield ta	ble mapped fr		(PO - YC 12 - 2	.7m - NT - NT)				
					Max M	AI age Initial	spacing	Stand area
Poplar		12					2.7	1.00
Age	Тор	Trees	Mean	ВА	Mean	Vol	Percent	MAI
yrs	ht m	/ha	dbh cm	m²/ha	vol m³	m³/ha	mortality	vol m³/ha
8	12.3	1320	14	20	0.07	91	0	11.3
9	13.5	1315	15	23	0.09	120		13.4
10	14.7	1310	16	27	0.11	150	0	15.0
11	15.9	1306	17	30	0.14	180	0	16.4
12	17.1	1301	18	34	0.16	210	0	17.5
13	18.3	1297	19	37	0.19	240	0	18.5
14	19.4	1286	20		0.22	278		19.9
15	20.4	1276		44	0.25	316		21.0
16	21.4	1266			0.28	353		22.1
17								23.0
								23.8
			24			463		24.4
20	25.2	1220	25	60	0.41	498	0	24.9
	Display yield tal Species Poplar Age yrs 10 11 12 13 14 15 16	Species Poplar Age yrs Top ht m 8 12.3 9 13.5 10 14.7 11 15.9 12 17.1 13 18.3 14 19.4 15 20.4 16 21.4 17 22.5 18 23.5	Age yrs Top ht m Trees /ha Age yrs Top ht m Trees /ha 12 Age yrs Top ht m Trees /ha 13 1320 9 13.5 10 14.7 11 15.9 13 18.3 13 18.3 15 20.4 16 21.4 15 20.4 16 21.4 17 22.5 18 23.5	Age yrs Top ht m Trees /ha Mean dbh cm 8 12.3 1320 14 9 13.5 1315 15 10 14.7 1310 16 11 15.9 1306 17 12 1301 18 18 13 13 18.3 1297 19 14 19.4 1286 20 15 20.4 1276 21 16 21.4 1266 22 17 22.5 1256 23 18 23.5 1246 24	Age yrs Top ht m Trees /ha Mean dbh cm BA m²/ha 8 12.3 1320 14 200 9 13.5 1315 15 233 10 14.7 1310 16 277 11 15.9 1306 17 300 12 1301 18 344 13 18.3 1297 19 377 14 19.4 1266 22 48 15 20.4 1276 21 44 16 21.4 1266 22 48 17 22.5 1256 23 51 18 23.5 1246 24 54	Age yrs Top ht m Trees /ha Mean dbh cm BA m²/ha Mean vrs Mean m²/ha Mean w²/ha 8 12.3 1320 14 20 0.07 9 13.5 1315 15 23 0.09 10 14.7 1310 16 27 0.11 11 15.9 1306 17 30 0.14 12 1301 18 34 0.16 27 10 14.7 1310 16 27 0.11 11 15.9 1306 17 30 0.14 12 17.1 1301 18 34 0.16 13 18.3 1297 19 37 0.19 14 19.4 1286 20 41 0.22 15 20.4 1276 21 44 0.25 16 21.4 1266 22 48 0.28 17 22.5 1256	Age yrs Top ht m Trees /ha Mean dbh cm BA m²/ha Mean vol m³ Vol m³/ha Initial Age yrs Top ht m Trees /ha Mean dbh cm BA m²/ha Mean vol m³ Vol m³/ha Initial 8 12.3 1320 14 20 0.07 91 9 13.5 1315 15 23 0.09 120 10 14.7 1310 16 27 0.11 150 11 15.9 1306 17 30 0.14 180 12 17.1 1301 18 34 0.16 210 13 18.3 1297 19 37 0.19 240 14 19.4 1286 20 41 0.22 278 15 20.4 1276 21 44 0.25 316 16 21.4 1266 22 48 0.28 353 17 22.5 1256 23	Age yrs Top ht m Trees /ha Mean dbh cm BA m²/ha Mean m²/ha Mean m²/ha Mean m²/ha Mean vol m³ Vol m³/h Percent mortality Age yrs Top ht m Trees /ha Mean dbh cm BA m²/ha Mean vol m³ Vol m³/h Percent mortality 8 12.3 1320 14 20 0.07 91 0 9 13.5 1315 15 23 0.09 120 0 10 14.7 1310 16 27 0.11 150 0 11 15.9 1306 17 30 0.14 180 0 12 17.1 1301 18 34 0.16 210 0 13 18.3 1297 19 37 0.19 240 0 14 19.4 1286 20 41 0.22 278 0 15 20.4 1276 21 44 0.25 316 0

Biomass expansion factor



For now, using top height as an input

Results: In progress

Scenario: YC: 10 Harvest year: 15 Extraction Distance: 200 m Haulage Distance: 50 km

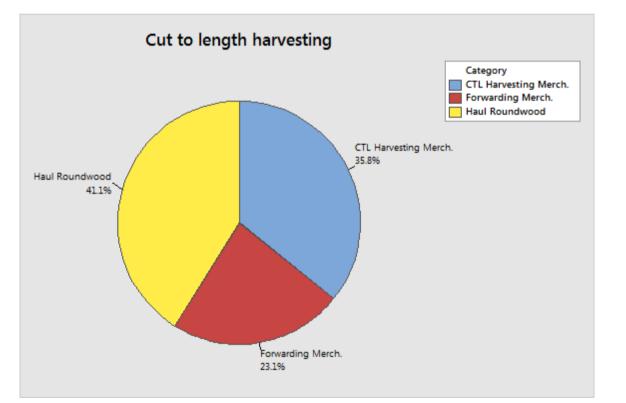
CTL harvesting

Merch.
Merch. Volume / ha
258

Operation		Cost / ha €
CTL Harvesting Merch.	Υ	1744
Forwarding Merch.	Y	1129
Haul Roundwood	Y	2005

Fuel Characteristics: Database

Value of products: Market Survey



Scenario: YC: 10 Harvest Year: 15 Extraction Distance: 200 m Haulage Distance: 50 km

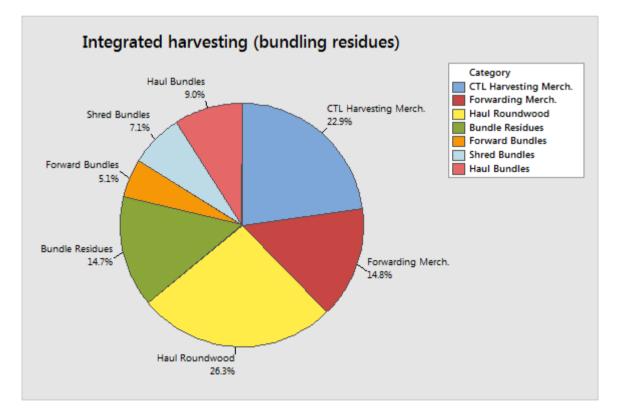
Integrated harvesting (bundling residues)

Merch. Volume / ha	Residues odt / ha
258	36

Operation		Cost / ha €
CTL Harvesting Merch.	Y	1744
Forwarding Merch.	Y	1129
Bundle Residues	Y	1123
Forward Bundles	Y	389
Shred Bundles	Y	542
Haul Roundwood	Y	2005
Haul Bundles	Y	688

Fuel Characteristics: Database

Value of products: Market Survey



Next: Include establishment and maintenance costs. Then evaluate the time cost

400	ha		
42	hour		
			250
150	ha		
		1	
330	tonne		82.5
		100 kg per ha	37
12.5	50 kg		87.5
		2500	625
130	1000	2500	325
		1	
6	m		
		I	
			120
130	ha		130
	1		
140	na		
57.5	ha @ 5 %		57.5
	42 390 250 150 330 370 400 12.5 250 120 130 33 4 6 17 6 130 IFA 140 140	120 1000 130 1000 3 m 4 m 6 m 17 m 6 m 17 m 1000 1000 1100 1000 1100 1000 1100 1000 1100 1100 1100 1100 1100 1100	42 hour 390 ha 250 ha 150 ha 330 tonne 250 kg per ha 370 tonne 100 kg per ha 400 tonne 12.5 50 kg 250 1000 12.5 50 kg 120 1000 130 1000 2500 130 130 1000 2500 130 130 1000 130 1000 1310 1000 140 ha 140 ha

Need fencing and roading

Run analysis for NPV and Discounted cash flow

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Vrogetation Clarance 0		400 ha	T							0	0	0	0 0	0	0	0 0	0	0	0
Ground Prop. Ground Prop. <td< td=""><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>0</td><td>0</td><td>0 0</td><td>0</td><td>0</td><td></td><td></td><td>0</td><td>0</td></td<>											0	0	0 0	0	0			0	0
Mounding 330 ha 0 <	Coursed Boose								· · ·										
Ploaghing 150 ha I <t< td=""><td></td><td>390 ha</td><td>1</td><td></td><td></td><td></td><td></td><td></td><td></td><td>0</td><td>0</td><td>0</td><td>0 0</td><td>0</td><td>0</td><td>0 0</td><td>0</td><td>0</td><td>0</td></t<>		390 ha	1							0	0	0	0 0	0	0	0 0	0	0	0
Fertilizer O <tho< td=""><td>Ripping</td><td>250 ha</td><td>250</td><td>1</td><td></td><td></td><td></td><td></td><td>Ripping</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>0</td></tho<>	Ripping	250 ha	250	1					Ripping										0
Fertilizer Pertilizer Pertilizer <td>Ploughing</td> <td>150 ha</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>-</td> <td></td> <td></td> <td>0</td> <td>0</td> <td>0 0</td> <td>0</td> <td>0</td> <td>0 0</td> <td>0</td> <td>0</td> <td>0</td>	Ploughing	150 ha						-			0	0	0 0	0	0	0 0	0	0	0
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NPK 400 toone Image: Sole grade and planting NPK 0	Nitrogen										v	-		~	-			-	0
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