Crown mechanization: a challenge!

- Motor-manual workforce
- Demand of biomass
- Invasion of irritating caterpillars (*Thaumetopoea processionnea*) in Moselle → human health problems
Crowns: a source of additional biomass

Important resource in public forests: 17 500 ha/year in 3 regions

=> 247 000 – 411 000 m³/year (oak and beech)

Last thinnings

Regeneration cuttings
(3 progressive regeneration cuttings and final clear cutting)
Specifications of the logging system

- Capable of processing the crowns from the permanent corridors while preserving the remaining trees and the regeneration
- Efficient whatever crown’s morphology, reliable and cost-effective
- Operated from an enclosed cab
The logging systems tested

Single machine system

Case studies: 2 forwarders, 5 logging sites, 2013/2014

Grapple saw

Weight scale on the boom

Two machines system

Case studies: 1 excavator + 1 forwarder, 2 logging sites, 2015
Single machine system

HSM 208F 12 T
+ Compactor

Valmet 801 Combi
13 T

- Crane 10 m + grapple saw + weight scale
- Enclosed cab with air filtration
- 8 wheeled machine with flat tiles tracks
Two machines system

**Excavator TEREX TCX 125**
- Crane 5.9 m
- Grapple saw

**Ponsse Gazelle 10 T**
- Crane 10 m
- Boom scale
Single machine system
Content of the case studies

- Time studies on a sample of cycles (from 5 to 18 forwarding cycles by site, total 73 cycles)

- Work step recorded every 15 seconds (Instant Observations method)
  - Moving empty
  - Processing: moving out the boom, preparation of the crown, crosscutting…
  - Loading and moving from one crown to another
  - Moving back with load to the landing area
  - Unloading
Characteristics of the 7 logging sites

Triangles = HSM, Scares = Valmet, Circles = 2 machines system. Fresh tons
Characteristics of the crowns

- 73 forwarding cycles for 276 crowns (522 tons)

Mean and confidence interval of 95%
Results: machines suited for the processing of the crowns!

- **Lesson 1** Machines equipped with grapple saw were able to process all crowns
- **Lesson 2** The distance between the corridors and the crane’s capacity are key factors
- **Lesson 3** Using a crane preserves the remaining trees and/or the regeneration
Productivity: main determinants (1/5)

- **Lesson 4** The forwarding distance influences forwarder’s productivity

*But distance is not the only criteria...*
Lesson 5: The high expansion rate of crowns hinders the overall transported tonnage… whereas the compactor increases loading rate.

Loading rate = mean load/theoretical load capacity

Loading rate: 0% - 120%

- SAN-P194
- RAN-P5
- Gazelle 10_S
- FEN-P076, FEN-P054, FEN-P083, FEN-P191
- COMBI_13_S, HSM F12_S, HSM F12_C
- CHA-P185

… whereas the compactor increases loading rate.
Lesson 6: Time consumption for processing crowns is the lowest for the single machine system.

- About 600 to 700 s/t for the 2 machines system, (global productivity of the whole system of 5.1 à 6.2 t/pmh)
- 200 to almost 400 s/t for the single machine system (9.7 up to 17.8 t/pmh)
Lesson 7: Productive working time is proportional to number of saw cuts.

Processing time (for the single machine system loading is included) and number of saw cuts.

Correlation coefficient (Pearson, $r$) = 0.92; $p < 0.0001$. 
Lesson 8 Additional processing of the slash hinders productivity

- 7% of the working time for RAN-P5
- and up to 21% for CHA-P185

Lesson 9 The higher the crop per ha, the better the productivity of the operation
Single machine system, the technical costs vary between 7.6 and 14 €/ton

Two machines system, the technical cost of the excavator varies from 12.8 to 16 €/ton + forwarder’s technical costs are about 7.3 €/ton => 20.1 €/ton to 23.3 €/ton
Conclusion

- The full mechanization of large broadleaved crowns is an operational reality and has been facilitated by the development of wood energy.
- The grapple saw has proven to be an efficient and easy to use tool, in addition to being a small investment for the entrepreneur.
- The single machine system, a forwarder equipped with a grapple saw, is the best performing system.
- An asset of the 2 machines system (excavator with grapple saw and forwarder) is the capacity to separate the operations in time.
- This study contributed to highlighting the various factors which influence the productivity of the systems.
Thank you for your attention!

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