Operation of energy wood plantation with special regard to harvesting technology and timber logistics

I Czupy

K Szakálosné Mátyás, A L Horváth, B Horváth S Beszédes and A Vágvölgyi

1 University of Sopron, Faculty of Forestry, Institute of Forest- and Environmental Techniques, HU

2 University of Szeged Faculty of Engineering Department of Process Engineering, HU

E-mail: imre.czupy@uni-sopron.hu

Abstract. One possible solution for the production of wood for energy or industrial purposes is the planting of energy wood plantations. In this type of target plantation, a large amount of dendromass can be produced in a short time. Before the afforestation the site survey is highly important. Based on the results the tree species can be chosen and the corresponding cultivation technologies can be planned. Energy plantations are generally man-made forests with fast-growing species and the rotation period is short. Therefore it is necessary to determine the method of harvesting and the corresponding machine system already at the planning phase. After harvesting the timber should be transported in a short period of time in order not to prevent the development of the next tree stand. At the transport large amount of wood chip must be moved for shorter or longer distance. Thus the applied logistic plays very important role in the whole process, by making the operation of timber utilizing power plants as profitable as possible.

1. Introduction

Biomass is of the most importance in renewable energy sources in Hungary. In the short time we have been able to produce large quantities of dendromasses, which can be used for industrial or energy purposes depending on the technology. Depending on state aid, energy wood plantations in the coming years may play a greater role in the production of decentralized energy production.

2. Establishing and nursing of energy plantations

Before the establishment of energy plantations, a site survey expertise must be prepared, that describes the areal conditions. Based on the expertise, yield- and impact study and the formulation of the cultivation technology performed in the planning phase or the working out of the potential extension opportunities. To the species selection a soil profile opening and checking is needed per 5 hectar. The common test of the taken soil samples is suggested (ex.: measurement of pH, CaCO₃, physical property of the soil, gross salt %, humus content %. Al- phosphorus, potassium, gross nitrogen). To reach the growth intensity of the plantation the usual recycling of nutrients into the soil required. For the planning of it, average sampling proposed per 5 hectars, at least from soil layers 0-30 and 30-60 (60-90) cm deep (depth of rooting importance). With the average sampling extended test – over the before listed factors – we measure the compactness index, water soluble gross salt, \( \text{NO}_3+\text{NO}_2 \), \( \text{P}_2\text{O}_5 \), \( \text{K}_2\text{O} \), Na,
Mg, SO₄, Mn, Zn, Cu contents. With the annual perform these tests the change of each arguments can followed up in the soil, hereby the nutrient needs and crop forecasting can be realized [6].

In the case of damaged areas naturally need to consider the kind and depth of pollution of area, why this has an affect on the choice of species. The cultivation technology of energy plantations need to choose individually, considering the local conditions. The applicable technologies: determine the magnitude of the plantation, areal conditions, available machinery and logistics influence factors [2].

The initial spacing depends on the species and clone, the predictable felling cycle, site, the utilization of crop and the applicable harvesting method. One or twin row initial spacing can be formed. The one row planting spacing every, with middle length or long-term rotation grown species can be suggested, but when we aimed short term rotation, then the twin row planting spacing proposed. The distance between twin rows is about 70-75 cm because of the effective mechanized harvesting and in-row spacing between plants is 50 cm [4]. The planting can achieved several ways: with notch planting; planting auger; sapling planter; small-, medium, and high productivity tree- or sapling planting machine etc.

In year of planting we can expect dense weed vegetation, that can handled with repeated weeding. In flat areas the mechanical interrow weeding is enough, the apply of rotary machine advised instead of rotavator or cultivator. The use of chopper is better on humid and semihumid lands, because the surface soil keepepd compact, so lesser erosion endangers it. In sloping lands, against the water erosion and deflation on the ground, among industrial crops the use of low growth, perennial xerophyte plants advised, which after reaching an allowed height need to cut back (crushing of stems). From aspects of enviromental and nature protection beside or instead of a mechanical weeding chemical weed control is required. Weed control with lubrication technology is belong to alternative treatments. The chemical lubricator machines get the chemical concentration liquor in form of liquid film up to the foliage of the plants. In case of sprinkling technology, with the help of a sprinkling unit set up on a rotavator, the mechanical and chemical weeding could perform in singlepass [3].

The rate of nutrient recycling into the soil affect by the producing-method and the areal conditions. Before the plantation, after the harvesting and after liquidation of plantation the amount of the main nutrients need to be checked. If the soil’s nutrient supply applied, then as a result of leaf shedding and the following mineralization, it is enough to supply the nutrient loss by the growth. The rate of nutrient recycling depends on the species, site, rotation period and on the yield. As long is the rotation period, so large is the ratio of nutrient-poor stems relative to the gross production. As small is the ratio of the branchwood, so small is the net of N-,P-, K-, Ca- és Mg-abstraction from the area [4]. Several opportunities presents itself for nutrient supply: organic fertilizers, other biological waist, mineral fertilizer, dry stabilizing compost, silt compost and ash.

3. The harvest of energy plantations

The harvest of plantations depends on the rotation period, but always happens out of the growing season. Must have an intention on working in the absolute vegetation dormant season. At this time the stand is leafless, and next year root and shoot growth haven’t started. That means the november-march period pending from the weather. The optimum for harvesting is in nip, because the soil is well passable, the rhizospher doesn’t suffer harm. By the first harvest evolved trunks (cut ends) has to be close to the soil surface, because by the next harvest cutting height by harvesting must be above the previous, to avoid bigger cut end, than ideal. By the harvest must have intention on to form the possibly most smooth cut end. In good practice harvesting period the product’s water content is about 50-55%, and in extreme cases the dry matter-content can reach 45-60%.

The marginal rows of the plantation, because of the advantageous site conditions (bigger growing space, more light and water) has larger base diameter, as the other individual of the plantation. In some cases the harvest of these trees (cutting) requires higher capacity machines or different harvest method. The costs of harvesting pending on the gross charges takes the producing costs 50-80%, so the small harvest cost and the choose of the optimal harvesting method is a key factor [4]. The short rotation wood energy plantations cut(harvest) working system essentially determine the producing technology (rotation, initial spacing), the type of harvesting(chopping, rolling or wholetree) and the size of the area [5].
Harvest working systems:
Depend on the rate of harvesting mechanization the following working systems can be isolated:
- manual harvesting;
- mechanical multiple harvest (periodic, multiphase, multipass);
- mechanical single harvesting (singlepass).

The type of the stand – coppicing or roller wood energy plantation – need to take into consideration by the choosing of working systems.

Table 1. To working systems belonging engine types and line-up

| Mechanical harvest working systems | Copping energy plantation | Roller energy plantation |
|-----------------------------------|---------------------------|--------------------------|
| Manual harvesting                 | Clearing saw              | Chain saw                |
|                                   | The U-bolt chain saw      |                          |
|                                   | Chain saw                 |                          |
| Cutting and controlled felling machines | Mounted logging machine | Crane power machine with feller-collector head (eg.: Naarva Grip 1500) |
|                                   | Crane power machine with circular felling head (eg.: Bracke C12.a) | Crane power machine with feller-collector head (eg.: Naarva Grip 1500) |
|                                   | Crane power machine with pressing knife felling head (eg.: Schnitt-Griffy HS 850) | Crane power machine with feller-collector head (eg.: Naarva Grip 1500) |
| Feller-buncher                    | Crane power machine with feller-collector head (eg.: Naarva Grip 1500) | Crane power machine with feller-collector head (eg.: Naarva Grip 1500) |
|                                   | Crane power machine with feller-collector head (eg.: Naarva Grip 1500) | Crane power machine with feller-collector head (eg.: Naarva Grip 1500) |
|                                   | Crane power machine with feller-collector head (eg.: Naarva Grip 1500) | Crane power machine with feller-collector head (eg.: Naarva Grip 1500) |
| Harvested timber processing machines | Branchwood-bundler machines (eg.: John Deere 1490D) | Mobile chipper (eg.: Mus-Max Wood Terminator 8XL) |
|                                   | Mobile chipper (eg.: Junkkari HJ500) |                          |
| Forwarder machines                | Forwarder inuts (tractor with trailer) | Forwarder inuts (tractor with trailer) |
|                                   | Forwarders (eg.: Valmet 860.3) | Forwarders (eg.: Valmet 860.3) |
|                                   | Collector-forwarders (eg.: Ponsse Buffalo Bio) | Collector-forwarders (eg.: Ponsse BTS) |
|                                   | Rolling bundlers (eg.: Salix maskiner) | Harvesters (eg.: Ponsse Ergo 8WD) |
| Feller and collective processing machines | Rolling-balers (eg.: Biobaler-WB 55) | Feller-bundlers (eg.: Valmet-Fixteri) |
|                                   | Feller-bundlers (eg.: Valmet-Fixteri) |                          |
| Feller-forwarder machines         | Windrowing-collector-forwarders | Feller-collector head equipped forwarders |
### Manual harvesting

In case of smaller ground plantations, this method is applied. The tool of cutting from base and controlled felling – by coppicing stands – is a clearing saw, the U-bolt chain saw, and chain saw. The U-bolt chain saw can be used to cut trees with a diameter of at most 10 cm. The tool for roller wood energy plantation harvest is the chainsaw. The chopping of timber can be materialized in the following ways:

- The timber chopped with mobile choppers, then transported to the place of use.
- They forward the timber to the edge of the ground or to a formed landing, where later the chopping happens with a mobile or installed chopper. The chips are transported by vehicles to the users.

### Mechanical multiple harvesting

In case of mechanical multiple harvesting, the harvest and chopping of timber in different time – in some cases on different places – comes true. The harvesting, the hauling and processing work phase made by variable machines. The make of chops could be done at felling site, at landing or at the place of use. (Figure 1. Schnitt-Griffy HS 850 - Crane power machine pressing knife felling head)
3.3. Mechanical single harvesting

By mechanical single harvesting the base cutting and chopping happens at once. The used machines do the felling, the chopping and deliver it to a storage unit (container, trailer). (Figure 2 Preuss-Silvatec-Feller chopper with container)

To the each working system belonging machine types and their line-up includes Table 1. Considering the economical aspects, need to intent on using machines, that for them in off-season cannot grant work on agri- and sylvicultural areas.

The harvesting and transporting tasks influenced by several factors. It merely claims complex planning to choose the method of harvesting, which encumbered by the defining of different transporting opportunities. The continuously changing and suddenly arising influencing factors, such as weather, can throw a spanner into the works and induce rapid redesign tasks.

4. Utilization of energy plantation timber

By the harvesting of energy woods – depend on their size, form and quality attributes – could be formed industrial wood, but frequently chops or other product produced. From industrial wood assortment mostly just pulpwood for boards, particle board bolt, pulpwood figured, that can give the source material of veneer plywood, paperboard, chemical pulp production. The chops usually goes to a heating- or power plant, but gives the base of pellet-, briquett- and biofuel (biomass to liquid)
production. Other exploitations have to be mentioned like nursery, flower arrangement and the make of ornamental pieces, and bailed baskets.

The delivery of timber of energy plantations to the user seems to be easier, like assortment transporting, but from the timber crop production forests, but that’s not true. The well built logistic system makes wooden chips transportation from energy plantations for power plant use smooth, and for this we require:

- The coordinates of the energy plantation need to be harvested or of the chips disposal site
- The computer planning of the transporting to the power plant
- Continuous, updated data traffic between the participants of the system (Figure 3)
- For the computer control of harvesting (chipping, drying), loading and transfer.

The chips transporting in logistics systems several benefits realisable. The wooden chips using plant have for ex. exact, updated information about the amount, quality and delivery of the material. The efficiency increasable, while there’s a chance of rapid and optimal planning, from which a detailed easily re-shaped transportation plan can be prepared. The amount of harvested timber known from the central database, so the supply capacities can be fixed to actual quantities. Online information is at the operators (harvester, chopper operator) disposal, so with known suitable coordinates the site of the work easily and quickly can be visited. Performance data of their work fixable updated. For the owner an manager of the land the place of a plantation and it’s area clearly defined, the yield datas and the quality of timber is at service [1].

5. Liquidation of energy plantations

Once the energy plantations have been eliminated, the state prior to the installation has to be restored. After last harvesting, the stumps, roots need to be remove and execute deep-ploughing on the ground onto which the equivalent is a three-point hitch, TLT driven, central positioned, reinforced special stump biter. The aim of the procedure is the machining of major proportion of stump and root parts and the deep-ploughing becomes possible with which the agricultural land-use assured.

![Figure 3. Chop-production and delivery logistic system](image-url)
6. Conclusion
Summerizing, it can be stated that the harvesting operation in the cultivation technology of energy tree plantations is of the most importance both technically and economically. In order to have the timber in the right quantity and in time for the power producer unit to have access to a well-established logistics system is required.

7. References
[1] J Benkő 2000 Logisztikai tervezés, Dinasztia Kiadó HU: Budapest 199 p
[2] B Barkóczy 2009 A dendromassza alapú decentralizált energiatermelés alapanyagbázisának tervezése Ph.D. dissertation MSc. in Forestry Eng. University of West Hungary Sopron HU
[3] T Kladiva 2007 Technológiai vizsgálatok energiaerdő telepítésénél az EGERERDŐ ZRt területén M.S. thesis MSc. in Forestry Eng. University of West Hungary Sopron Hungary
[4] P Liebhard 2010 Energetikai faültetvények Cser Kiadó HU Budapest
[5] B Marosvölgyi and B Horváth 2010 Biomassza-előállítás és- hasznosítás FVM Vidékfejlesztési Képzési és Szaktanácsdási Intézet HU Budapest
[6] I Riesing 2007 Tápanyag-utánpótlási kísérletek energetikai faültetvényeken M.S. thesis MSc. in Forestry Eng. University of West Hungary Sopron Hungary
[7] J Rumpf, K. and K Szakáloesné Mátyás 2004 Logisztikai rendszerek alkalmazása az erdőgazdálkodásban, Logisztika Évkönyv MLE HU: Budapest pp 137-142
[8] H Habbig Maschinenbau The Schnitt-Griff – Cutting and clearing in one work step. Leaflet Schnitt-Griffy [Online] 2 p Available: https://www.hans-habbig.com/fileadmin/user_upload/prospekte_2017/650-850/leaflet_schnitt-griffy_en.pdf
[9] A L Horváth 2015 Többműveletes fakitermelő gépek a hazai lombos állományok fahasználatában Ph.D. dissertation MSc. in Forestry Eng. University of West Hungary Sopron HU

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