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Conception of the technology of wood production out of short rotation coppice – Part 1

To reach the ambitious german aims in energy and climate politics within ten years, it will be necessary to focus on renewable resources. Great potential is seen in short rotation coppices (SRC), which are based on fast growing wood to use it for energetic and material applications. So far, the installation of these coppices was not very successful, because farmers had have to enter unknown territory and got no overview of economic risks. A lot of scientific institutions acquired knowledge, so they are able to give basics to farmers.

Keywords
Short rotation coppice, energy wood production, wood chips

Abstract
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In Germany there are currently about 3,500 ha of SRC [1]. In view of the neighboring countries such as Sweden [2], Denmark or Poland [3] that seems to be minor. However, the previous growth rates promise a quick catch up for the following years because the acreage has already been doubled since 2008. So, the few existing tree nurseries acknowledged a real sell-out of their production far in advance [4]. One example is given: In 2009, the RWE Group announced their ambitious aim to build 10,000 hectares of SRC in Germany within the next four years [5], and encounters already problems in land acquisition. Today, it is essential to solve the conflict between food and energy production while farmland permanently decreases. If short rotation coppices turn out to be particularly beneficial, they can produce a much higher yield than conventional forestry.

For most farmers in Germany the cultivation of fast growing tree species is in many ways unknown territory. So, large-scaled projects such as DENDROM or AGROWOOD were accomplished in order to get experience in SRC. The latter project has highlighted a shortage of mechanization, founded in a basic lack of technology for economic processing of SRC [6]. At the professorship of agricultural machines of the Technische Universität Dresden research is carried out at several stations throughout the process chain. One aim is to offer technical solutions for the installation, maintenance and harvesting of SRC as well as the drying, storage and preparing of wood chips. Initial developments and knowledge will be presented below.

Challenges in the mechanization of the process line

According to an investigation by Scholz [7] the amount of the available machines on the market was determined for individual steps of the process line. For example, approximately 40 machines could be identified that are suitable for harvest. However, most machines existed only as prototypes, and many solutions are not currently pursued any further. So, the number of providers of mature technology remains manageable compared to the number of conventional agricultural machines. A great potential in the increase of machine performance is expected for processing machinery in SRC.

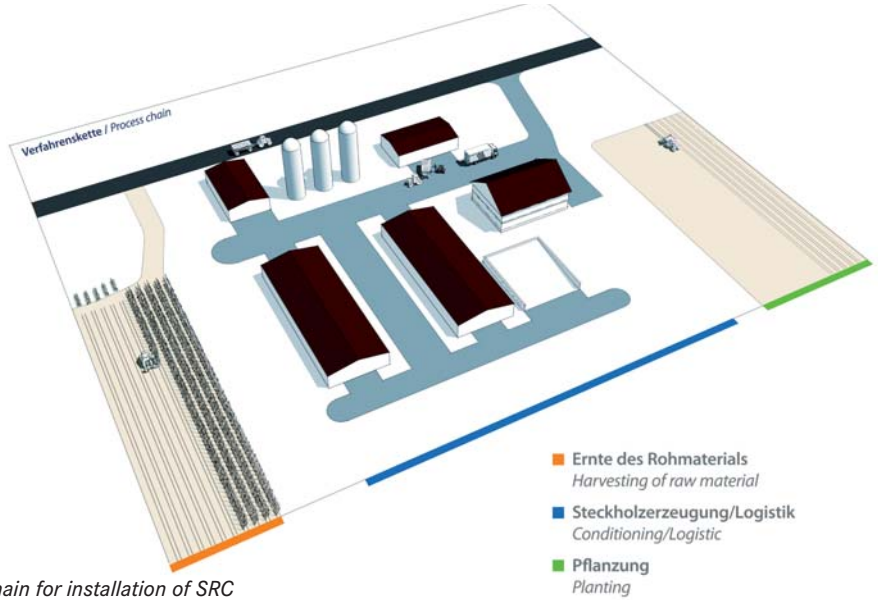
Provision of cutted rods and installation of plantations

As shown in **figure 1**, the following sub-processing steps are necessary to install new farmland within SRC. These steps are divided spatially and temporally:

- Harvest of raw material (rods)
- Manufacturing and confectioning of cutted rods, warehousing and distribution
- Installing of new SRC farmland

The current situation shows that especially the second step is dominated by a manual employment up to 100 %. The large seasonal demand on manpower leads to low productivity, poor availability and high seed costs. Ongoing and planned R&D projects at the professorship of agricultural machines of the Technische Universität Dresden aim at identifying technical solutions for efficient plant production that covers the demand.

Fig. 1



Necessary process chain for installation of SRC

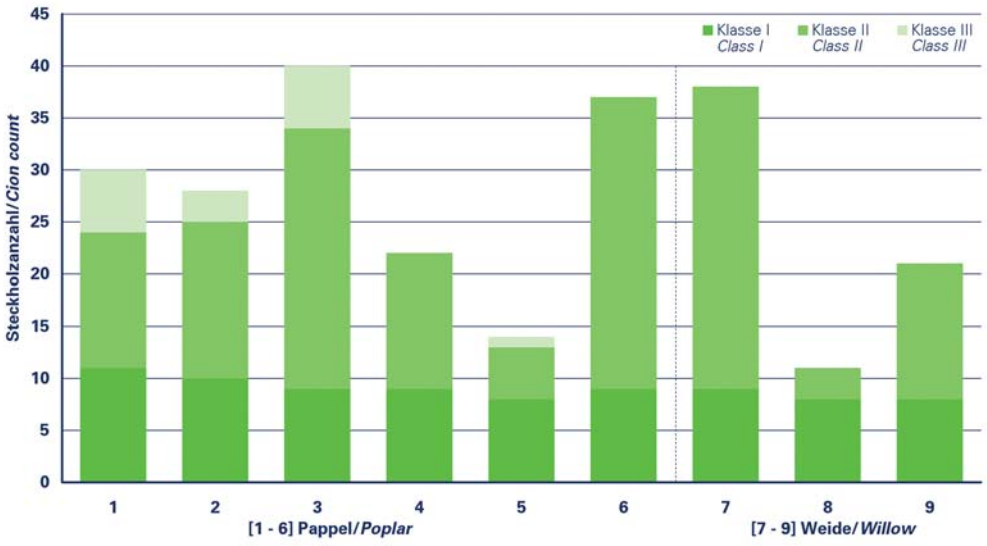
Harvest of raw material

At tree nurseries the harvest of the rod-shaped propagating from mother plantations has to be carried out with low loss and no damage at tree stock and rod rind. If it is possible, the raw material is harvested at the first frost. The production of cutted rods and their logistics have to be accomplished within 6-8 weeks before the beginning of planting time.

The attainable yield varies significantly, depending on location and tree species (**figure 2**). After deducting harvesting and processing losses, only 60,000 to 300,000 cuttings/ha can be obtained for vegetative reproduction. Up to 50 % of the harvest is waste that can not be used for further production. A classification of thickness (**figure 3**) is favored so that a constant growing up of new installed SRC is guaranteed. Additionally, a higher functionality of automatic planters is achieved by applying this classification, which was confirmed by research results at the Technische Universität Dresden.

Manual harvest of raw material limits the quantity of production in tree nuseries, especially when unfavorable weather conditions dominate. Therefore a versatile crop cultivation implement for tractors with a vertical crop flow (**figure 4**) was developed. Currently, the field tests with the prototype are running. After the first operations with the machine at harvest, the required manpower was reduced from four to two (manual binding) even at a higher crop performance. The bundle of rods was mechanically laid down at the end of the row.

Fig. 2



Typical variance of the sort, shown is the maximum of recoverable cuttings per plant for poplar and willow

Manufacturing and confectioning of cutted rods

The conditioning of raw material to cutted rods is executed stationary in a storage building and contains the following steps at least: Preparing/quality control, cutting, sorting/portioning, bundling, packaging.

The cutted rods are then stored for sale in cold rooms. The added value of further conditioning stages, such as sealing the cut ends, application of growth additives and thickness classification is discussed by experts, but scientifically (still) not established. These steps still request more handwork which can not be realized in the short available time. Therefore, the Technische Universität Dresden, especially the professorship of agricultural machines is looking for modular, technical solutions for this issue.

Fig. 3

Klasse I/*Class I*: 8-12 mm
Klasse II/*Class II*: 13-17 mm
Klasse III/*Class III*: 18-30 mm

Favoured classification of thickness by TU Dresden

Planting

On the market available planters handle whole rods or put single cutted rods, usually using planting wheels, directly into the ground. Whole rods handling planters have proved themselves when installing willow plantations (straight rods, slightly sticking out buds). Machine systems, such as Step Planter (manufacturer: SalixPhere) or Energy Planter (manufacturer: Egedal) do not operate reliable at poplar planting, however. For the planting of poplar cutted woods, machines were developed on bases of forestry planting technology (manufacturer Spapperi, model: Piantatalee). The feeding of cutted woods is done manually directly on a ground-driven plant wheel. Rod planting machines need one tractor and half a worker per row. Cutted wood-planters require one worker per row. 2-6-row planting machines have been already used. The direct assignment of the operator to the plant organ (planting wheel) is ergonomically disadvantageous and causes huge compromises in the overall conception of the machines. Also the mechanical planting on rocky soil still creates problems. The professorship of agricultural machines of the Technische Universität Dresden is pursuing the aim to separate physically the main functions of dosage and planting and to do an automation in a second step. For transport processes from the dosing unit to the planting wheel and the removal of cutted rods from the ordered heap in a storage a patented process is used which optionally works pneumatically. By using a consistently modular machine design, it is possible to increase the storage capacity for transported cutted rods onboard on the machine. Currently, preliminary investigations are running to study pneumatically assisted automation of the main functions feeding, transporting and embedding the cutted rods in the seed groove. To explore new concepts of planters and the effects of varying planting material (thickness classification, different species and pretreatment) with respect to the function of the modules, a modular test machine was built in cooperation with the industrial partners „Bioenergiehof Böhme GmbH“ and „Mohn Manufaktur GmbH“ (**figure 5**). The aim of current field tests is to develop a new machine design, find and

Fig. 4

Fig. 4: Prototype, while harvesting bunches (left), mechanical discarded bunch (right). Fotos: Grosa, TU Dresden

test possible shapes and configurations of functional modules. The medium-term aim of the R & D work is to achieve an operating performance of 3.0 to 4.5 ha/h (4- or 6-row planting) at an operating speed of 6.0 km/h.

Conclusions

For multiannual crops, such as the wood producing short rotation coppices, the costs for planting can be allocated to the total lifecycle costs. Nevertheless, the sufficient availability of hig quality planting material, acceptable performance while planting (> 3 ha / h) at reduced requirement of manpower are minimum demands for a growing number of installed SRC.

These requirements can only be met with the development of new machine technologies for each individual process step. The presented machines are new solutions for rod harvesting at mother plantations and planting of cutted rods. Experiments have already demonstrated an augmented process performance in comparison to conventional technology. In future, great potential is seen especially in technologies with reduced bed preparation (mulch planting or direct planting) and in a further increase of operating speed while harvesting and planting. Technical concepts have to fulfill these requirements in order to generate producer acceptance of wood producing SRC.

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Fig. 5

Two-rowed prototype planter, while testing mulch planting on stony ground

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