Short Rotation Forestry – Growth Productivity of Four Cutting Cycles

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Keywords: short-rotation forestry, cutting cycle, poplar clones, optimal biomass production

ABSTRACT

According to a study by the Austrian Energy Agency the demand of forest products for energy purposes increases year by year. In 2007 the demand will nearly touch the range of 20 mill solid m³ per year. To deliver according to the needs of the Austrian as well as the European forest industry, several researches in timber mobilization were conducted. An emerging alternative might be the timber - respectively biomass production in short-rotation plantations.

In 1987 a series of field trials were established in Austria to determine optimal biomass production on short-rotation poplar plantations. The objective was to gain the increment of five different poplar clones, planted at different spacings and harvested at several cutting cycles. Cutting dates were 1991, 1998, 2001 and 2006. The space layout was 0.8 x 0.8, 1.1 x 1.1, 1.4 x 1.4 to 1.7 x 1.7 m. For each combination a repetition was installed. Altogether 40 sample plots were applied. As the most favorable combination the poplar clone J 104 in a five year rotation at spacing of 1.4 x 1.4 m turned out. Overall sample plots and over all clones the average productivity was 9.86 odt/ha/year.

INTRODUCTION

The demand in Austria of forest products for energy purposes only, will pass the range of 20 mill solid m³ per year. This estimation was conducted by the Austrian Energy Agency for the year 2008. In the year 2006 the biggest solely timber driven CHP-plant in central Europe with its capacity of 66 MW (230.000 m³ solid) has been started to operate in Vienna. A lot of others, partly only marginal smaller have followed. Nemstothy (2007) identifies producers of biofuel of the second generation (biomass to liquid) as another prospective player on the market for timber and biomass. To deliver according to the needs of the Austrian as well as the European forest industry, several researches in timber mobilization were conducted. During the last decades, oil crisis, agricultural surpluses and global climate change has enhanced the interest in short-rotation forestry (SRF) (Vande Walle et al., 2007).

The STATISTIK AUSTRIA (2006) disclosed an area of 1722 ha of short rotation forestry in the report of agricultural affairs. This part of surface shall be increased in the future in a significant manner. Therefore much work in research (all over the world) has already been done, determining the right species, the right cultivar, the right spacing, and the right rotation time for
its respective site and country respectively. Beside the limited transferability of international research results on a national or even sub national level, most of the studies just cover one or two cutting cycles with a total duration of not more than ten years. The Austrian regulatory framework for short rotation forestry determines a life time of thirty years. In order to get constant information over such a period, long term test are necessary.

In Austria in 1987 a series of field trials were established, to determine the optimal biomass production on short-rotation poplar plantations. The aims of these field trials were to investigate the increment of five different poplar clones, at different spacings and at different cutting cycles for Austrian conditions. A particular focus was on results which were provided over the so far 20 year lasting testing period, in specific the change in productivity according to the sequence of the rotations.

MATERIAL AND METHOD

The timber and wood chip production by short rotation forestry is a special branch of the agricultural crop production and can be considered as a further development of the low forest management of former and also present times. Sun loving, fast growing deciduous tree like poplar, willow and robinia are the favorite species in Austria (Liebhard, 2007). According the Austrian law short rotation forestry has to be applied as such at the government agency. The maximum lifetime of a SRF is limited with 30 years. After this period the stools have to be removed (uprooting) otherwise former arable land would (turn into) become forest land.

In 1987 an accurate field trial has been designed in Ritzlhof. Ritzlhof is situated in the basin of Linz with its global position of 48° 18’ 11” N, 14° 17’ 26” E and an altitude of 335 meters above sea level. Over the last thirty years mean temperature and mean precipitation per year amounts in 8.8° C and 754 mm respectively (Linz, 2008). The soil can be described as periodically wet, primarily wet phases with a moderate storage capacity. A surface water gley has been identified as soil type. The soil can be characterized as arable land of average kind and quality.

Five different poplar clones were planted at spacings of 0.8 m x 0.8 m, 1.1 m x 1.1 m, 1.4 m x 1.4 m, and 1.7 m x 1.7 m. For each combination a repetition was installed. Altogether 40 lots were applied. Each lot consists of a peripheral and a core zone (Figure 1). The peripheral zone consists of two rows of poplar which were planted around the core zone in order to avoid fringe effects. Due to the different spacings the core zones of the lots varies in size between 71.4 m² and 150.0 m². The total sample area was 1.2 ha (Figure 1).
Figure 1: Design of the field trial

The five different clones were Muhle Lasen (ML), an intraspecific hybrid of Trichocarpa (Trichocarpa x Trichocarpa), I 130 an interspecific hybrid of populous nigra x populous deltoids, and three intersectional hybrids, two of them maximowicii x nigra (J 104, J 105) which are close related to the Max clones as well as maximowicii x P. x berolinensis (Oxford).

In 1990/91 the first harvesting operation took place. After seven years (1997/98), four years (2001/02) and five years (2006/2007) respectively, rotation number two, three and four followed. Right before the harvesting, the clones from the peripheral zone were removed in advance. Afterwards the clones of each lot in the core zone were cut by chainsaw and chipped onto a trailer. The weight of the loaded and unloaded trailer was leading to the weight of the cargo. By a heating cabinet two wood chip samples for each lot were dehumified at 105°C until equilibrium. In consideration of oven dry mass, lot size and rotation time the average annual increment of each clone per hectare has been derived.

RESULTS

The first harvesting operation of the poplar clones took place in the year 1990. Then only a few lots were cut. Between 1991 and 1993 the remaining lots were harvested. From Winter 1997/98 on, at each rotation the total field was cut at the same time. Due to this primarily inconsistent use the results of this period are only documented in a reduced style in here. The average yield of the rotations 1997/98, 2001/02, and 2006/07 over all clones and spacings was 9.86 odt/ha/year. The clones J 104 and Oxford were most productive. Both have achieved an average yield of about 10.7 odt/ha/year. The clones J 105 and ML were nearly in touch with a productivity of 10.0 odt/ha/year. Only the clone I 130 performed with a yield of 8.0 odt/ha/year below average (Figure 2).

Regarding spacings overall clones the results were roughly identical. Figure 3 represents the average values which vary between 9.8 and 9.9 odt/ha/year. By a detail examination of the
combination of clone and spacing, clone J 104 at a spacing of 1.4 m x 1.4 m turns out as most productive (~12.0 odt/ha/year). More than 11.0 odt/ha/year have still achieved the clone J 104 at a spacing of 1.1 m and the clone Oxford at spacings of 0.8 m and 1.7 m each squared. On the other hand the combination of clone I 130 at a spacing of 1.4 m x 1.4 m emerged as worst combination (6.0 odt/ha/year (Figure 2)).

![Average yields in oven dry tones (odt) of different clones at different spacings of three rotations (1997/98, 2001/02 & 2006/07)](image)

Figure 2: Average yields in oven dry tones (odt) of different clones at different spacings of three rotations (1997/98, 2001/02 & 2006/07)

The Comparison of the different results provided by the single lots and their appropriate repetitions showed a high variability in yield. The results of the clone I 130 between the two different lots at the same spacing of 1.4 m x 1.4 m at the rotation 1997/98 for example vary up to 4 odt/ha/year (Figure 4). In consideration of different rotations the results varied even more. This picture was not only shown by the clone I 130, this variability in yield was also offered by all other clones.
Figure 3: Average yields in oven dry tones (odt) over all clones at different spacings of three rotations (1997/98, 2001/02 & 2006/07)

Figure 4: Yields of the clone I130 at different spacings at different rotations
The first rotation in 1990 and 1991 respectively, provided results between 4.6 und 14.1 odt/ha/year. Over the 30 lots in average almost 8 odt/ha/year was harvested (Figure 5). Only 2 sites exceed the level of 10 odt/ha/year. At the second rotation in the Winter 1997/98 the average yield has increased to 9.6 odt/ha/year. Seventeen of 40 sites have passed the level of 10.0 odt/ha/year. Seven sites have even passed the level of 11.0 odt/ha/year. Another rotation later the average growth remained more or less at the same level as in 1997/98 (9.6 odt/ha/year). Seven sites had a yield of less than 8.0 odt/ha/year, 15 sites exceeded the 10.0 odt level. The so far last rotation took place in winter 2006/2007. The average increment was 10.3 odt/ha/year. Twenty five sites had more than 10.0 dt/ha/year. Seven of forty sites exceeded the 12.0 odt level.

**Figure 5: Average yields of different rotations over all clones and all spacings**

**DISCUSSION**

I 130 (Nigra & Deltoides) was the least performing clone with an average productivity of 8.0 odt/ha/year over a period of three rotations. For hybrids of Nigra & Deltoides (Gaver, Gibecq and Primo) Laureysens et al. (2005) reports under suboptimal soil conditions and during a second, three year lasting turnover productivities of 7.1, 6.0 and 3.0 odt/ha/year respectively. As a possible reason Laureysens et al. (2005) mentioned the poor rooting capacity of Populus Deltoides.

For Fritzi Pauley and Trichobel (Trichocarpa & Trichocarpa) which are close related to Muhle Larsen (ML) the yields in her study for each clone were 8.2 odt/ha/year. Hofmann-Schielle et al. (1999) achieved at fertilized and non fertilized sites for ML in a first rotation (5 years) 3.2-6.0 and 3.8-7.1 odt/ha/year respectively, in a second rotation (5 years) 6.8-12.4 and 6.1-13.6
odt/ha/year respectively. In the present study non fertilized sites with Muhle Larsen achieved 9.9 odt/ha/year over a period of three rotations.

Scholz & Ellerbrock (2002) investigated growth production i.e. of Clone J 105 on sandy soil in two year rotation cycles over a period of six years and got similar results to this study (9.86 odt/ha/year over a period of three cutting cycles). The annual growth per ha was about 9.2, 11.0 and 10.0 odt in respect to the sequence of the rotation.

Productivity differences related to spacing were found to be minor (Strong & Hansen, 1993). In this study the results regarding spacing overall clones vary merely between 9.8 and 9.9 odt/ha/year.

Proe et al. (2002) reports 14.4 and 11.2 odt/ha/year for “Balsam Spire” hybrid poplar in a five year rotation period according to spacing of 1.0 m and 1.5 m.

Due to nowadays applied fully mechanized harvesting systems like e.g. Claas Jaguar, spacing and rotation time has to be fitted to the cutting capacity of the machines and might not gain in importance anyway.

Most medium-term planning for power generation assumes that crop yields in the first rotation will be significantly lower than in subsequent cycles. This is a reasonable assumption, based on plant’s natural emphasis on root growth during early development (Mitchell et al., 1999). In this study the average yield had his maximum at the fourth rotation (10.3 odt/ha/year).

In the present study but also in other studies the majority of crop yield data are derived from intensively managed, small experimental lots and plots (Mitchell et al. (1999). The validity of exploratoring these experimental yields to field scale might lead to an overestimation and shall be considered.

REFERENCES


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