HERBICIDE-FREE ESTABLISHMENT OF SHORT ROTATION AGROFORESTRY SYSTEMS WITH DIFFERENT TREE SPECIES - RESULTS FROM AN ORGANIC FIELD TRIAL IN BAVARIA

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Introduction

One of the aims of organic agriculture is the minimisation of the use of non-renewable resources. Therefore a more and more important part of the concept of organic farms is to grow renewable energy for their own supply. One option is the production of short rotation coppice (Jørgensen et al. 2005). Due to its high environmental services, such as carbon storage, conservation of biodiversity and soil protection (Jose 2009, Kaeser et al. 2010) the cultivation of energy wood according to the principles of agroforestry is particularly suitable.
Which tree species are suited best and how can short rotation agroforestry systems be established according to the regulations of organic farming? So far in Germany there is only little experience with the cultivation of coppicing fast-growing tree species in organic agriculture. In conventional agriculture a combination of mechanical and chemical weed control has been recommended (KTBL 2008). Since herbicides are not allowed in organic farming weed regulation is an essential component.
The study aims to identify suitable methods how to establish and cultivate fast growing trees for woody biomass production without the use of total herbicides in a cost efficient manner. It is part of a cooperation project of the Bavarian State Research Center for Agriculture and the Bavarian State Institute of Forestry “Development and testing of an agroforestry system combining organic agriculture and short rotation coppice”.
Various strategies to reduce weed competition were examined. Furthermore, autochthonous tree species were compared with conventional hybrid poplar which is the mostly used tree species grown for energy purposes in Bavaria. The paper evaluates the efficiency of different procedures to establish short rotation coppice stripes and the performance of the tree species tested. Finally, it will present methods and preliminary results.

Material and methods

The experimental site is located in Germany (Bavaria), in the Franconian Jurassic near Kaisheim (48°46'50.5"N, 10°48'10.0"E, 520 m AMSL) at the LfL experimental farm “Neuhof”. Within the research project partial areas were converted to organic farming in 2009. The study area is characterised by an unfavourable groundwater supply (karst aquifer). The long term average annual precipitation is 780 mm and the mean annual temperature is 8.2 °C (30 year average 1981-2010). Soil types have been classified as cambisol/planosol from loess loam. The soil texture is silty clay, the pH value is 7.5.
In April 2009 the field trial (two-factorial strip plot design, five replications, plot size 75 m²) was set up. Previous crop was a grass-clover-mixture; the plant bed was prepared with plough (~ 30 cm) and rotary harrow. Poplar cuttings 'Max 1' and 'Max 3' (*Populus maximowiczii* x *Populus nigra*) and bare-rooted seedlings of grey and black alder (*Alnus incana*, *Alnus glutinosa*) were planted in a distance of 1.50 m x 1.25 m. The alders had an initial tree height of 80 cm. The poplar cuttings were planted at ground level. All tree species were tested in a rotation period of 7 years. For weed control in the first year the undersown crops black medic (*Medicago lupulina*), white clover (*Trifolium repens*), false flax (*Camelina sativa*), rye (*Secale cereale*, sowed in spring) and a self-degradable mulch membrane were compared with an untreated control plot (same tillage as the other variants).
Investigated parameters were the annual determination of the tree growth rate: average height (= highest shoot); diameter at breast height (1.30 m above ground; not presented); root collar (10 cm above ground; not presented). In 2013 measurements on poplar could not be carried out because of bent trees after storm damage. In winter 2015/2016 the trees were harvested. The

statistical analysis was performed using SAS 9.2. Thereby a PROC GLM with Student-Newman-Keuls test (SNK test) has been applied. Except 2013 and 2014 every year was evaluated separately.

Results

The analysis of the final tree height after a rotation period of 7 years according to the different variants of weed control shows that the trees on self-degradable mulch membrane grew best, reaching on average 977 cm (**Figure 1**). On black medic the trees were lowest (853°cm) - compared to the untreated control and the both undersown crops false flax and rye with a variation in the growth rate from 894-899 cm. The different results are mainly based on the increments during the first two vegetation periods. From the third vegetation period onwards there were no statistical differences regarding the annual growth rate, except the rate of the trees planted in the self-degradable mulch membrane in the year 2012 which differs significantly from the other variants.

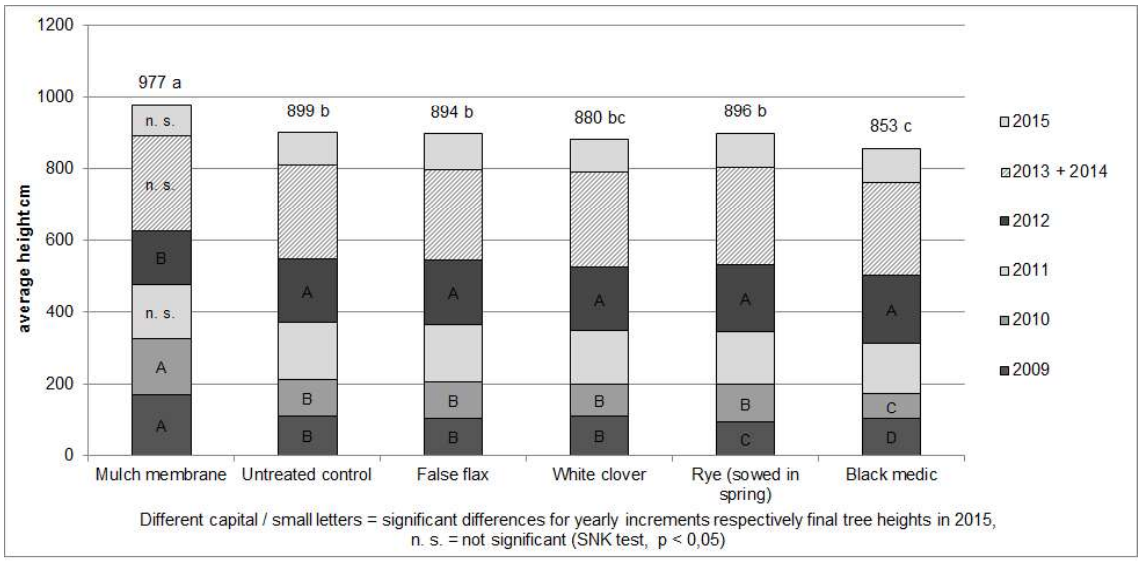

Figure 1: Tree height in 2015 and yearly increments depending on variants of weed control (average over all tree species).

The comparison of the different tree species (**Figure 2**) shows that the poplar clone 'Max 3' grew best with 1025 cm final tree height, followed by 'Max 1' (899 cm) and grey alder (885 cm), each with statistical differences. Black alder was significantly the lowest, with an average height of 718 cm. An analysis of the yearly increments indicates a higher growth rate of the poplars in the first four years compared to the alders. From the fifth vegetation period onwards an increasing growth performance of grey and black alder could be observed, with statistical differences between the black alder and the two poplar clones and between the grey alder and 'Max 1'. In 2015 the differences in the annual growth rate were not significant.

Discussion

Establishing a short rotation agroforestry system with poplar clones ('Max 1', 'Max 3'), grey and black alder is possible under organic farming conditions in southern Bavaria. The good growth performance of fast-growing trees on self-degradable mulch membrane compared to an untreated control plot has also been confirmed in a study of Spangenberg and Hein (2011). This could be attributed to stronger soil heating, higher soil moisture and a good weed-suppressing effect of the membrane (Kell and Henning 2007). The results indicate that black medic cannot be suggested as a strategy for the establishment. The lower tree heights might be caused by a stronger competition for water and/or nutrients between the trees and this undersown crop in the year of the establishment.

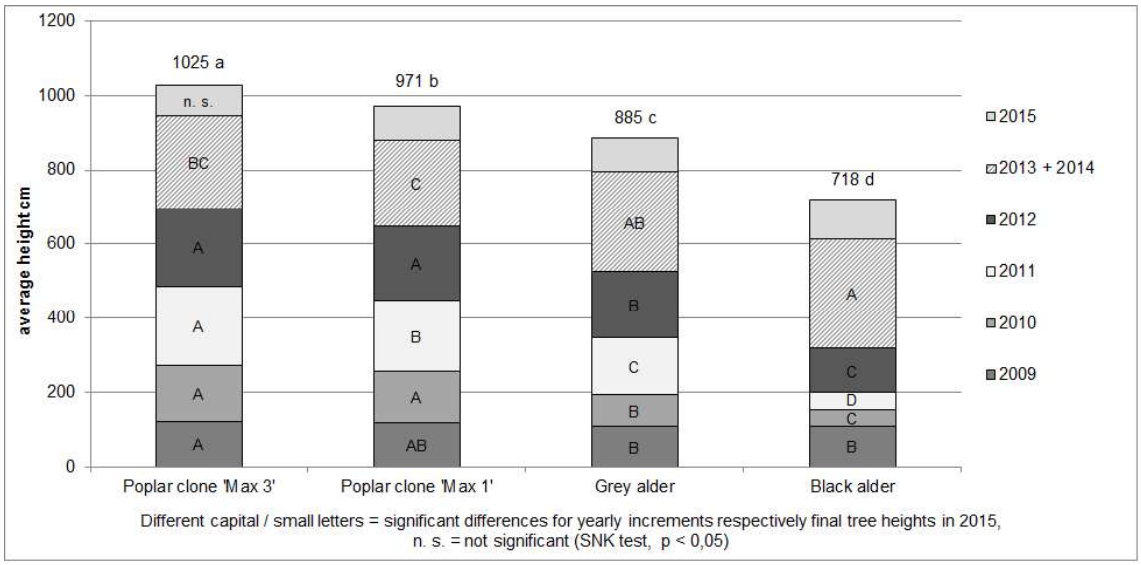

Figure 2: Tree height in 2015 and yearly increments (average over all variants of weed control).

An analysis of the final tree height over all variants showed that none of the tree species in combination with the N-fixing undersown crops white clover and black medic had a significant growth advantage compared to the untreated control (data not shown).

Against our expectations black medic and white clover as legume undersown crops had no positive effect on the growth rate of poplars (non-N-fixing) compared to the alders (N-fixing). The results of the study endorse the evidence of Stoll and Dohrenbusch (2009) that sowed crop plants like different clover species do not raise the increments of poplar clones compared to an untreated control plot with natural side vegetation.

Huber et al. (2014) described that agroforestry systems under organic cultivation can have the same tree biomass production as under integrated cultivation. Our results show that an establishment without herbicides can lead to satisfying tree growth. The poplar clone 'Max 3' had higher increments after seven vegetation periods compared to conventional studies of biomass production in short rotation on a site very close to our experimental site (Stoll et al. 2012). However, this could also be caused by other factors, like different weather conditions in the years of the establishment.

The stronger growth of the poplar clones compared to the alders can be explained through the breeding selection; additionally 'Max 3' and 'Max 1' are tested clones with a recommendation for cultivation in Bavaria (Schirmer 2010). Considering the fact that grey and black alder on the other hand are unbred tree species, the grey alder showed a satisfying growth rate. According to other Bavarian field trials in conventional agriculture the black alder achieved considerably reduced yields compared to the tested hybrid poplar clones (Burger 2010).

Low increments in 2015 can be explained to the dry climatic conditions in summer 2015. But the annual growth rate of alder in 2013 and 2014 indicates that tree growth rate has not yet reached its maximum. Perhaps longer rotation periods -of more than seven years- would lead to a stronger advantage in growth.

A final (concluding) suggestion regarding choice of tree species and strategies of establishment can only be given after an economic evaluation of the tree harvest. The results acquired under conditions of organic farming could also be applied to conventional agriculture, especially for greening measures in the context of the Common Agricultural Policy (CAP).

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