Aboveground woody biomass production of different tree species in silvoarable agroforestry system with organic and integrated cultivation in Southern Germany

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Abstract

The increasing demand for bioenergy and the combination of agricultural production with conservation has made agroforestry to a sustainable land-management option. Aboveground woody biomass plays a decisive role considering the economic value of the agroforestry systems as well as the carbon storage. With the objective to study aboveground woody biomass production of agroforestry systems with different cultivation methods (organic/ integrated), short rotation plantations of different tree species were established 2009 and coppiced in 2012. The studied tree species were black alder (Alnus glutinosa), black locust (Robinia pseudoacacia), poplar "Max 3", (Populus maximowiczii x Populus nigra) and willow "Inger" (Salix triandra x Salix viminalis). At the end of each growing season biomass production was estimated by an allometric model that predicted individual tree biomass from stem diameter. At the end of the rotation biomass was estimated directly by harvesting. Biomass production ranged from 3.9 to 10.9 t_{DM} $ha^{-1}a^{-1}$ *with poplar and locust having highest growth rates. Significant variation was observed between tree species, but not between management (organic/ integrated), what indicates that organic and integrated agroforestry systems can have a comparable tree biomass production. Small-scale differences of the soil caused high intraspecific variation and suggest the inclusion of further soil investigations.*

Introduction

Agroforestry systems have the potential to combine agricultural production, the supply of woody biomass and the provision of numerous environmental services, such as carbon storage, conservation of biodiversity and soil protection (Jose 2009). Aboveground woody biomass plays a decisive role considering the economic value of the agroforestry systems as well as the carbon storage.
The aim of this study was to measure aboveground woody biomass production of four year old agroforestry systems in southern Germany and to compare between organic and integrated cultivation. Furthermore, different tree species were studied.

Material and methods

The study was conducted at the Research Platform Scheyern (40 km north from Munich; 445 - 498 m altitude). Mean annual temperature is 7.5 °C; mean annual precipitation 833 mm (Auerswald et al. 2000). Occuring soil types are classified as Cambisol, with thin layer of loess, with sand and gravel subsoil and partially small-scale clay soils embedded (Scheinost et al. 1993). The agroforestry systems were set up on four fields, two with integrated and two with organic cultivation. Three rows of different tree species for bioenergy production were planted 2009 on every field with a spacing of 30 m for the field crops (Figure 1). The studied tree species were black alder (*Alnus glutinosa*), black locust (*Robinia pseudoacacia*), poplar "Max 3", (*Populus maximowiczii x Populus nigra*) and willow "Inger" (*Salix triandra x Salix viminalis).* At the end of each growing season aboveground woody biomass was estimated by an allometric model that predicted individual tree biomass from stem diameter. In the last year of the four-year rotation, biomass was estimated directly by harvesting.

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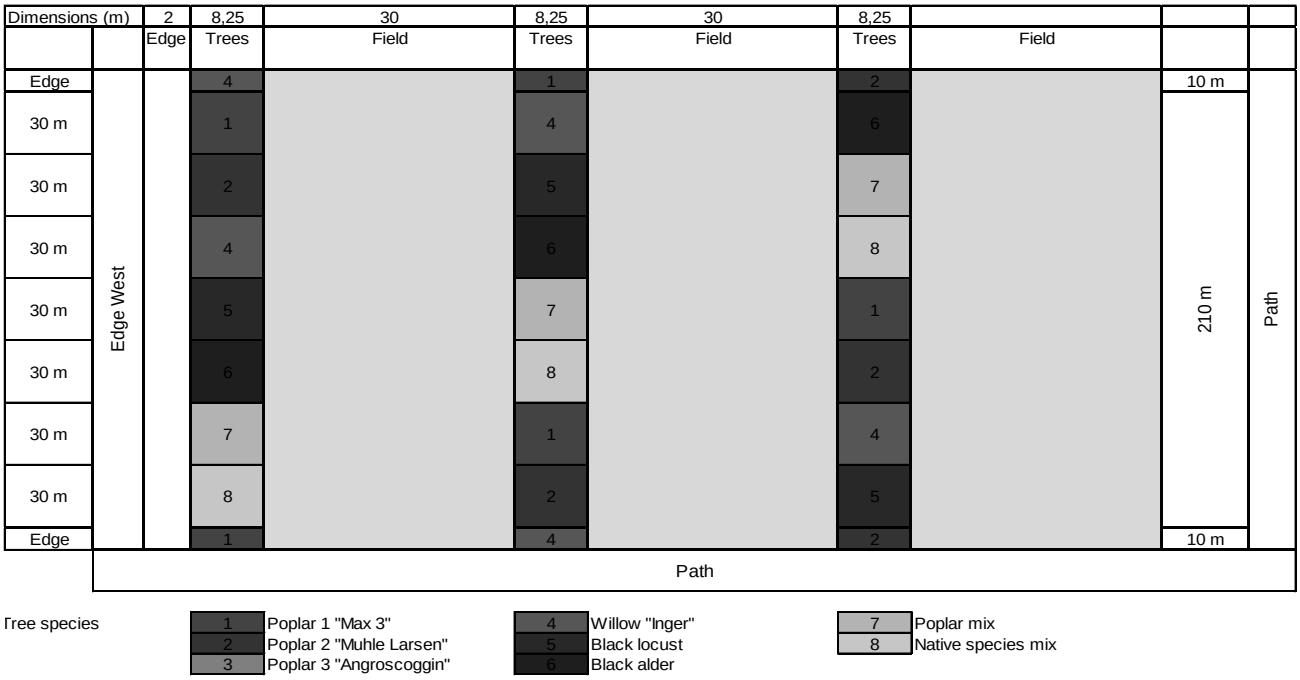

Figure 1: Experimental design of the agroforestry systems at the Research Platform Scheyern

Results

Mean annual growth rate varied from 3.9 to 10.9 t_{DM} $ha^{-1}a^{-1}$ across the species and the cultivation method (Table 1). On the fields with integrated cultivation, locust had the highest growth rate of 9.7 t_{DM} $ha^{-1}a^{-1}$, followed by poplar, alder and willow. But only willow differed significantly. On the fields with organic cultivation, poplar had the significantly highest growth rate of 10.9 t_{DM} $ha^{-1}a^{-1}$, followed by locust, alder and willow. Aboveground woody biomass production varied with tree species, but not with farming system. Small-scale differences of the soil caused high intraspecific variation (indicated by standard deviation) and suggest further investigations of the soil properties.
In the last growing season, mean biomass increase was 100 % (not shown here), what indicated that tree growth rate has not yet reached its maximum. Furthermore, the second rotation is expected to have higher biomass production than the first and especially willow is assumed to have higher biomass production after coppicing due to increasing the number of stems.

Table 1: Aboveground woody biomass production of four-year old agroforestry systems (first rotation) with organic and integrated cultivation; mean and standard deviation (SD)

Tree species	Aboveground woody biomass			
	Integrated cultivation		Organic cultivation	
	mean [t_{DM} ha^{-1} a^{-1}]	SD [t_{DM} ha^{-1} a^{-1}]	mean [t_{DM} ha^{-1} a^{-1}]	SD [t_{DM} ha^{-1} a^{-1}]
Alder	7,6[a]	2.0	7.4[a]	1.6
Locust	9.7[a]	3.7	8.1[a]	1.2
Poplar	8.5[a]	2.0	10.9[b]	3.1
Willow	3,9[b]	2.0	6.4[a]	1.2

[a,b] significant differences between species (Tukey-Test, $p < 0.05$)

Discussion

Production systems like agoforestry have to meet ecological and socio-economic sustainability as a condition for acceptance and implementation by producers and society (Abrahamson et al. 1998). Aboveground woody biomass of plays a decisive role for the assessments of the economic viability and

several ecosystems studies on carbon sequestration, energy and nutrients flows, forest and greenhouse gas inventories (Afas et al. 2008).

Mean annual growth of the trees was 3.9 to 10.9 t_{DM} $ha^{-1}a^{-1}$. However, tree growth rate has not yet reached its maximum. Aboveground woody biomass production varied significantly with tree species but not with farming system. It could be shown that, contrary to the crop yields, in Scheyern the agroforestry systems with organic cultivation can have the same tree biomass production as the agroforestry systems with integrated cultivation.

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