BIOMASS AND BIOENERGY 35 (2011) 1925–1934

Available at www.sciencedirect.com

ScienceDirect

http://www.elsevier.com/locate/biombioe

Increment and biomass in hybrid poplar and some practical implications

Tord Johansson*, Almir Karačić

Swedish University of Agricultural Sciences, Department of Energy and Technology, 750 07 Uppsala, Sweden

ARTICLE INFO

Article history:
Received 17 February 2010
Received in revised form
14 January 2011
Accepted 19 January 2011
Available online 12 February 2011

Keywords:
Basic density
Biomass production
Farmland
Hybrid poplar
Mai
Soil types

ABSTRACT

Growth data were collected from 41 stands of poplar (*Populus* sp.) growing on former farmland in Sweden, situated between latitudes 55 and 63° N. The mean age of the poplar was 20 years (range 4–73), the mean stand density 1327 stems ha^{-1} (range 155–4690), and the mean diameter at breast height (over bark) 210 mm (range 49–447 mm). Soil types in the poplar stands were mainly clay (25 stands), other sediments (six stands) and sandy-silty till (10 stands).

The mean total standing dry weight above stump level (≈200 mm) for poplar was 141.9 ± 13.9 ton ha^{-1} with a range of 19–438 ton ha^{-1}. In addition to estimating conventional dry weights of trees and tree components, SLA, PLA and LAI, among other measures, were estimated and were in agreement with published figures.

The results indicate that poplar stands could produce 70–105 ton ha^{-1} after 10–15 years growth mainly used for biofuel. Otherwise, the stands could be thinned for pulpwood and timber production with a rotation period of 25–30 years and the thinnings used for biofuel.

1. Introduction

Short rotation forestry (SRF) is usually defined as a silvicultural practice in which fast-growing tree species are grown under intensive management [1]. The most widely used species in SRF belong to the genera Eucalyptus, Populus and Salix. At present, SRF is mainly based on poplar species (*Populus* spp.) and their cultivars [1–3]. Poplars can be grown for biomass production and as carbon sinks, for recycling some waste products from society and for buffering against nutrient leaching.

The first industrial poplar plantations were established in Italy at the beginning of the 1900s, producing wood for mechanical pulp and plywood [4]. The trees generally used in the plantations were fast-growing natural hybrids of native and North American species that had been introduced to Europe toward the end of the eighteenth century, usually hybrids of European black poplar and North American eastern cottonwood (*Populus nigra* L. × *Populus deltoides* Bartram ex Marsh. = *Populus euramericana*, syn. *Perisoreus canadensis*).

In European countries with a long tradition of poplar cultivation, such as Italy, France, Belgium, Spain, Hungary, and Serbia, plantations are usually established on fertile sites [5]. Rotation periods are commonly 10–15 years in southern Europe (with 4 × 4 m tree spacing) and 25–40 years (with 7 × 7 m tree spacing) in Belgium, Germany and the Netherlands [5,6], with variations according to final product and local climatic conditions. Poplar coppicing has been of interest in Belgium, France, Germany, Italy, the UK and North America [3,6–10]. The rotation period of poplar coppice plantations is dependent on the initial plant density and

* Corresponding author.
E-mail address: tord.johansson@et.slu.se (T. Johansson).
0961-9534/$ – see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.biombioe.2011.01.040

growth rate [9]. The best results in the UK and USA are achieved with planting densities between 5000 and 7000 trees ha^{-1} and rotation periods of 3–4 years cutting cycles [11]. In Europe, mean annual production in both single-stem and coppice poplar stands varies between 2 and 13.5 ton ha^{-1} yr^{-1} [3,9–11]. In the USA the spacing recommendations during the last three decades of the development of SFR have shifted toward planting densities of 1200–1400 or less stems ha^{-1}. If the final product is pulpwood, the spacing of 3 × 3 m to 4 × 4 m is preferable. However, coppicing has been largely abandoned as a regeneration method in North America [6–12], since the improved yields of coppice regeneration [8,13–15] are usually lost over rotations of 6–10 years [16–18] and the harvest costs per unit produced biomass are reduced at wider planting densities. The land is cleared after poplar harvests and replanted using 20–30 cm long woody cuttings of one-or two-year-old shoots [12,19]. The harvest operations are based on traditional technological systems used in forestry [6]. Commercial North American poplar plantations and large experimental plots on fertile land reportedly reach yields of 18 ton ha^{-1} yrs^{-1} [19,20].

In Sweden, substantial areas of willow coppice were established at the end of the 1980s and the beginning of the 1990s, when the Swedish government subsidized land conversion, with the aim of decreasing the farmland area by 0.5–1 million hectares. This resulted in c. 15,000 ha of commercial SRF willow plantations, along with ca. 500 ha of poplar plantations, by the end of the 1990s [21–24]. Today, willow coppice is usually established at densities of 12,000 cuttings ha^{-1}, harvested in cutting cycles of 3–5 years and replanted every 25–30 years. Production in Swedish field trials has been estimated at 8–12 ton ha^{-1} yr^{-1} [25].

During the last 20 years, there has been a general increase in interest in the management of broadleaved trees in the Nordic countries (and elsewhere), despite the lack of suitable climate-adapted clones and uncertainties regarding appropriate management, pest control, economic factors, markets and future land-use policy at both EU and national levels. The earliest trials with poplars in Sweden were started with plant material originating from Oregon and Washington, with the aim of breeding material for the Swedish Match Company [26].

In a long-term Swedish experiment the mean annual yield of hybrid poplars was 6.7 ton ha^{-1} year^{-1}, in a 24 year rotation period [27]. High yields have also been recorded in southern and central Sweden after 6–12 years of growth at initial densities of 1100–5000 trees ha^{-1} [28,29]. In Norway, trials with clones of *Populus trichocarpa* (Torrey & Gray) started at the beginning of the 1950s [30], and similar studies have been undertaken in Denmark [31]. Results from the Norwegian studies showed that 10-year-old clones produced 18 m^3 ha^{-1} yr^{-1} [30].

'The present study is a part of a series on the biomass of broadleaf species, either planted or self-generated, and growing on forest or farmland. The methods used, including an estimation technique and definitions of the components, are summarized in Johansson [32,33]. However, Madgwick [34] studied the importance of sample selection in the estimation of dry mass for a stand. He found that the sampling method and estimating technique were of less importance than the sample size. His studies indicated that a sample size of 10% or more of total stem number gave increasingly accurate estimates of the stand value. Since leaf and canopy characteristics, such as projected leaf area (PLA), leaf area index (LAI) and specific leaf area (SLA), are important structural parameters of forest ecosystems, leaf and canopy measurements were made. Leaf characteristics, mainly LAI, have an important influence on the exchange of energy, gas and water in trees. LAI is a key component of biochemical cycles in ecosystems [35] and information on it is frequently demanded by scientists and managers.

The aim of the present study was to measure the biomass of poplars in Swedish stands and their components, including dead twigs (= all branches and twigs) to facilitate assessments of their utility for biomass production and attempts to optimize their productivity. Constructed biomass estimation functions were based on data from planted stands of poplars growing on former farmland. Characteristics such as LAI, SLA and PLA were estimated and calculated for stands.

2. Material and methods

2.1. Study site

In this study, 41 stands of hybrid poplar located between latitudes 56° and 65° N in Sweden (Fig. 1 and Table 1) were evaluated. There was a lack of information about the origin of some of the planted hybrid poplars, but the most frequent was clones of balsam poplar (*Populus balsamifera* L.) [11] and OP-42 (*Populus maximowiczii* × *P. trichocarpa*) [10]. Other poplar varieties found were Boelare (*P. trichocarpa* × *P. deltoides*) [6] and *P. trichocarpa* [6], Table 1. The age of the stands ranged from 4 to 73 years (Table 1). Some of the stands had been thinned

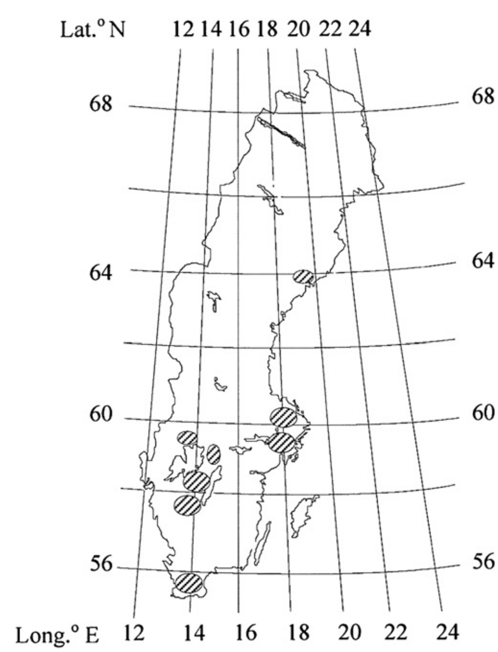

Fig. 1 – Localities of sample trees of poplar growing on abandoned farmland in Sweden.