Biomass and Bioenergy 87 (2016) 39–45

Contents lists available at ScienceDirect

Biomass and Bioenergy

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

Research paper

Alternative planting method for short rotation coppice with poplar and willow

Sara Bergante [a], Marco Manzone [b, *], Gianni Facciotto [a]

[a] Consiglio per la Ricerca in Agricoltura e l'analisi dell'Economia agraria (CREA), Unità di Ricerca per le Produzioni Legnose fuori Foresta (PLF), Strada Frassineto Po 35, 15033, Casale Monferrato, Alessandria, Italy
[b] University of Turin, Via Leonardo da Vinci, 44, 10095, Grugliasco, Torino, Italy

ARTICLE INFO

Article history:
Received 11 November 2015
Received in revised form
4 February 2016
Accepted 17 February 2016
Available online xxx

Keywords:
Short rotation coppice (SRC)
Poplar
Willow
Plantation

ABSTRACT

A reduction in energetic and economic costs is key to the sustainable development of Short Rotation Coppices (SRC) for energy purposes. During their cultivation, the highest costs are incurred during the planting and harvesting phases. A new planting method, which involves the horizontal disposition of stems or cuttings 120 cm long, at a depth of 5–10 cm, could provide energy and cost savings during planting. The results of three experimental plots in Casale M. to (AL), one in Cannara (PG) and one in Chioggia (VE) are shown: horizontal stems and long cuttings were able to produce from 1 to 5 sprouts per meter (sp m^{-1}), depending on the genotype and environmental conditions. Willow was able to produce on average from 2.1 to 4.8 sp m^{-1} and between poplars, the species *P.* ×*canadensis* produced more sprouts that *Populus deltoides* (3.9 sp m^{-1} compared with 1.9 sp m^{-1}). Yields reached a maximum in a Casale M. to trial with 12.7 oven dry tons per hectare (Odt ha^{-1}) for poplar 'Orion' and 12.3 Odt ha^{-1} for willow 'Levante' at the end of first year. The variability of sprouts production and growth of trees makes this method suitable for SRC or stool-beds.

1. Introduction

Regardless of whether they are perennial or annual crops, dedicated crops for energy production represent an important environmental, economic and social alternative to fossil fuels [1]. However, to be useful in different situations, dedicated crops should be sustainable on three levels: agronomical production, environmental and economical [2]. Maybe in the future these crops will become economically viable, but currently the price of the primary product (wood chips) does not always cover cultivation costs and any economical return on investment depends on public financing [3–5]. However, the choice of an appropriate genotype and cultivation model suitable to a specific environment and farm organization does enable high yields to be obtained, improving the economic returns [6]. In addition, new technologies and advanced mechanization in this sector could also bring great advantages in terms of time and economic expenditure: for example, in the cultivation cycle of dedicated crops with fast growing woody species, the plantation phase requires an investment of both time and money for the production of cuttings or seedlings, soil preparation and plantation. However, if new methods and machines were introduced, hand-labour to produce cuttings/seedlings and planting costs could be reduced and plantation could be increased.

Among other species, poplar and willow are largely utilized for biomass purposes due to their characteristics [7]. They are fast growth species and show very high rooting ability: stem cuttings or young trees can be planted without roots, both in traditional poplar stand (as one or two year old stems, 4–6 m tall) and biomass stand (as cuttings, 20–30 cm long, or 90 cm long) with a success probability near to 100% [8–12]. So the vegetative reproduction of a selected genotype is very fast and simple.

In Italy many different types of vegetative materials (like cuttings with variable length, one or two year old stems), planting machines and plantation methods [13–15] were tested in the past. Currently, the short rotation coppices (SRC) are established with cuttings 20–30 cm long and with a diameter above 1–2 cm; for each cutting it is possible to obtain one or more sprouts, but whether done manually or with dedicated machines (like Rotor) [16], each cutting should be planted individually in a row. Considering the high density of SRC (5000–10000 trees ha^{-1}), labor and

* Corresponding author.
E-mail addresses: sara.bergante@entecra.it (S. Bergante), marco.manzone@unito.it (M. Manzone).

http://dx.doi.org/10.1016/j.biombioe.2016.02.016
0961-9534/

time for cuttings preparation and planting has a very high cost [17].

Taking advantage of the rooting ability of poplar and willow, an experiment was set up to evaluate an alternative planting method that uses horizontal stems instead of cuttings, to avoid the costs of cutting preparations. Indeed, in many natural situations and especially in a river basin environment or in traditional poplar stands, the alive branches that fall on the ground horizontally after pruning produce roots and new trees in the spring. Depending on branch or stem portion length, it is possible to count one or more alive sprouts. This characteristic can be exploited to maximize the cost/benefits ratio in the planting phase (mainly in cultivations) as the SRC don't yet ensure suitable rents; in fact, a new method of planting based on such characteristics could reduce both the cost for material production and the time for stand establishment.

2. Material and methods

The main aim of the research herein described was test a new method of planting poplar and willow SRC, utilizing stems or stem portions, avoiding cuttings preparation. The goal is to determine the sprouting ability, growth and productivity of SRC plantations established with this new planting method.

Three experimental plots were established from spring 1997 to spring 2006 on the 'Mezzi' farm of CREA-PLF in Casale Monferrato (AL), northern Italy.

The first experiment (CM1) compare horizontal planting of one year old stems (350 cm long) with the cuttings method of SRC plantation (cuttings of 10, 20 or 30 cm long, vertically planted in the soil). CM1 used the most cultivated poplar clone in Italy, *P. ×canadensis* 'I-214', and the results confirmed the possibility of planting poplar horizontally.

The second experiment, CM2, tested the horizontal planting with improved material: from the basal and median part of each stem were obtained 2 portions 120 cm long, while the apical part was discarded. These are named in the paper 'cuttings 120 cm long'.

The experiment also compared behavior of two species of poplar was compared: *P. ×canadensis* and *Populus deltoides* (cuttings of the latter generally have a poor rooting ability [9]). In the third experiment, CM3, the method of horizontal planting was applied to a wider number of poplar clones and it was extended to willow clones. This experiment also tested a prototype planting machine made in collaboration with the researchers of the University of Turin, Italy (its characteristics will be explained in a separate paper).

Finally, this new plantation method was applied on two other sites, Cannara (PG) in the region of Umbria and Chioggia (VE) in the region of Veneto, to test its response with different clones and other soil and climate environments: in a heavy soil (PG, central Italy) and a peat soil (VE, north-eastern Italy). Table 1 summarizes the main information of all trials, including the clones tested.

In all trials, the stems were harvested from a stool-bed in January and stored at 0–4 °C until it was time to produce the planting material that needed to be re-hydrated for at least 2 days before planting (water immersion).

The planting method for horizontal stems and long cuttings consisted in opening a furrow, 5–10 cm deep, using a small ploughshare the operator must lie down the stems (CM1) or long cuttings (other trials) in such a way that the upper part of one overlaps the basal portion of the next; the furrow is then closed.

2.1. Mezzi farm, Casale Monferrato (AL)

The 'Mezzi' farm of CREA-PLF is located in Casale Monferrato in northern Italy, on the river Po floodplain (Lat45°08′N, Long08°27′E, Alt116 m asl). The climate is sub-continental with a mean annual temperature of 13 °C and rainfall of about 750 mm per year (with 400 mm during the vegetative season, from April to October). The soil is sandy-loam [18]. The water table is not available for trees as it is at an average depth of 4 m.

2.1.1. First trial: CM1

CM1 was carried out in spring 1997. One-year old stems of clone 'I-214' were planted horizontally: stems were 350 cm long and the apical part of each stem (50 cm) was laid over the bottom part of the next. This plantation method was compared with traditional cuttings plantation (vertical planting). The cuttings were prepared in different ways: the cuttings long 10 cm (Cutt10), 30 cm (Cutt30) and part of the cuttings 20 cm long (Cutt20) were mechanically prepared with a band saw; another part of cuttings 20 cm long was manually and accurately prepared (Cutt20m), choosing the best buds. Both cuttings and stems were manually planted. Inter-row spacing was 1.80 m and inter-plant distance between vertically planted cuttings was 0.70 m. A plot included 30 vertically planted cuttings or 7 horizontally planted stems. A randomized complete block with 5 replications was the experimental design applied. Soil was ploughed (35 cm) and harrowed before planting. Weed control was performed with a three disc harrow and a manual hoeing along the rows during the growing season. Three sprinkling irrigations (35 mm each time) were applied during growing season to support shoot growth.

2.1.2. Second trial: CM2

CM2 was established in Spring 2004 with cuttings 120 cm long deriving from the basal-medium portion of the stem. Three different clones, one *P. ×canadensis* 'Neva', and two *P. deltoides* 'Dvina' and 'Lena' were tested.

Three randomized blocks were applied to evaluate sprouting and growth ability. Soil was ploughed (30 cm) and harrowed before planting. Weeds were controlled by applying chemicals (*Metholachlor* 2.5 l ha^{-1} + *Pendimetalin* 2.5 l ha^{-1}) immediately after plantation. Between rows, the soil was disc harrowed twice during the vegetative season of the first year; in addition, two sprinkling irrigations with 80 mm of water were needed due to sandy soil for support the young trees during the dry season. One treatment with *Chlorpyrifos-methil* + *Deltamethrin* 2 kg ha^{-1} was needed against *Chrysomela populi* L. The clones selected are resistant or tolerant to the other main poplar diseases [19].

2.1.3. Third trial: CM3

CM3 was planted in spring 2006; it covers a surface of 2500 m^2 and it is a SRC plantation with 7 poplar clones and 3 willow clones. The spacing between rows is 2 m. The experimental design was randomized complete blocks with 3 replications. Field preparation and field management were done in the same way as for CM2.

2.2. Cannara (PG)

Cannara is located near Perugia, in Central Italy (Lat42°59′N, 12°34′E, Alt185 asl). The experimental trial was within a commercial stand that covers a surface area of more than 6 ha. Mono-clonal plots, with a surface area of 37.5 m^2, were completely randomized with 3 replications.

In spring 2007, due to the high clay content, the soil was prepared using subsoiling to reduce soil compaction before being plowed and harrowed. Herbicides were not applied during plantation or plant establishment, no disease control was carried out, and no irrigation or fertilization was carried out; only one weeding (mechanical control) was needed in each vegetative season. Cuttings 120 cm long of 19 clones of *Populus* and *Salix* genus were horizontally planted with an inter-row distance of 2.50 m.