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Research paper

A prototype for horizontal long cuttings planting in Short Rotation Coppice

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ABSTRACT

Recently, some experiments carried out on Short Rotation Coppice have been focused on a new planting method consisting of burying long cuttings horizontally in substitution of conventional short cuttings planted vertically, with the intent of improving field capacity. The goal of this study is to evaluate the performance of a planter prototype set up by the DISAFA at the University of Turin, which is able to plant long cuttings following this new planting method. In detail, the planter prototype was tested simultaneously with a conventional cuttings planter (Rotor). The performance of each planter was evaluated using three poplar clones (Neva, Dvina, and Lena) and three willow clones (I.131–25, Levante, and SI64-017).

An analysis of the data highlights that forward speed was greater for the prototype (2.0 km h^{-1}) when compared to the Rotor planter (1.0 km h^{-1}) but that no difference was found between the two methods in terms of quality with good rooting results (higher than 97.7%). The hourly fuel consumption determined during the tests was approximately of 7 L per hour for both planters. Differences in specific fuel consumption were, in this case, higher for the Rotor planter (548 g kWh) and lower for the Disafa prototype (507 g kWh). The Disafa prototype showed good performance compared to standard planters both in terms of field capacity, working quality, and fuel consumption. The use of this planter also allows for a reduction in the working time needed for the preparation of cuttings.

1. Introduction

The short rotation coppice can represent an important environmental, social and economic alternative to fossil fuels, independent of the duration of their life cycle [1,2]. Nevertheless, dedicated crops, to be a valid source of energy, must guarantee good agronomical production and environmental and economic sustainability [3,4]. At present, these crops are not always economically viable because the current price of their primary product (woodchip) is lower than cultivation costs; for this reason, their economic sustainability in many cases depends on public incentives [5–7]. Nevertheless, one must consider that, adopting a correct choice of tree variety and cultivation model suitable to a farm organization, it is possible to increase the eventual gain [8–10]. In addition, the use of specific machines and adoption of innovative technologies could offer advantages in time and cost reduction. For example, in the cultivation cycle of dedicated crops with fast-growing woody species, the planting phase represents a greater economic and time effort due to production of cuttings/seedlings, soil preparation and planting. However, it is possible to reduce manual work in the production of material and increase planting efficiency by introducing new methods and machines [11–13].

Poplar (*Populus* spp.) [14,15], willow (*Salix* spp.) [16,17], and black locust (*Robinia pseudoacacia* L.) [18] are the primary tree species planted as energy crops. These fast-growing wood species show a very high rooting ability; in fact, in general biomass crops of Salicaceae are planted using cuttings and rods (stems) without roots because they highlight the root nearly 100% [19–23].

In the course of many years, cutting and rods of Salicaceae with different sizes, planting machines and methods were tested to find the best combination under an economic and production efficiency point of view [24–26]. From these studies, it has been found that cuttings 20–30 cm long and with a diameter near 1.0–2.5 cm and planted using dedicated machines (such as Rotor) show the best performance.

Recently, some experiments have been focused on another new planting method consisting of burying long cuttings horizontally in substitution of conventional short cutting planted vertically [27]. Adopting this method, it is possible to increase the number of plants per row because the sprouts are present over the long cuttings, which reduces the cost related to production of the planting material as well as the time for planting. In fact, subdividing the stems in short cuttings

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requires significant time, whereas burying long cuttings takes less time comparatively. Furthermore, with this new method, it is possible also use whips/rods or basal parts of rods that have a diameter larger than 25 mm or with nodes, that cannot be used for traditional cuttings (about 20 cm long) [27].

The goal of this study is to evaluate the performance of a planter prototype built by the DISAFA at the University of Turin, which is able to plant long cuttings following this new planting method. In detail, the planter was tested using two different tree species, poplar and willow because these species are the most common tree species used in Europe for establishing SRC [14].

2. The planter prototype

The prototype has been developed to work with long cuttings of at least 1.2 m in length because these cuttings have shown better performance in rooting [27]. The developed prototype is able to work on two rows and it is composed of a steel frame fixed to a tractor by three joint points. Two steel boxes to store the long cuttings (1.4 m length, capacity of approximately 250 pieces) are mounted on the frame and two conveyor belts are fixed to the two sides (one pair per side) of the planter. These are used to convey the long cuttings from the storage box to the furrow in the soil opened by two dedicate ploughshares. Successively, each furrow is closed by a couple of wings appropriately inclined. The movement of the long cuttings from storage box to the conveyor belt is guaranteed by two operators (one operator per row), while the rotation of the two conveyor belts is provided by two wheels (one wheel per conveyor belt). In the present version of the planter, the operators work in standing, but in a later version the ergonomics of the workers will be improved. In this configuration the prototype show a mass of 670 kg. The distance between two rows can be widened or tightened (2.4–3.6 m) by the frame of an oleodynamic cylinder. The long cuttings are placed in the soil at 50–100 mm depth. To improve the rooting of the long cuttings after the furrow closing, the soil is pressed using a rubber roller (Fig. 1). The building cost of the prototype was approximately 4000 Euro.

Fig. 1. The planter prototype. Note for editor: to be rendered in black and white.

Fig. 2. The Rotor planter.

3. Materials and methods

To verify the real performances of the prototype, this latter was tested alongside with a cuttings planter (Rotor) (Fig. 2). This was on the basis that the rooting of the material planted can be affected not only by the planter used but also by soil and weather conditions.

A rotor planter was chosen in the test because it is one of the best cutting planters actually used in Short Rotation Coppice (SRC) and in nurseries planting [26]. In the test, both planters were coupled with a same 44-kW tractor.

The trials were carried out in Casale Monferrato (AL) in northwest Italy (45° 8′ 33″ N; 8° 28′ 11″ E) during the 2015 planting season. The planters worked on sandy soil with a moisture content ranging between 9 and 11% [28]. The study area was approximately 3 ha, 200 m in length and 150 m in width, and was collocated on flat country. The area was divided in 24 plots of 1200 m^2 (2 planters x 6 tree clones x 3 replications). All plots had a similar physical soil characteristic. Both machines were manual fed by the same couple of operators.

The planters were tested using three poplar clones (Neva, Dvina, and Lena) and three willow clones (I.131–25, Levante, and SI64-017). These clones have shown better performance in terms of rooting and biomass production when planted in the horizontal position [27]. The trials were carried out assuming a distance between rows of 3.00 m for both machines, while for the cutting planter (Rotor) a distance between plants of 0.50 m (starting plant density of 6700 plants per hectare) was adopted [26]. Cuttings of a diameter of 10–25 mm and a length of 220 mm were used for the Rotor planter. The prototype worked with long cuttings of a basal diameter of 20–40 mm and a length of 1.20 m [26,27] and they were planted at the distance of about 0.05 m from each other. Cuttings with a diameter of greater than10 mm were planted because this is the minimum size to maintain an adequate carbohydrate reserve to sustain the cutting before establishment [29]. In contrast, 25 mm in diameter is the size limit of the planting system of the Rotor planter. Short and long cuttings were prepared by a manual method using pruning scissors.

Before planting, the vegetation material was preserved for two weeks at 0–4 °C and, successively, it was immersed in water for 2 days to hydrate it as much as possible to make for easier rooting and to preserve water prior to an eventual drying after the planting.

In the testing area, the soil was ploughed to 0.30 m depth and was prepared with a harrowing passage.

3.1. Working times

Working times were determined in the field, following CIOSTA (Comité International d'Organization Scientifique du Travail en