GROWTH AND YIELD RESULTS OF TIMBER TREES MIXED WITH POPLAR SRC: 9 YEARS OF AN EXPERIMENTAL PLOT IN THE PO VALLEY

Facciotto G[(1)*], Paris P[(2)], Bergante S[(1)]

* Correpondence author: gianni.facciotto@crea.gov.it

(1) Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria (CREA), Unità di ricerca per le produzioni legnose fuori foresta (PLF). Casale Monferrato, Italy. (2) CNR-IBAF, Porano, Italy

Introduction

Modern intensive agriculture is progressively facing several major ecological problems, such as i) loss of biodiversity, ii) soil erosion, iii) eutrophication, including nitrate leaching. Alley coppice systems could provide a solution to these problems: in fact, the possibility to utilize the soil for multiple cultivation and to grow high-value trees in combination with Short Rotation Coppice (SRC) crops for biomass production would meet the need for sustainable agriculture, as it would provide important productive and environmental benefits. The main advantages of such alley coppice (AC) system could be that: i) farmers would receive payments for biomass every 2-5 years for 10 or more years when high-value timber trees are in the juvenile phase, ii) the high-value timber trees could be planted with definitive spacing, thus avoiding the costs of thinning iii) the SRC, with a rapid canopy closure, would have a positive environmental impact reducing soil erosion, improving GHG absorption and increasing biodiversity, iv) the SRC could protect the high-value timber trees from wind and storms, v) the light competition of SRC would help the stems of high-value timber to grow more straight and with a lower number of thin branches than in the traditional mono-cultural model of plantation forestry (Loewe et al. 2013; Morhart et al. 2014). Thus, the alley coppice system is a specific form of agroforestry system in which the long lasting element is the timber trees population. Mixed timber trees plantations, although strongly recommended for their productive and environmental advantages, are rarely realized because their technical management is more complex in comparison to mono-specific timber plantations (Kelty 2006). In order to evaluate the feasibility of alley coppice systems and the effect of SRC on high-value timber trees an experimental plantation was established in the Po Valley, northern Italy, in 2006, to compare alley coppice plots and pure timber plots, in particular as regards height and diameter growth and stem form.

Material and methods

The plantation, covering a total area of 1.5 ha, was established at Casale Monferrato (Northern Italy), on flat agricultural land with alluvial soil (sandy soil). The climate is sub-continental, with a mean annual temperature of 13 °C and rainfall averaging 750 mm per year (with 400 mm during the growing season, from April to October). Experimental plots were established to compare pure plantations of *Sorbus torminalis* and *Pyrus communis* with the combination of these timber trees with poplar clones under SRC management grown as an alley coppice system. A randomized block design with 2 replications for each of the two treatments (pure timber trees and alley coppice) was applied. One-year old rooted seedlings were planted at 8 × 8 m spacing. Three poplar clones were used for the SRC: 'Lux', 'Oglio' (*P. deltoides*) and 'Triplo' (*P ×canadensis).* The distance between poplars and timber trees was 3 m. Poplars were planted using 120 cm long unrooted stem cuttings, placed horizontally on the soil surface with an inter-row distance of 2 m (Bergante et al. 2016). Before the establishment of the plantation, the soil was ploughed and arrowed. Ryegrass (*Lollium perenne*) was sown as cover-crop and organic mulch was utilized on *Sorbus* and *Pyrus* trees. During all the growing seasons all plots were irrigated 2-3 times by sprinkling; during the summer of the first year, harrowing was carried out three times, only between the SRC rows. During the second and following years, cultivation operations were reduced: in pure timber tree plots ryegrass was harvested twice per year (to feed farm cattle) and during the 2nd, 4th, 5th and 9th spring all timber trees were manually fertilized with localized nitrogen. In the alley coppice (AC) plots weed control was carried out by mulching only once in late spring. One-two treatments against *Crisomela populi* were applied on poplar in spring and summer. SRC was harvested mechanically at the end of the 2nd, 4th, 6th and 8th year. At the end of each growing season, tree survival (in %), stem diameter at breast height (Dbh) and total stem height (H) were recorded both on timber trees and poplars. Aboveground dry biomass was estimated using allometric regressions between the Dbh and shoot dry weight recorded. On December 2013, measurements of the timber tree stem shape were carried out in order to detect any positive effects of the combination with SRC poplar on

the wood quality of the timber trees, as described in Paris, 2014. The data on growth, yield and quality of timber trees were compared in order to study the effects of the inter-relationship between high-value timber trees and SRC poplar. Data were analyzed with ANOVA, and a post hoc test was performed when possible, utilizing R software and 'Agricoale' package (R Core Team 2015; De Mendiburu et al. 2014).

Results and discussion

At the end of the 9th year, the timber tree species in alley coppice stands showed a steady growth, reaching a total average H of 438 and 395 cm for *Pyrus* and *Sorbus* respectively (**Figure 1**), while the maximum height was reached in the pure stands (523 and 453 cm respectively). SRC poplar reached an average total H of 316 cm.

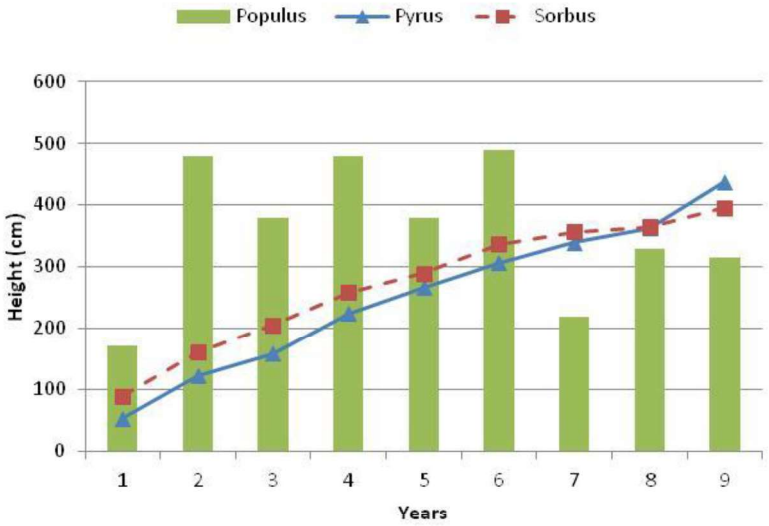

Figure 1: Total height of high-value timber trees (*Sorbus* and *Pyrus*) and SRC poplar, in the alley coppice experimental field, with biennial coppicing rotation, for the first nine years since establishment.

Dbh reached in average 63 mm for *Pyrus* and 47 mm for *Sorbus* with a maximum growth in the pure stands (**Figure 2**). In 2015, at the end of the first growing season after the 4th harvest, poplars reached a mean Dbh of 20 mm and statistical differences were found for Dbh among clones (**Figure 3**).

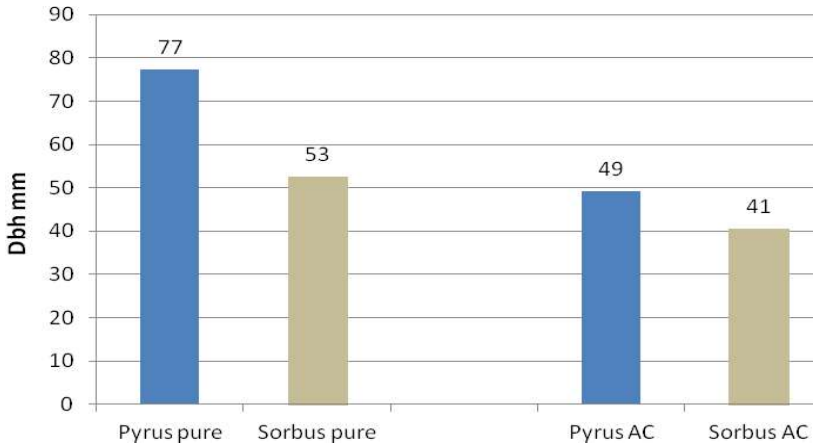

Figure 2: Mean dbh in mm of *Pyrus* and *Sorbus* grown in pure stands and AC after nine years.

The best performing clone, 'Oglio' reached a total average H of 340 cm and differences between 'Oglio' and the other two clones were statistically significant. The light competition of poplar towards the associated high-value timber trees seems to cause a slower growth, although during the last year (2015), due to water availability and low competition in height, timbre trees improved their growth. As for Dbh and height, differences between treatments are

significant, and timber trees in pure stands are bigger than those grown in association with SRC poplars. On the other hand, light competition positively affects the wood quality, as demonstrated by the value of the index of wood quality (Q), measured at the end of the 7th growing season, which is higher for plants grown in combination with SRC poplar (55) than for those grown in pure stands (32): the competition improved the stem shape and forced the high-value timber trees to grow with a straight stem and thinner branches (Paris et al. 2014).
These results are in full agreement with other experiments on mixed timber tree plantations, demonstrating the positive effect of trees mixture on timber wood quality (Loewe et al. 2013; Mohni et al. 2009).

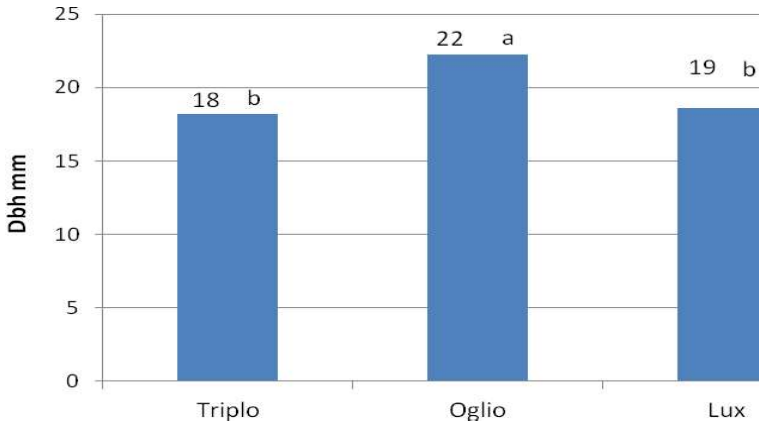

Figure 3: Mean and Waller-Duncan test ($p<0.05$) of poplar dbh in mm at the end of the first growing season after the 4th harvest (2015).

Conclusion

After nine growing seasons, the timber trees in the alley coppice stands reached satisfactory dimensions, besides improved stem shape and wood quality, in comparison with the timber trees grown in pure stands. We used a distance of 3 m between the high-value timber trees and SRC poplar rows, which seems to have caused some competition, with statistically significant effects on the timber trees: negative ones on growth, particularly in the first years, and positive ones on their stem shape. The competition could be avoided by increasing the distance between timber trees and SRC poplar.
The alley coppice design applied in this trial could be an innovative system in consideration of its ease of management, simple timing and high mechanization of cultivation operations. Among the positive effects of alley coppice are an improved stem shape and better wood quality of the timber trees, as well as a contribution to the reduction of GHG emissions if a bioenergy intercrop with a high capacity of soil C sequestration is used (Sabbatini et al. 2016).

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