PRODUCTIVITY OF SILVOARABLE SYSTEMS ESTABLISHED WITH PRUNUS AVIUM L. IN GALICIA (NW SPAIN)

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Introduction

Galicia (NW Spain) is characterized because two thirds of its area is classified as forest, being the livestock sector which generates most of the final agricultural income. In the last years, the forest area has increased gradually (IV IFN 2011) and therefore the availability of agricultural area has decreased. These factors could favor the establishment of silvoarable systems in Galicia, in which trees are intercropped with annual or perennial crops on the same unit of land (Mosquera-Losada et al. 2009). Such systems can increase productivity and profitability, relative to arable production, and, at the same time environment benefits are enhanced (Palma et al. 2006).

In Galicia, maize (Zea mays L.) is the main crop to overcome shortage periods during the summer and winter, which makes advisable to establish silvoarable systems with this crop. Moreover, due to the high productivity, maize produces silage of high quality from an energy point of view, but with low protein content. Maize usage for feeding dairy cows is less costly than grass silage, but also with less flexibility (maize lands cannot be used for grazing in low productive springs). In silvoarable systems, the production of the crops depends, among other aspects, on tree species and its density when planted, because the interception of light and rainfall by trees is a key factor for the understory production. In this study, maize was established under Prunus avium L. because this tree species allows would probably provide adequate crop production due to the low shade it generates compared with more extended use tree species in Galicia region (i.e. Pinus spp, oak…). Moreover, Prunus avium L. is one of the most important European timber species of the Rosaceae family due to its rapid growth which promotes its valuable timber and the delivery of better returns than other broadleaf species (Horgan et al. 2003).

The aim of this study was to evaluate the production of maize and the tree growth in silvoarable systems under Prunus avium L. established at three densities (333, 666 and 2500 and 1333 trees ha-1) in Galicia compared with exclusively agronomic and forest systems.

Material

The experiment was established in Boimorto (A Coruña, Galicia, NW Spain) on a plantation of Prunus avium L. managed by the Bosques Naturales company. Bosques Naturales is a forestry company focused on the management, maintenance, monitoring and research of high-value hardwood species plantations, mainly walnut and cherry. The plantation of Prunus avium L. was carried out in 2008. Initially, the plantation was a mixed stand which was managed to establish Prunus avium L. at the final densities of 6 m x 1.25 m, 6 m x 2.5 m and 6 m x 5 m, equivalent to 333 (LD), 666 (MD) and 1333 (HD) trees ha-1, respectively. Therefore, the treatments consisted of three tree densities. No differences on tree growth between tree densities have been observed before 2015.

In May 2014, after soil preparation, forage maize was sown with conventional farm machinery following a randomized block design with three replicates. The maize variety used was DKC 4608 Ponho. Maize was sown in 3 m alleys, leaving 1.5 m of distance between the alley at the base of the trees (1.5 m both sides of the tree row). The distance between plants rows was 0.75 m and the distance between plants within a row was 0.15 m. Each experimental plot had an area of 36 x 15 m2 (7 trees separated by 6 m (6 m x 6 m) x 13, 7 or 4 rows of trees (12 m x 1.25 m, 6 m x 2.5 m or 3 m x 5 m)). Sowing was carried out in one of the alleys, whilst the other alley remained uncropped to allow access for machinery for annual pruning and phytosanitary application to the trees. Two control treatments were also established: maize grown in tree-less areas (NT) and trees grown without maize at the three plantation densities.

To estimate the production of the forage maize, in each plot ten plants of maize were collected and weighed while fresh in October 2015, and maize final density was accounted in rows. In the laboratory, the plants were fractionated into the components: aborted cobs, cobs without grains, stems, leaves and grains. These components were dried and weighed to estimate the dry matter production (60ºC x 48 hours). The maize production per hectare presented in this study was carried out considering the area occupied by the trees and assuming that the maize was sown in all alleys of the plot. Total maize production was calculated by summing the production of the different components.

In the case of the trees planted at medium (6 m x 2.5 m) and high (6 m x 1.25 m) density, the tree height and the tree diameter at breast height were measured with a vertex and a calliper, respectively, in June 2015.

Data were analysed using ANOVA and differences between averages were shown by the LSD test, if ANOVA was significant. Regression analyses were also performed. The statistical software package SAS (2001) was used for all analyses.

Results

Figure 1 shows that total maize production and its components (aborted cobs, cobs without grain, stems, grains and leaves) were higher in the plots without trees (NT) than in those treatments on which maize was combined with trees established at different densities (LD, MD and HD) (p<0.001). **Figure 2** shows that maize production decreased when the tree density increased.

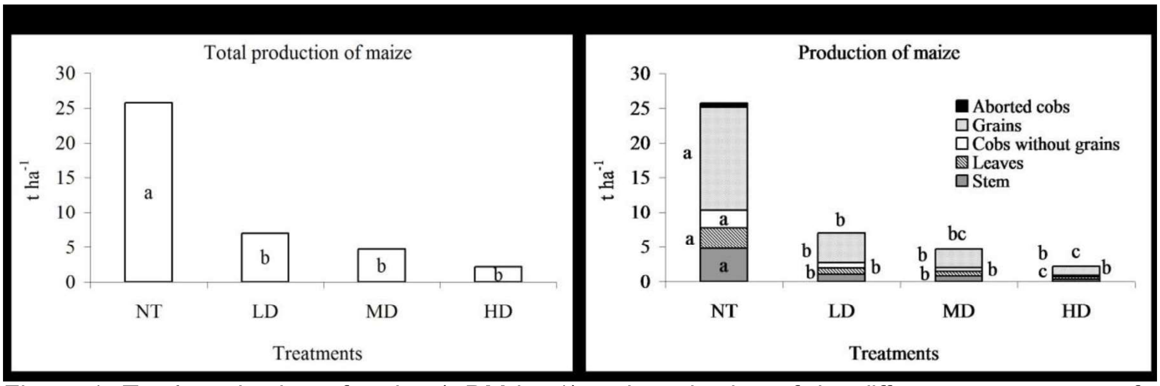

Figure 1: Total production of maize (t DM ha-1) and production of the different components of maize (aborted cobs, cobs without grain, stems, grains and leaves) (t DM ha-1) under the different treatments in 2015. NT: 0 trees ha-1, LD: 333 trees ha-1, MD: 666 trees ha-1 and HD: 1333 trees ha-1. Different letters indicate significant differences between treatments.

On the other hand, it was found a negative effect of the maize sowing on the height and the diameter of the trees planted at a medium density (MD) (p<0.001) and at a high density (HD) (p<0.05), respectively (**Figure 3**).

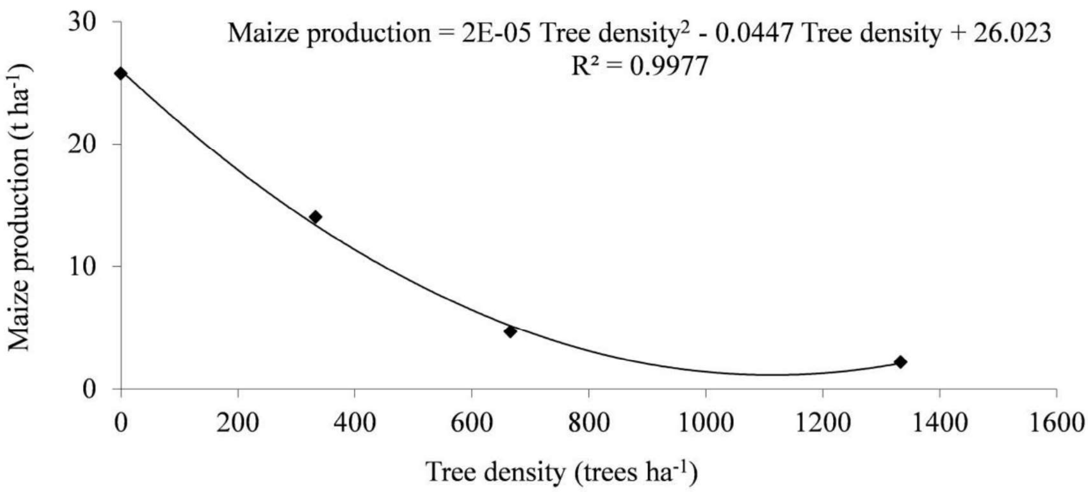

Figure 2: Relationship between the total production of maize (t DM ha-1) and the tree density (trees ha-1)

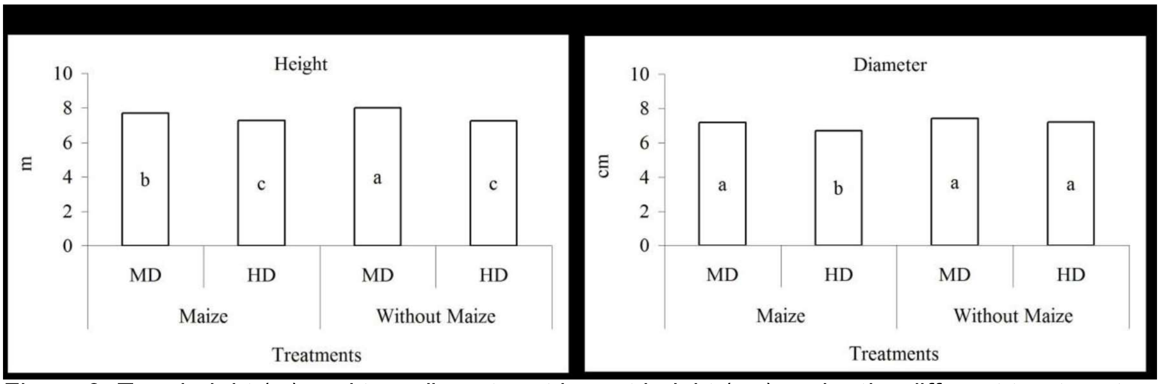

Figure 3: Tree height (m) and tree diameter at breast height (cm) under the different treatments in 2015. MD: 666 trees ha-1 and HD: 1333 trees ha-1. Different letters indicate significant differences between treatments.

Discussion

Maize production obtained in the plots without trees (NT) was similar to the production found in different areas of Galicia from 1999 to 2014 (22.9 t ha-1) for the same variety (CMR 2015). However, maize production in tree-less treatment (NT) was significantly higher than those found in the plots where maize was combined with trees (LD, MD and HD). Lower production in the agroforestry plots could be explained by the lower available area of maize in the plots with trees (tree land was discounted) compared with the plots without trees, but also by the shade generated by the trees. This is exacerbated due to the fact that maize is a shade intolerant C4 species. If the area occupied by the trees had not been discounted, the maize production obtained in the agroforestry plots would also be lower than in the plots without trees (LD: 14.05 t DM ha-1, MD: 9.35 t DM ha-1 and HD: 4.41 t DM ha-1). Similar results were previously observed by Reynolds et al. (2007) and Ding and Su (2010) in poplar-maize systems. However, other authors as Rao et al. (1998) reported on the intercropping of maize with Peltophorum, a slow-growing tree with a small compact canopy, where a positive interaction between the trees and the crop was observed, being the production of maize positively affected. Moreover, in our experiment, the production of maize was decreased as the tree density was increased, which indicates that tree thinning , removing alternate trees in rows, or even removing alternate tree rows, would probably help to reduce the tree shade effect on the crops and the possible competitive effects for soil nutrients and water. However, if timber production is the main objective of the farmer, some shade maize adapted varieties should be developed or another types of agroforestry practices implemented, like, for example, silvopasture (Pardini et al. 2010, Ferreiro-Domínguez et al. 2016).

Regarding tree growth, the initial negative effect of maize sowing on tree height and diameter established at medium (MD) and high (HD) tree density, respectively, could be explained by the tilling carried out in the plots sown with maize. The soil aggregate structure was probably destroyed by the tilling process (Dexter 1988) which could also have damaged the most superficial roots of trees thus decreasing the tree growth. However, other authors, as Chifflot et al. (2006) found a beneficial effect of intercropping on the tree growth due to the improvement in tree nitrogen nutrition when silvoarable practices were established with Prunus avium L. and maize in France. Therefore, these results indicate that it is necessary continue our study to properly evaluate the tree growth combined with the production of maize.

Conclusions

Maize production was decreased as the tree density increased probably due to the shade generated by the trees and the surface occupied by trees and because maize variety was selected for open sites. Moreover, tree growth decreased in the plots with maize which could be explained by the tilling process carried out before the maize sowing that destroyed tree roots that should be further tested to evaluate if tree recovery is produced. Therefore, it is necessary continue our study to properly evaluate the tree growth and the production of maize in this type of agroforestry systems.

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