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Influence of plantation age and density on Cornel-Tree yields

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Abstract

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The present work studies the influence of plantation age and density on cornel-tree yields from a tree and per decar. The analyzed period ranges from five to eighty years, and the plantation density is between 45 and 159 trees per decare. The theoretical data are processed by a combination of mathematical approaches. A correlation analysis is applied to determine the extent and direction of the impact of age and density on the yield. The proven dependencies are represented by linear regression models. The number of trees has a significant, negative effect on the yield from a tree (R = - 0.678 **). The plantation age has a moderate, positive impact both on the yield from a tree (R = 0.397 **) and on the yield per decare (R = 0.436 **). As a result of the analyzes it was found that in case of shorter-term cultivation the plantation should consist of a larger number of trees, which at an earlier stage increase their productivity. However, if planning is longer, optimal yields will be achieved with fewer trees over a period of at least 20-25 years.

Keywords: Cornus mas L.; yield; correlation analysis; regression models

Introduction

There are many cornel-tree studies based on different mathematical approaches. Yilmaz et al. (2009) studies the potential of some cornel-tree genotypes to improve their nutritional value. For this purpose, the authors analyze the antioxidant properties and the chemical composition of cornel-tree fruit by correlation and regression analysis. They present linear relations between antioxidant characteristics and common phenols. It is known that cornel-tree fruits are widely used in medicine because of their healing properties. They are also raw materials for many products in the food and beverage industry. These facts determine the interest of both scientists and farmers to increase the productivity of this plant. One of the major producers of cornel-tree is Turkey and, in particular, the North Anatolia area (Ercisli et al., 2008). Guleryuz et al. (1998) study the yields of different types of cornel-tree in Turkey from gardens located around the river valleys. Differences in yield, fruit size, and other characteristics related to the quality of cornel-tree have been proven. The average fruit weight ranges from 2.907 to 3.906 grams, although some researchers in Turkey report fruit with a weight of 5.600 grams.

Cornus mas L. is a naturally growing dogwood species in Anatolia. In Ersoy et al. (2011) the antioxidant activity of 50% aqueous methanol extracts of 12 cornelian cherry types were evaluated by various antioxidant assay, including free radical scavenging, hydrogen peroxide (H_2O_2) scavenging and metal (Fe^{+2}) chelating activities.

Pirlak et al. (2003) select valuable genetic resources of cornelian cherries (*Cornus mas* L.) grown in Northeastern Anatolia during 1990-1996 for fruit size and yield. The results suggest that the cornelian cherries selected may be suitable for commercial cultivation in the region. Many phenotypes were evaluated as promising for further breeding efforts.

Dokoupil & Reznicek (2012) study the growth and yield of selected cornel-tree varieties that are over five years old. They evaluate the differences in growth, plant size, appearance, yield, composition of the fruit, the content of various minerals, etc. They prove that the most productive among the varieties they consider is the Fruchtal variety (6.99 kg.plant^{-1}). The results obtained confirm that cornel-tree is a valuable plant, which doesn't require special agro-ecological conditions for cultivation, and which has extensive use.

Cornel-tree is known for its high antioxidant content. Gunduz et al. (2013) study the width, length and weight of the fruit, acidity, sugar/acid ratio, phenols fruit color, and other characteristics in four stages of maturity. They found that different periods have different effects on individual varieties, but the tannin content, as well as the tendency in color and fruit size variation are similar. A number of observations have been made on the fertility of cornel-trees in Bulgaria and in other countries (Klimenko, 2013; Tzolov, 1983; Leontyk, 1984). Empirical yields have been reported and no link is sought between age and density of the crop, as well as the impact of these factors on the yields. The purpose of the present study is to analyze the influence of the age of cornel-tree plantation and its density on its economic qualities.

Materials and Methods

The research is made on the basis of theoretical data obtained from a scientific team of the Plovdiv Institute of Fruit Growing, as well as from a number of Bulgarian and international literary sources in this field. They provide information on the yields from a tree and per da[1] of common cornel-tree from plantations of 45, 67, 83, 125 or 159 plants per da, five to eighty years of age at a five-year interval. To determine the direction and degree of influence of plant density and age, a correlation analysis was applied by determining the Pearson-Brave coefficient. To avoid the impact of the different dimensional variables, the data were previously standardized.

The presence of proven correlation coefficients justifies the use of regression analysis. In view of the authors' goal to study both the individual and the complex influence of plant age and density on the productivity of cornel-tree, single-factor and multi-factor linear regression analyzes were applied.

[1] 1 da = 1000 m^2

The mathematical data processing uses the IBM Statistics SPSS 24 (George & Mallery, 2016; Hilton et al., 2014).

Results and Discussion

As a result of the applied correlation analysis, it has been shown that the number of trees has a significant, negative effect on the yield from a tree (R = -0.678 **) and the age has a moderate positive effect on both the yield from a tree (R = 0.397 **) and the yield per da (R = 0.436 **) The larger the number of trees on an area of one decare, the smaller the yield of a single cornel-tree. Increasing the age of the plantation improves its economic qualities. There is no proven link between the density and the productivity per da (Table 1).

Table 1. Correlation coefficients presenting the influence of the density and age of the plantation on cornel-tree yields

	Number of trees	Age
Yields from 1 tree	-0.678**	0.397**
Yields per 1 da	-0.051	0.436**

**. Correlation coefficients statistically proven at level 0.01

The presence of statistically proven correlation coefficients gives a reason to subject the theoretical data to mathematical processing by linear regression analysis. Table 2 presents the obtained models, in which x_1 и x_2 indicate the independent variables, respectively number of trees and age, and y – the dependent variable, respectively, either the yield from one tree or per da. The negative regression coefficients before x_1 in both models proves the negative impact of density on the quantity of production and the positive ones before x_2 – the positive effect of age.

The MS Excel program product provides an opportunity for graphical presentation of the influence of two independent variables on a third one. Using this tool, Figures 1 and 2 visualize the complex effect of the density and the age of the plantation on its productivity, respectively, from one tree and per da.

Figure 1 shows that regardless of the number of trees per

Table 2. Linear regression models, presenting in an analytical form the influence of the density and the age of the plantation on the cornel-tree yields at a level of significance equal to 0.05

Dependent variable	Linear Regression Model	F-criterion	Sig.
Yields per 1 da	$y = 2005.117 – 1.310x_1 + 19.859x_2$	9.212	0.000
Yields from 1 tree	$y = 52.671 – 0.351x_1 + 0.366x_2$	62.181	0.000

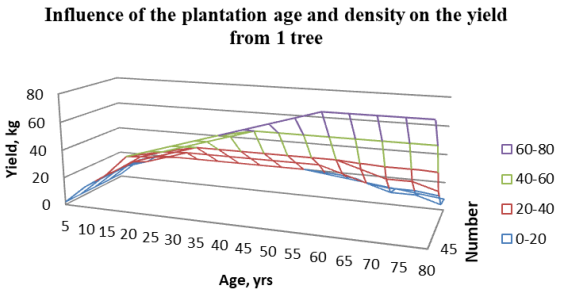

Figure 1. Influence of the plantation density and age on the yield from one tree

decare, with increasing the number of years, productivity also increases. This tendency is preserved until the 20th year. This is followed by a period of about 30 years, when the increase in the density increases the yield in thinner plantations and in those with 125 and 159 trees the productivity is preserved. After the age of 50, with fewer trees, the yields from one tree are stable and with a larger number the tendency is towards decreasing.

The change in the yields per da is largely overlapping with that of a cornel-tree. It turns out that the more trees in the plantation, the shorter the period of increase in the yields. At a density of 125-159 cornel-trees, there is stability of the quantities from the10th to the 50th year (3750 kg/ha and 3180 kg/ha respectively) and then they decrease (respectively 1250 kg/ha and 1272 kg/ha). With fewer trees, the increase in production continues until the 80th year, and in the period from the 60th to the 80th year it ranges from 3600 kg/da for 45 trees to 4020 kg/da for 67 trees.

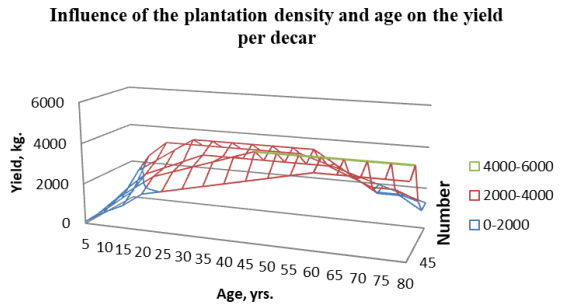

Figure 2. Influence of the plantation density and age on the yield per decare

Conclusions

As a result of the analyzes of the economic qualities of common cornel-tree it has been shown that they depend, moderately or to a significant extent, on the density and age of the plantation. Considering the yields from a tree, the most optimal option should be considered to be a few plants and a longer cultivation period. Considering the results for the quantity of fruit obtained per da, two approaches could be reviewed. If the researcher or manufacturer's goal is to rapidly increase yields, the plantation should consist of 125-159 trees, of which large quantities will be produced in the tenth or fifteenth year. However, if planning is longer, optimal yields will be achieved with fewer trees over a period of at least 20-25 years.

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