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CORRELATION AND REGRESSION DEPENDENCES BETWEEN VEGETATIVE AND REPRODUCTIVE INDICATORS IN TEGERA AND ELENA CULTIVARS (*PRUNUS DOMESTICA* L.) AS A RESULT OF DIFFERENT AGROTECHNICAL SISTEMS

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Abstract

During the period 2016-2018 at the Research Institute of Mountain Stockbreeding and Agriculture in Troyan a study was conducted to analyze different agrotechnical systems (organic and conventional fertilizing technology) in plum plantations. As a result of the fertilization, the vegetative and reproductive manifestations of plum cultivars with different ripening periods (Tegera and Elena) were monitored. Correlation and regression analysis established the relationship between the studied indicators. Depending on the applied system, genotypic similarity but also cultivar difference was analyzed. The biological fertilization of the Tegera cultivar determines a positive correlation between the average fruit weight and the average yield kg/tree at a correlation coefficient (r = 1.000) and regression equation y = 11.422 x - 341.62 with a coefficient of determination R^2 = 1.0. In contrast to organic production, in the conventional technology in both cultivars a correlation was found between the average mass of the stone and the average yield kg/tree; (Tegera r = 0.866; Elena r = 0.714), with a coefficient of determination (Tegera R^2 = 0.750; Elena R^2 = 0.510).

Key words*: Prunus domestica L., fertilizers, vegetative and reproductive indicators, correlation and regression dependences.*

INTRODUCTION

The agrotechnics that is used today in the cultivation of stone fruit species must be environmentally and economically sustainable. This means that the production systems that are used, in addition to improving fruit yield and quality, are important to maintain natural resources (Rombolà et al., 2012). Fertilizing and the choice of fertilizer is one of the main cultural practices in the orchards, contributing to the efficiency and intensity of fruit production. (Pešaković et al., 2020). The growing interest in organic food provokes many comparisons of products grown in different (organic and conventional) production systems, and the differences may be due to different technologies of organic and conventional fertilizing (Mditshwa et al., 2017; Rahman et al., 2021). The analysis of existing relationships between the studied indicators is extremely important due to the possibility to choose a combination of several effective characteristics (Tripon et al., 2016). The aim of the present study is to study the correlations between vegetative and reproductive indicators in Tegara and Elena (*Prunus domestica* L.) cultivars as a result of different agrotechnical systems.

MATERIALS AND METHODS

The experiment was conducted in 2016-2018 at the Research Institute of Mountain Stockbreeding and Agriculture - Troyan at a plum plantation of cultivars with different ripening periods, such as Tegera (early ripening) and Elena (late ripening), with a planting scheme 4 x 2.5 m.

In both plum cultivars, organic and conventional fertilizing (soil and foliar) was applied, analyzed in parallel with the untreated control variant.

Agriful (soil) fertilizers - 5 l/da, with content of Total Humic Extract - 306 g/l were used in the biological fertilizing; Fulvic acids-306 g/l; Nitrogen (N) -55 g/l; Phosphorus (P_20_5) - 13 g/l; Potassium (KjO) -13 g/l; Total organic

matter – 551 g/l; pH - 4.7, applied five times since the beginning of the vegetation, over a period of 15-20 days.

Tekamin Flower (foliar) - 0.3%, with a composition of seaweed extract-51 g/l; Free "L" amino acids - 38 g/l; Nitrogen (N) - 38 g/l; Phosphorus (P_2O_5) - 127 g/l; Boron (B) - 13 g/l; Molybdenum (Mo) - 6.5 g/l; pH - 2, applied twice, before blossoming and during fruit setting.

Teknokel Amino Ca (foliar) - 0.4%, with content Calcium oxide (CaO) water-soluble-148 g/l; Boron (B) water-soluble-3 g/l; Free "L" amino acids - 89 g/l; pH - 4.0-4.5, applied after blossoming and a month before harvesting.

Yara Mila Complex fertilizers (soil) - 0.500 kg/tree, with nitrogen composition (N) -12% were used in the conventional fertilization; Potassium (K) -18%; Magnesium (MgO) - 2.7%; Boron (B) - 0.015%; Manganese (Mn) - 0.02%; Phosphorus (P) -11%; Sulfur (SO_3) - 20%; Iron (Fe) - 0.2%; Zinc (Zn) - 0.02%, applied once before vegetation in 2016 and 2018; **YaraVita Frutrel** (foliar) - 0.500 ml/da, with content Calcium oxide (CaO) - 280 g/l; Phosphorus (P) - 104 g/l; Nitrogen (N) - 69 g/l; Magnesium (MgO) - 100 g/l; Zinc (Zn) - 40 g/l; Boron (B) -20 g/l, applied four times. First in the winter bud phase, in the white bud phase, during fruit setting and one month before harvest; **Yara Vita Universal Bio** (foliar) - 0.500 ml/da, with composition Nitrogen (N) - 100 g/l; Phosphorus (P2O5) -40 g/l; Potassium (K2O) - 70 g/l; Manganese (Mn) -1.3 g/l; Copper (Cu) - 1.0 g/l; Zinc (Zn) - 0.7 g/l; Boron (B) - 0.2 g/l; Molybdenum (Mo) - 0.03 g/l, applied three times - before and after blossoming and after harvest.

The reported vegetative and reproductive characteristics of fruit trees were performed according to the methodology for studying plant resources (Nedev et al., 1979).

Vegetative indicators:

• trunk circumference (cm) - measured at a height of 40 cm from the soil surface, after the end of vegetation;

• crown height (m) - measured from the level of the first skeletal branch to the top of the tree;

• width of the crowns (m) - is reported in two directions - between the rows and in the row;

• crown volume (m^3) - calculated by the formula $V = \pi * d^2 * h/12$, including: π - 3.14; d - circumference, on average from the two mutually perpendicular directions, excluding individual protruding branches; h - crown height (m) (excluding the stem), measured from the level of the first skeletal branch to the top of the tree;

• Annual shoot length growth - the indicator includes, average length (cm) of branches over 5 cm and total annual shoot length growth on marked branches, after the end of vegetation;

Reproductive manifestations:

• percentage of useful fruit-set, reported thirty days after full blossoming, on marked branches;

• average weight of fruit and stone (g) - determined by measuring 25 randomly selected fruits and their stones by technical scales;

• average yield kg/tree.

Statistical processing

The obtained experimental data were statistically processed using the software products Analysis Toolpak for Microsoft Excel 2010, at a level of statistical significance, p-value <0.05.

Correlation and regression analysis were applied to determine the impact of individual indicators in different agro-technical systems.

RESULTS AND DISCUSSIONS

The correlation dependences of the studied vegetative and reproductive indicators presented in Table 1 in early and late ripening plum cultivar with biological agrotechnical system show genotypic similarity, but also a difference. In contrast to the Elena cultivar, the trunk circumference of Tegera cultivar correlates positively with the percentage of useful fruit-setting and the average fruit weight (r = 0.867). It was found that the reported reproductive manifestations in Elena cultivar as average fruit weight, stone weight and average tree yield are positively correlated with the vegetative indicators, such as height, width of crowns in the row and their volume. The reported dependencies are absent in the early maturing cultivar Tegera. Similarity in both tested cultivars was found between the indicators useful fruit-settings percentage and the average fruit weight with correlation coefficient (Tegera r = 1.000) and (Elena r =

0.820). The percentage of useful fruit-setting in the Tegera cultivar also showed a positive correlation with the average stone weight (r = 0.866) and the average yield kg/tree (r = 1.00). The average fruit weight of both cultivars is positively correlated with the average stone weight (Tegera r = 0.866) and (Elena r = 0.952). Only in the Tegera cultivar, the average fruit weight has a correlation coefficient (r = 1.000) compared to the average yield kg/tree.

Table 1. Correlation dependences between vegetative and reproductive indicators of plum cultivars obtained in biological cultivation system

	Trunk circumference (cm)	Crown height (m)	Crown width in the row (m)	Crown width in the row spacing (m)	Crown volume (m^3)	Annual shoot length growth (cm)	Total annual shoot length growth (cm)	Percentage of useful fruit-set (%)	Average fruit weight (g)	Average stone weight (g)	Average yield kg/tree
					Tegera						
Trunk circumference	1.000										
Crown height	-0.865	1.000									
Crown width in the row	-0.952	0.978	1.000								
Crown width in the row spacing	-0.992	0.795	0.905	1.000							
Crown volume	-0.994	0.915	0.980	0.972	1.000						
Annual shoot length growth	-0.090	0.577	0.392	-0.037	0.199	1.000					
Total annual shoot length growth	-0.090	0.577	0.392	-0.036	0.199	1.000	1.000				
Percentage of useful fruit-set	0.867	-0.500	-0.671	-0.923	-0.807	0.419	0.418	1.000			
Average fruit weight	0.867	-0.500	-0.671	-0.923	-0.806	0.419	0.419	1.000	1.000		
Average stone weight	0.501	0.000	-0.211	-0.606	-0.403	0.817	0.817	0.866	0.866	1.000	
Average yield kg / tree	0.867	-0.500	-0.671	-0.923	-0.807	0.419	0.418	1.000	1.000	0.566	1.000
					Elena						
Trunk circumference	1.000										
Crown height	-0.786	1.000									
Crown width in the row	-0.938	0.951	1.000								
Crown width in the row spacing	0.638	-0.025	-0.332	1.000							
Crown volume	-0.855	0.993	0.982	-0.146	1.000						
Annual shoot length growth	-0.998	0.750	0.917	-0.680	0.825	1.000					
Total annual shoot length growth	-0.998	0.748	0.916	-0.683	0.823	1.000	1.000				
Percentage of useful fruit-set	0.089	0.546	0.262	0.823	0.441	-0.144	-0.147	1.000			
Average fruit weight	-0.498	0.928	0.768	0.350	0.876	0.449	0.446	0.820	1.000		
Average stone weight	-0.739	0.997	0.927	0.047	0.981	0.700	0.698	0.605	0.952	1.000	
Average yield kg / tree	-0.989	0.687	0.878	-0.743	0.770	0.996	0.996	-0.233	0.366	0.633	1.000

The theoretical regression line and the equation y = 11.422 x – 341.62 of the regression dependence between the average fruit weight and the average yield are presented in Figure 1, with a determination coefficient R^2 = 1.0. Such a functional dependence was not observed for cultivars with a conventional fertilizing system.

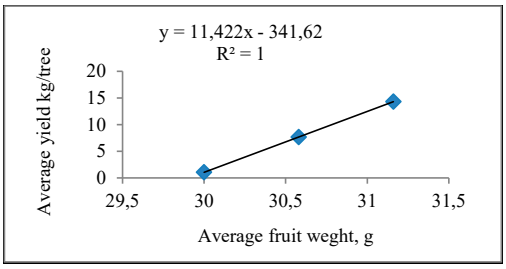


Figure 1. Graphical model of regression dependence for Tegera cultivar between the average fruit weight and average yield kg/tree with applied biological cultivation system

In their study of biological fertilization in plum varieties Butac & Chivu (2020) found a negative correlation between the average fruit weight and average yield kg/tree (r = -0.444), in the regression equation y = -0.3254 x + 46.709 and a coefficient of determination (R^2 = 0.1972).

Table 2 presents the correlations between vegetative and reproductive indicators of plum cultivars obtained by applying a conventional cultivation system.

In contrast to biological fertilizing, in the conventional system, the trunk circumference of the Tegera cultivar is reported to correlate positively with the length of the annual (r = 0.838) and total annual shoot length growth (r = 0.837).

Table 2. Correlation dependences between vegetative and reproductive indicators of plum cultivars obtained under conventional cultivation system

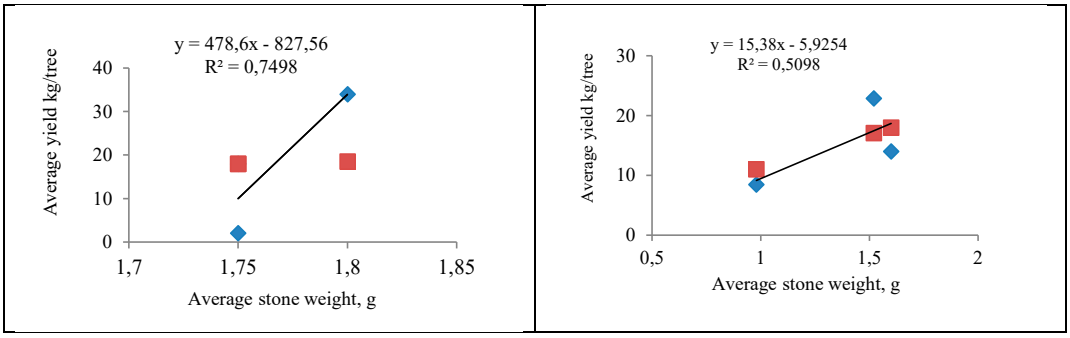
	Trunk circumference (cm)	Crown height (m)	Crown width in the row (m)	Crown width in the row spacing (m)	Crown volume (m^3)	Annual shoot length growth (cm)	Total annual shoot length growth (cm)	Percentage of useful fruit-set (%)	Average fruit weight (g)	Average stone weight (g)	Average yield kg / tree
					Tegera						
Trunk circumference	1.000										
Crown height	-0.915	1.000									
Crown width in the row	-1.000	0.909	1.000								
Crown width in the rowspacing	-0.954	0.994	0.950	1.000							
Crown volume	-0.975	0.981	0.972	0.997	1.000						
Annual shoot length growth	0.838	-0.546	-0.845	-0.638	-0.697	1.000					
Total annual shoot length growth	0.837	-0.544	-0.844	-0.635	-0.695	1.000	1.000				
Percentage of useful fruit-set	0.284	0.128	-0.296	0.015	-0.065	0.760	0.763	1.000			
Average fruit weight	-0.283	-0.129	0.296	-0.016	0.065	-0.760	-0.762	-1.000	1.000		
Average stone weight	-0.234	0.607	0.221	0.513	0.443	0.334	0.337	0.866	-0.866	1.000	
Average yield kg / tree	0.284	0.128	-0.296	0.015	-0.065	0.760	0.763	1.000	-1.000	0.866	1.000
					Elena						
Trunk circumference	1.000										
Crown height	-0.334	1.000									
Crown width in the row	-0.465	0.990	1.000								
Crown width in the row spacing	-0.561	0.968	0.994	1.000							
Crown volume	-0.303	0.999	0.985	0.959	1.000						
Annual shoot length growth	-0.998	0.391	0.518	0.611	0.360	1.000					
Total annual shoot length growth	-0.998	0.390	0.517	0.610	0.359	1.000	1.000				
Percentage of useful fruit-set	0.020	0.936	0.876	0.816	0.947	0.041	0.040	1.000			
Average fruit weight	-0.630	0.942	0.981	0.996	0.931	0.676	0.675	0.764	1.000		
Average stone weight	-0.756	0.869	0.931	0.966	0.853	0.795	0.794	0.639	0.985	1.000	
Average yield kg / tree	-0.998	0.275	0.409	0.509	0.243	0.992	0.993	-0.082	0.581	0.714	1.000

Identical to the biological agrotechnical system, in the cultivar Elena a high correlation was found between the vegetative (height, width and volume of the crowns) and reproductive indicators (average fruit weight and average stone weight).

As a result of the conventional fertilizing technology applied for Tegera cultivar, the percentage of useful fruit-settings is in a high positive correlation with the length of the annual (r = 0.760) and total annual shoot length (r = 0.763).

The length of the annual and total annual shoot length in both tested cultivars has a high correlation coefficient against the average yield kg/tree Tegera r = 0.760; r = 0.763) and (Elena r = 0.992; r = 0.993), as in the cultivar Elena the vegetative indicators are in correlation with the average stone weight (r = 0.795; r = 0.794). Both in the biological agrotechnical system and in the conventional, the percentage of useful fruit-setting in Tegera cultivar has a correlation coefficient r = 0.866, relative to the weight of the stone and r = 1.000, compared to the average yield kg/tree. In the case of Tegera, the percentage of useful fruit-setting is in negative correlation dependence with the average fruit weight (r = -1.000), but with a positive correlation coefficient between the indicators in the cultivar Elena (r = 0.764).

In contrast to biological fertilizing, in the conventional system in both cultivars a correlation was found between the stone weight and the average yield kg/tree (Tegera r = 0.866; Elena r = 0.714). The regression equations between the indicators are presented in Figure 2, as for Tegera it is y = 478.6 x - 827.56 at a coefficient of determination R^2 = 0.749 and Elena y = 15.38 x - 5.9254 at a coefficient of determination R^2 = 0.509.



Tegera cultivar Elena cultivar

Figure 2. Graphical model of regression dependence in Tegera and Elena cultivars between the average stone weight and the average yield kg/tree in the applied conventional cultivation system

CONCLUSIONS

Depending on the applied fertilizing systems (biological and conventional), genotypic similarity was found, but also a difference between the cultivars in some of the indicators.

In the biological fertilizing of Tegera, the trunk circumference correlates positively with the percentage of useful fruit-settings and the average fruit weight (r = 0.867).

The positive correlation was analyzed between the average fruit weight and the average yield kg/tree at a correlation coefficient (r = 1.000) and regression equation of y = 11.422 x - 341.62 with a coefficient of determination R^2 = 1.00.

In contrast to organic production, in conventional technology the trunk circumference of Tegera cultivar correlates strongly positively with the length of annual growth (r = 0.838) and total annual growth (r = 0.837).

In both cultivars, a correlation was found between the average stone weight and the average yield kg/tree (Tegera r = 0.866; Elena r = 0.714), with a coefficient of determination (Tegera R^2 = 0.750; Elena R^2 = 0.510).

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