

**CORRELATION BETWEEN VEGETATIVE AND
REPRODUCTIVE INDICATORS IN THE BULGARSKI
RUBIN RASPBERRY CULTIVAR**

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Abstract

The aim of this study is to trace and establish the correlations between the vegetative (average number, average height, and average thickness of shoots) and reproductive characteristics (average fruit weight and average yield) of the Bulgarski Rubin cultivar grown in the semi-mountainous conditions of the Central Balkan Mountains.

Bulgarian raspberry varieties are adapted to our soil and climatic conditions and successfully realize their genetic potential in them. The study was conducted during the period 2018–2020 in a demonstration plantation of Research Institute of Mountain Stockbreeding and Agriculture, Troyan, which was established in 2016, with a planting scheme of 3.00/0.50 m. The study was carried out in two stages: the first stage was carried out in 2018, and the second stage was carried out in 2019.

Statistical analyses show a high correlation between the average number of shoots and the average yield during the first two experimental years, and very high in the third year. During the three-year period, a very high correlation was found between the vegetative indicators of average height and average shoot thickness.

Key words: fruit weight, raspberries, *Rubus idaeus* L., vegetative indicators, yield

Introduction. Cultivated raspberry (*Rubus idaeus* L.) is a fruit crop with economic, nutritional, and medicinal significance. Its fruits are a rich source of biologically active substances, which is why they are widely used in daily human diet, both fresh and processed in the form of juices, jams, jellies, fruit milks, as additives in the confectionery industry, for freezing, etc.

Raspberries are a fruit species traditionally grown in the mountainous and semi-mountainous regions of the country, where conditions are favourable for the development of their vegetative and reproductive potential. In these habitats, soil and atmospheric humidity are high and, combined with suitable soil and climatic conditions, meet the requirements of the crop.

One of the main soil surface management systems is the natural mulching of the inter-row strips in fruit plantations. It has been found that it helps to increase the organic matter in the soil and reduces the variation in soil temperature values. Mulching of the inter-rows in the semi-mountainous and mountainous regions of the country is a practice that can prevent soil erosion by surface rainwater. In addition, it has been proven that the soil surface maintenance system has a certain impact on the quantity and quality of the fruits.

Cultivated raspberries are characterized by poor drought tolerance. Drought has a particularly critical impact during the intensive vegetative growth of shoots, the flowering phenophase, the formation and ripening of fruits. Insufficient soil and air humidity during the growing season have a negative impact on their shoot-forming ability and the development of newly formed, one-year shoots. Strong vegetative growth is a prerequisite for the full realization of reproductive varietal potential.

In addition to soil and climatic conditions, the productivity of raspberry plants is also influenced by propagation methods, cultivation technologies, varietal characteristics, etc. [1–7]. The reproductive potential of raspberries is determined by the number of shoots per linear meter, their height, and the average weight of the fruit per shoot. Yield is one of the main indicators in characterizing the potential of a cultivar, determining its application in practice [8].

Various cultivation technologies are used worldwide (container, field conditions, polyethylene tunnels, conventional and organic cultivation, etc.) to improve the productive performance of raspberry plants [3, 5, 6, 9].

The aim of this study is to trace the correlation between the vegetative and reproductive indicators of the Bulgarski Rubin raspberry cultivar grown under the agroclimatic conditions of Troyan region.

Material and methods. The study was conducted during the period 2018–2020 in a collection plantation of Research Institute of Mountain Stockbreeding and Agriculture, Troyan. The subject of this study is the Bulgarski Rubin raspberry cultivar.

It was obtained by crossing the Kaliningrad and English raspberries by ZAHOV and NIKOLOVA in 1941 [9]. The bushes are moderately to strongly growing,

with very good suckering, reaching a height of 1.5–2 m. The fruits are medium-sized, blunt-conical to elongated, with moderate density and intense red colour. They begin to ripen in mid-June and mass harvesting continues until the second half of July. The raspberry plantation was established in 2016 and is located on a northeastern slope, at an altitude of 460 m above sea level. The planting pattern is 3.00/0.50 m, with drip irrigation provided. The inter-row distance is maintained in black fallow, through repeated shallow tillage. The soil surface maintenance system includes natural grassing of the inter-rows, with the application of the necessary grass mowing, contributing to the reduction of erosion processes on the sloping terrain.

The soil on which the plantation is located, is gray forest soil, characteristic of the semi-mountainous conditions of the Central Balkan Mountains. In terms of mechanical composition, it is heavy sandy-clay, moderately eroded with low humus content [10]. To improve soil fertility and to satisfy the biological requirements of raspberry plants, a fertilization scheme was applied with: 20 kg/da ammonium nitrate, 15 kg/da triple superphosphate and 7.5 kg/da potassium chloride.

The scientific experiment was conducted in three replicates, each covering one linear meter of the inter row area of the plantation.

The following vegetative and reproductive indicators were traced:

- average number of shoots per linear meter;
- average height of shoots (m);
- average thickness of shoots (mm), measured 10 cm from the soil surface;
- average fruit weight (g);
- average yield per 1 m (kg).

The indicators were recorded using the methodology for studying plant resources in fruit plants [11]. The data were processed using correlation analysis, using MS Excel 2010 software.

Results and discussion. Tracing the correlations between vegetative indicators: average number, average height, and average thickness of shoots with average yield and fruit weight largely determines the pomological and economic qualities of the cultivar.

The value of the indicator average number of shoots for the three-year experimental period is 8.67 pcs., with no significant differences noted between the individual years (Variation Coefficient (VC) 6.66%) (Table 1).

High variation was observed in the average height of the shoots (VC 24.21%). In the first experimental year, their height was 0.90 m, in the following year they were highest – 1.00 m, and in the last year they were lowest – 0.61 m. The average data for the three-year period is 0.84 m, which defines the cultivar under the

specific soil and climatic conditions with low shoots. A probable reason for the divergence in the values of this indicator is due to the varying climatic factors, which specifically affect the development of raspberries. High summer temperatures and droughts and the uneven distribution of precipitation characteristic of most habitats, during the research period, have an impact on the development and fruiting of raspberry plants.

Similar results were obtained for the average shoot thickness indicator. At the beginning of the first experimental year, their thickness was 6.42 mm, during the second year, the value was highest at 8.58 mm, and during the third year, the lowest result was recorded at 6.11 mm. The average value for this indicator for the three-year experimental period was 7.04 mm (VC 19.12%).

Comparing the vegetative characteristics of another Bulgarian raspberry cultivar – Shopska Alena, GEORGIEV et al. [12] report higher values for the average height of shoots – 1.24 m and similar values for the average thickness – 7.48 mm.

The average fruit weight in the first experimental year was 2.29 g, the highest result was recorded in the following year – 2.38 g, and the lowest value was recorded in the third year – 1.80 g. The average data for the three-year research period for the reported indicator is 2.16 g (VC 14.47%).

There is specific varietal difference in the weight of the fruit, which ranges from 2.40 g to 4.90 g between different varieties [9]. Testing different cultivation densities, ATANASOVA et al. [10] report similar results regarding the measured average fruit weight of the Bulgarian cultivar Magdalena, 2.65–2.71 g.

The yield depends on the biological characteristics of the cultivar studied, the soil and climatic conditions, and the cultivation technology applied. The main difference in yield per unit area is observed between individual years. There is a proven upward trend in yield over the three-year period ($P < 0.05$). During the first two experimental years, the yield obtained is close in value, while in the third year it increases more than twofold (1.04 kg/m). Recalculated per decare, the yield is 346.66 kg/da. The average value of the studied indicator for the three-year period is 0.58 kg/m². The significantly higher yield in the third year is probably a consequence of the plants entering full fruiting, as well as the greater average height and thickness of the shoots from the previous year (2019), which bear fruit in the following year, 2020.

LINNEMANNSTÖNS and SCHREY [13] investigated the effect of different planting densities of Lagorai Plus raspberry shoots on yield and fruit weight and found that at lower planting densities the average fruit weight increased, but the yield per unit area decreased.

Tables 2–4 present the correlation dependencies between the average values of the vegetative and reproductive indicators for the three experimental years. In the first year of the experiment, a significant correlation was observed between the average number of shoots and their average height (0.61) and average thickness (0.64) (Table 2).

T a b l e 1

Vegetative and reproductive indicators for the Bulgarski Rubin cultivar
for the period 2018–2020 per 1 linear m

Indicators	Average number of shoots per 1 m	Average shoots height (cm) per 1 m	Average shoots thickness (mm) per 1 m	Average fruit weight (g)	Average yield (kg) per 1 m
2018	8	0.90	6.42	2.29	0.31
2019	9	1.00	8.58	2.38	0.38
2020	9	0.61	6.11	1.80	1.04
2018–2020					
Average	8.67	0.84	7.04	2.16	0.58
SE	0.33	0.12	0.78	0.18	0.23
SD	0.58	0.20	1.35	0.31	0.40
VC%	6.66	24.21	19.12	14.47	69.85

T a b l e 2

Correlation between vegetative and reproductive indicators for 2018 per 1 linear m

	Average number of shoots per 1 m	Average height of shoots (m)	Average shoots thickness (mm) per 1 m	Average yield (g) per 1 m
Average number of shoots	1			
Average height of shoots	0.61	1		
Average shoots thickness	0.64	1.00	1	
Average yield	0.77	−0.03	0.00	1

A high correlation was observed between the average number of shoots and the average yield (0.77) and a very high correlation between the average height and the average thickness of the shoots (1.00). During the second experimental year, a moderate but negative correlation was observed between the average number of shoots and their average thickness (−0.35) and a positive correlation between the average thickness of the shoots and the average yield (0.39) (Table 3). A significant negative correlation was observed between the average number of shoots and their average height (−0.68). A high correlation was recorded between the average number of shoots and the average yield (0.72) and a very high correlation between the average height of shoots and their average thickness (0.93).

During the third experimental year, higher correlations between the indicators were recorded. A significant correlation was observed between the average shoot

T a b l e 3

Correlation between vegetative and reproductive indicators for 2019 per 1 linear m

	Average number of shoots per 1 m	Average height of shoots (m)	Average shoots thickness (mm) per 1 m	Average yield (g) per 1 m
Average number of shoots	1			
Average height of shoots	-0.68	1		
Average shoots thickness	-0.35	0.93	1	
Average yield	0.72	0.02	0.39	1

T a b l e 4

Correlation between vegetative and reproductive indicators for 2020 per 1 linear m

	Average number of shoots per 1 m	Average height of shoots (m)	Average shoots thickness (mm) per 1 m	Average yield (g) per 1 m
Average number of shoots	1			
Average height of shoots	0.92	1		
Average shoots thickness	0.84	0.99	1	
Average yield	0.97	0.80	0.69	1

thickness and the average yield (0.69) (Table 4). High correlations were recorded between the average height of shoots and the average yield (0.80) and between the average number of shoots and their average thickness (0.84). A very high correlation was found between the average number of shoots and their average height (0.92), between the average number of shoots and the average yield (0.97), and between the average height and the average thickness of the shoots (0.99).

Conclusions. The results obtained regarding the vegetative and reproductive characteristics of the Bulgarski Rubin raspberry cultivar during the three-year experimental period show the following correlation dependencies:

The degree of repeatability of correlation relations for some indicators during the study period was recorded.

A high to very high correlation was found between the average number of shoots and the average yield (0.72–0.97).

A very high correlation was recorded between the indicators of average shoot height and average shoot thickness.

A lower degree of correlation was observed between the indicators of average number of shoots and their average height and thickness, with a degree of significant to very high correlation.

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