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PHENOLOGICAL TRAITS OF GOJI BERRY (*LYCIUM BARBARUM* L.), GROWTH AND REPRODUCTIVE CHARACTERISTICS OF SOME VARITIES CONDUCTED AS A TREE

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Abstract

The study was conducted in the experimental base of the Department of Fruit Growing at the Agricultural University - Plovdiv in the period 2018-2020. In vitro propagated plants of four varieties: goji berry (BioTree) of the species (Lycium barbarum L.) - JB 1, JB 2, JB 4 and JB 10 were planted at distances of 3 m x 2 m in June 2014. They were fortmed as trees with a stem height of 70-90 cm. The results of the study showed that starting of vegetation for variety JB 2 started about a week earlier than in other varieties. Mass flowering in the varieties occurs in May and damages from late frosts in goji berry are not possible. It takes 30 to 40 days from flowering to fruit ripening. At the end of the seventh vegetation, the growth of the trees has not yet weakened. With the 3 m / 2m planting scheme, the plants have not fully occupied the available space and closer planting distances are possible. From the goji berry varieties studied, the most productive was the JB 1 variety, followed by the JB 2 variety. The aim of the study was to examine the phenological, growth, reproductive and other features associated with the cultivation of goji berry, conducted as a tree under the open field conditions. The data from the study would be useful, when selecting the appropriate variety and plant densities for cultivation as well for using various agro-technological practices such as fertilization, harvesting and storage of fruits.

Key words*: Goji berry, growth, Lycium barbarum L., phenology, yield.*

INTRODUCTION

One of the main factors determining the great diversity of the assortment of the fruit crops is the climate. The goji berry species originates from Asia and is naturally adaptable to the conditions of this continent. With the establishment of the beneficial properties of the goji berry plant (fruits and vegetative parts), studies of the suitability for growing the plant in many places around the world began. Growth and productivity of goji berries are related to climatic conditions.

The species has been identified as adaptive to the climatic conditions of Mongolia (Liu, 1999), Romania (Mencinicopshi et al., 2012). In Georgia, it is recommended for cultivation in the Shida Kartli region and in other parts of the country with similar soil and climatic conditions (Bobokashvili et al., 2017). Dzhugalov et al. (2015) studied the growth and reproductive manifestations of two *in vitro* propagated goji berry varieties (JB 1 and JB 2) under the conditions of Plovdiv region-Bulgaria and identified them as suitable for cultivation. They registered better productivity of variety JB 1 - 0.56 kg/tree with theoretical yield - 93.52 kg/dka, as in the other variety, the yields were, respectively 0.31 kg/tree and 51.77 kg/dka, respectively. The authors also found differences in terms of variety growth. Differences in growth and productivity have also been identified by (Lichev et al., 2020). Very often genetic characteristics influence different growth and reproductive characteristics. They must be taken into account when creating plantations.

The fruits appears on the current growth during the vegetation for a long period of time. The shoots are long. Due to the weeping habit of the plant when grown as a shrub, most of the fruits are contaminated and damaged, and their collection is quite time consuming. An opportunity to avoid the disadvantages associated with the cultivation of goji berry is the training of the plant as a tree. For this purpose because the plant does not form a thick stem and is quite unstable, a supporting

structure is needed. There is little information related to pruning practices and planting distances (Zhang Haizhou, 2001; Chen Fang and Liu Fue, 2008). In China it has been established a standard for growing goji berries (Lee Yoon et al.). Several crowns have been described in the cultivation of the plant as a tree:

- Naturally semicircular with 5 to 8 main branches: 3 to 5 on the first level and 2 to 3 branches on the second level. The crown after formation is 1.7 m high and 1.8-2 m in diameter.
- Semicircular with 5 to 8 main branches, which are evenly distributed on the central leader branch. The tree is about 1.7 m high and 2 m in diameter.
- Conical: The tree has 16 to 20 branches with a nude central leader and a single level. After formation, the diameter of the crown is about one meter and the height about 1.7 m.

Umbrella-shaped (with one or more levels of branches, with 4 to 5 branches per level). After 4 to 5 years, the tree is expected to be about 1.6 m high, with crown diameter 1.0 m and thickness of the stem 5-6 cm.

In Canada (Penn State College), offer the formation of a conical crown. A well-shaped tree with a conical crown should have 16 to 20 semi-skeletal branches and be about 1.80 m high and 1.0-1.2 m in diameter. The other offered crown for goji berry is with a few levels of branches. Crown (with three levels), after the formation should have from 10 to 15 main branches, height from about to 2.2 m and crown width 1.5-1.8 m.

There is no information available about the phenological development of goji berry in Bulgaria. Also for the growth, reproductive and other features associated with the cultivation of goji berry, formed as a tree under open field conditions. The permanent maintenance of the average daily air temperature above 5°C in spring is considered to be the beginning of the active vegetation in fruit plants (Vandova et al., 1984). For the region of Plovdiv in assessing the agro-climatic conditions for growing some fruit crops in Bulgaria it was found that the permanent increase in air temperature above 5°C is in early March, the difference between the earliest and latest date is 42 days (Vandova et al., 1984).

The information from the study would be usefull, when selecting the appropriate variety and plant densities for cultivation as well for using various agro-technological practices such as fertilization, harvesting and storage of fruits.

MATERIALS AND METHODS

The study was performed with 4 *in vitro* propagated plants (BioTree) in the period 2018-2020. The experimental plants were planted in June 2014. They are conducted as trees with a stem height of 70-90 cm and are on a supporting trellis and are cultivated with drip irrigation. Additional water with 40 l/tree per week was assured during the months of July and August.

With the winter pruning (before the beginning of the vegetation), the branches growing inwards and downwards are removed. During the vegetation the current vegetative growth is shortened when reaching a length of 30 cm. Each tree is fertilized with 300 g NPK (14:10:12), first after the winter pruning and then in May before flowering. The climate in Plovdiv is typical for the temperate climate zone with 3900° active temperature sum and with precipitat-ion in the amount of about 515 mm.

The information for the dates of occurrence of the main phenological phases (beginning of vegetation, bud burst, mass flowering and fruit ripening) is given. The indexes for the high of the trees, diameter of the stem (mm), diameter and volume of the tree crowns and the yield characteristics (kg/tree) are taken into account.

Ripe fruits are those, which are shiny and rich in color. Usually they are easily separated from the stalk. The data are processed statisticaly.

RESULTS AND DISCUSSIONS

The information about the main phenophases is presented in (Table 1). The bud burst in the studied period 2018-2020 was observed in middle of March, beginning of April. The vegetation in JB 2 variety started every year earlier than in the other cultivars. The first flowers was seen in middle of April and the mass flowering occur in June.

The first red fruits were observed in June and next month is a good time for the first picking.

Flowering and fruiting, takes place over a long period of time. Harvesting once a month usually is enough. It took about 30 minutes to harvest a tree full of fruit. The last harvest in this study has been done in early November. Even during this time, flowers still were observed on the plants.

Table 1. Main phenophases in goji berry varieties in the period 2018-2020

Variant	Vegetation			Flowering			Maturity		
Copr	2018	2019	2020	2018	2019	2020	2018	2019	2020
JB 1	14.03	25.03	14.03	09.06	05.06	29.05	13.07	18.07	29.07
JB 2	09.03	19.03	09.03	02.06	05.06	29.05	03.07	18.07	29.07
JB 4	20.03	22.03	14.03	12.06	14.06	24.05	25.07	22.07	16.07
JB 10	20.03	22.03	14.03	12.06	14.06	20.05	25.07	22.07	16.07

The results regarding the growing characteristics are presented in Table 2. The trees of the varieties JB 4 and JB 10 are higher than those of JB 1 and JB 2. The harvest of the JB 1 and JB 2 still can be done without additional equipment, while for JB 4 and JB 10 such in future probably will be needed. The results for the diameter of the stem show that after seventh vegetation (2020) the diameter of the stem in studied varieties ranged from 15.65 mm to 31.17 mm. The thickest stem form JB 2 variety, followed by JB 1. The most unstable in terms of stem thickness are the other two varieties - JB 4 and JB 10. The supporting trellis for the studied varieties is still useful and in the future removal of the supporting structure can be done first in JB 2 than in JB 1 variety.

The diameter of the crowns in the studied varieties after seventh vegetation (2020) year, is in range 81.75-136.25 cm. Variety JB 2 formed the wider crown and the narrowest have JB 4. At the end of the seventh vegetation, at the selected planting distances of 3 m/2 m, the trees have not yet completely occupied their defined area. The winter and summer pruning is helping to maintain the width of the crowns in the desired size. The trees are shown in Figures 1-4.

Table 2. Growth characteristics of goji berry plants after 7-th vegetation (2020) year

Variety	High of the trees, cm	Diametar of the stemm, mm	Diametar of the crown, cm	Volume of the crown, m^3
JB 1	196.67	21.89	120.00	0.37
JB 2	197.50	31.17	136.25	0.58
JB 4	247.50	15.65	81.75	0.26
JB 10	250.00	19.45	116.25	0.59

Significant differences by p < 0.05%

Figure 1.
Tree of JB 1

Figure 2.
Tree of JB 2

Figure 3.
Tree of JB 4

Figure 4.
Tree of JB 10

The results related to the yield characteristics are presented in Table 3. The data indicate variety JB 1 as the most productive with total yield of 4.02 kg and on average 1.34 kg per tree for the studied period 2018-2020. The variety JB 2 follows the most productive variety JB 1, in terms of average yield of 0.73 kg/tree as well with total yield of 2.20 kg. Less number of fruits in total for the period 2018-2020 and average were obtained by the varieties JB 4 and JB 10, respectively 0.49 kg and 0.16 kg. Closer planting distances could compensate the low yield to some extent in those two varieties, as well as finding proper pruning methods for them.

Table 3. Yield of fresh fruit kg/tree

Variety	2018	2019	2020	average	total
JB 1	0.66	1.71	1.65	1.34	4.02
JB 2	0.62	0.71	0.87	0.73	2.20
JB 4	0.15	0.09	0.25	0.16	0.49
JB 10	0.18	0.12	0.19	0.16	0.49

Significant differences by p < 0.05%

Goji berry varieties visibly differ in shape, size (Figure 5). The largest fruit had been noticed at the JB 4 variety followed by JB 10. These two varieties are sweet when are fully ripen and can be eated immediately after picking, while JB 1 and JB 2 varieties need to be dried and then consumed because of their bitter taste.

The sweetness of the JB 4 and JB 10 varieties attracts ants and insects, so it is imperative that the fruits of these two varieties to be harvested, when they acquire the characteristic ripening color. Characteristic for the ripe fruits is the easy separation of the stalk.
The skin of the JB 2 fruit, which is the juiciest, is thickness and juice is released when the fruit is detached from the stalk. In case of poor ventilation during drying, the fruits of this variety stick together and are easy damaged when separated.

Figure 5. The mature fruit of goji berry

CONCLUSIONS

The trees of JB 4 and JB 10 varieties are higher in comparison with JB 1 and JB 2.
The vegetation starts in the middle of March, first the JB 2 variety. The flowering occurs at the end of May and beginning of June and the fruits are mature in July.
The supporting trellis for the studied varieties is still useful and the future removal of the supporting structure can be done, first in JB 2 and then in JB 1 variety.
At the end of the seventh vegetation, at the selected planting distances of 3 m/2 m, for the trees have not yet completely occupied their dedicated area.
The most productive variety is JB 1 followed by JB 2 one.

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