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PRODUCTION OF PLANTING MATERIAL OF RASPBERRY VARIETY "GLEN AMPLE" IN THE NORTH MONTENEGRO

SUMMARY

The objective of the paper is to present the method of production, quantity, and quality of obtained planting material per unit area of continental fruit within the period of three years (2018-2020), and, in particular, the nursery of raspberry variety "Glen Ample" in Polimlje, Bijelo Polje municipality, northern Montenegro. The paper shows the initial condition, preparation for the formation of nurseries, production, and quality of raspberry seedlings, which are among the most important berry fruit species grown in northern Montenegro. The production of nurseries was within the limits for the production of raspberry planting material. The number of plants per square metre (m^2) at the end of the season was 20.2, and 202,000 per hectare (ha). The height of the seedlings at the end of the vegetation was 1.06 m, and the diameter above the root neck was 9.5 mm. The planting material met the prescribed standards. Based on the standard, seedlings were classified into three classes, and most seedlings of class I (73%) were obtained, followed by class II (24%), while only 3% of seedlings were out of class. Raising raspberry plantations with quality planting material is one of the most important factors for intensifying the production of this type of fruit in Montenegro.

Keywords: planting material, *Rubus idaeus* L., fruit growing, Montenegro.

INTRODUCTION

Raspberry (*Rubus idaeus* L.) is one of the most important berry fruit types in Montenegro (Jovancevic, 1970). Among fruit trees, it has been ranked at the 24th place in terms of production in the world, so that, after strawberries and blackcurrant, it is the most important berry fruit tree (Nikolić and Milivojević, 2010). Raspberry is a fruit of the northern hemisphere. The largest gene centres of

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this plant are located in Asia and North America (Mišić, 1998). The first varieties of raspberries were created at the beginning of the 17th century. They were formed by somatic mutations, selection, natural and planned crossing of wild species. It is known that there have been more than 1100 varieties of raspberries of different biological and production characteristics (Petrović and Milošević, 2002). Regardless of the fact that there have been a large number of varieties of raspberries, we have still been working on its breeding to create new varieties with improved production characteristics (Petrovic and Leposavić, 2009). According to Mišić (1998), the main goals of raspberry breeding are to create new, better varieties (more fertile, larger, firmer fruits), resistant to unfavourable abiotic environmental factors and pathogens, as well as to create varieties of good quality fruits, suitable for mechanized harvesting and freezing.

The production of healthy and quality planting material is the basis of successful, modern nursery production (Lučić *et al*., 1996; Nikolić *et al*., 2006, Ivić and Fazinić, 2011). One of the factors for achieving high yields and good quality of raspberry fruits is the use of quality, varietal and healthy planting material. Raspberries are propagated in the following ways: 1) from rootstocks, 2) by root cuttings and 3) by tissue culture ("*in vitro*"). The rootstocks should be formed in an open field that is spatially isolated from other rootstocks or native raspberry plantations. The advantage of using root cuttings is the accelerated multiplication of newly created varieties. Root cuttings are cut so that they have developed at least one underground bud, and 2-3 buds are optimal. Cuttings produced in this way should have well-developed veins, with at least 3-4 mm in diameter.

The most modern and safest way of producing raspberry planting material is "*in vitro*" propagation (tissue culture) performed in laboratory conditions which results in virus-free, healthy and varietal pure planting material of high gender potential (Petrović and Leposavić, 2016). In practice, raspberries are propagated *en masse* with mature and green shoots. It is not recommended to use raspberry shoots from native plantations for raising new plantations, which is prohibited by the law on seeds and planting material. Such way of production and use of shoots can lead to several dangers such as the spread of fungal diseases and viruses and multiplication of clones (seedlings) that have lost the positive characteristics of the variety and have become germinating from the seeds of fallen fruits.

For these reasons, only raspberry planting material produced in a modern way, which is under the professional and health control of authorized persons by the competent Ministry of Agriculture (in Montenegro), should be used for raising new plantations. The highest quality raspberry shoots are obtained from rootstocks that are raised from varietal pure and healthy planting material, in separate and closed spaces (Lolić, 2018).

The introduction of new varieties and the use of healthy planting material is the key to the rapid and proper development of fruit growing. Therefore, this study aimed to examine the possibility of producing planting material of raspberry cultivar "Glen Ample" in agro ecological conditions of northern Montenegro.

MATERIAL AND METHODS

The location of the studied area of Loznice (Municipality of Bijelo Polje-Montenegro) is presented in the Figure 1.

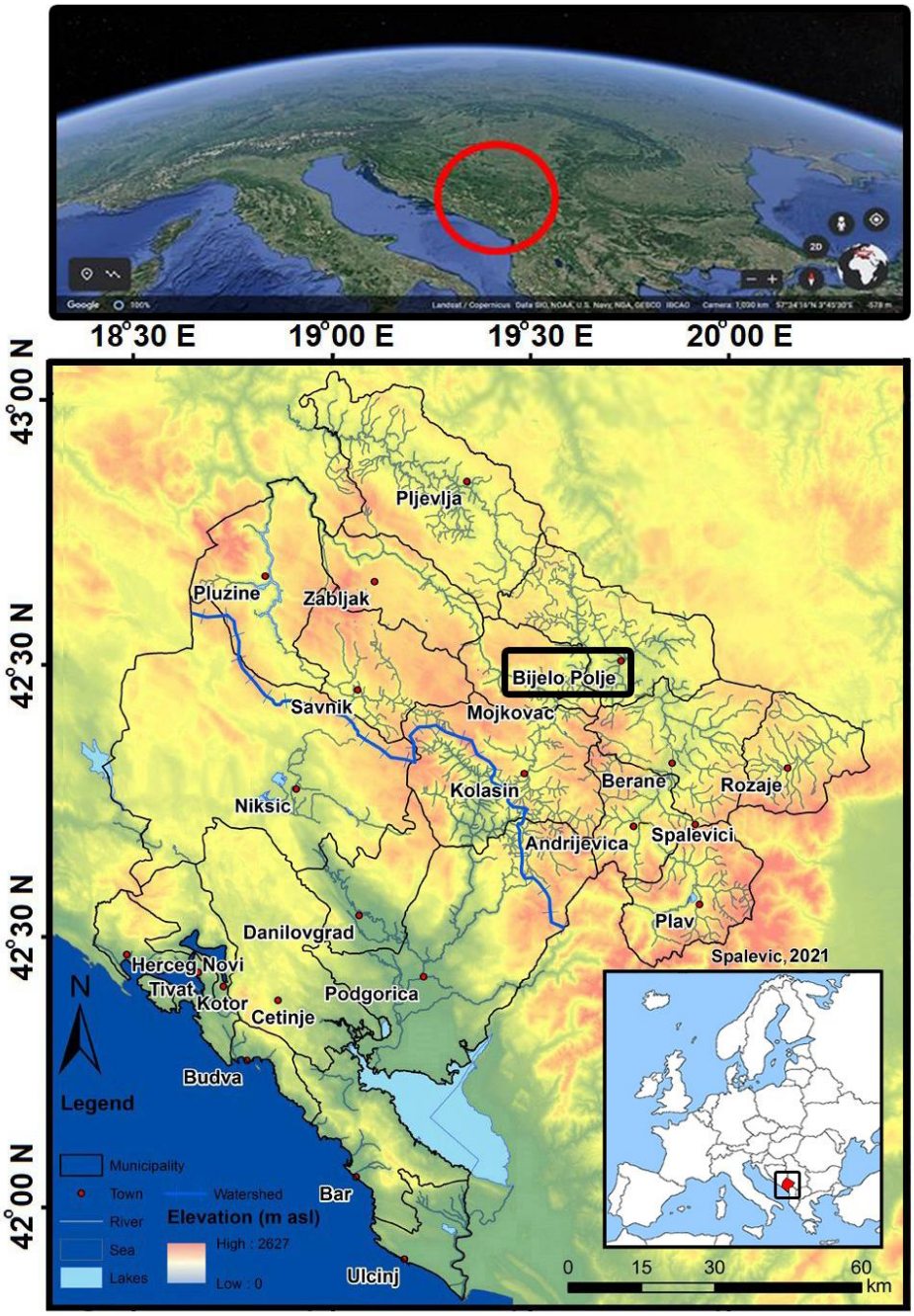

Figure 1: Location of the study area of Loznice, Bijelo Polje, North Montenegro

The municipality of Bijelo Polje, located in the north Montenegro along the main road and railway Belgrade-Bar, has been set at the position of 43.04° N 19.75° E. It has been framed on the south by the mountain Bjelasica and on the north by Lisa at the area of 924 km^2. The climate is moderate continental, since it has been located at the valley-mountainous area with very favorable conditions for the development of many branches of agriculture and tourism (https://www.bijelopolje.co.me).

Raspberry nursery was formed on an area of 0.5 ha, where the previous crop was a perennial meadow with the brown acid soil (*District Cambisol*), plots with a slight slope of about 3%, located at an altitude of 650 m a.s.l. in the village of Loznice, 43°02'08.8"N, 19°45'47.3"E (Figure 1-4).

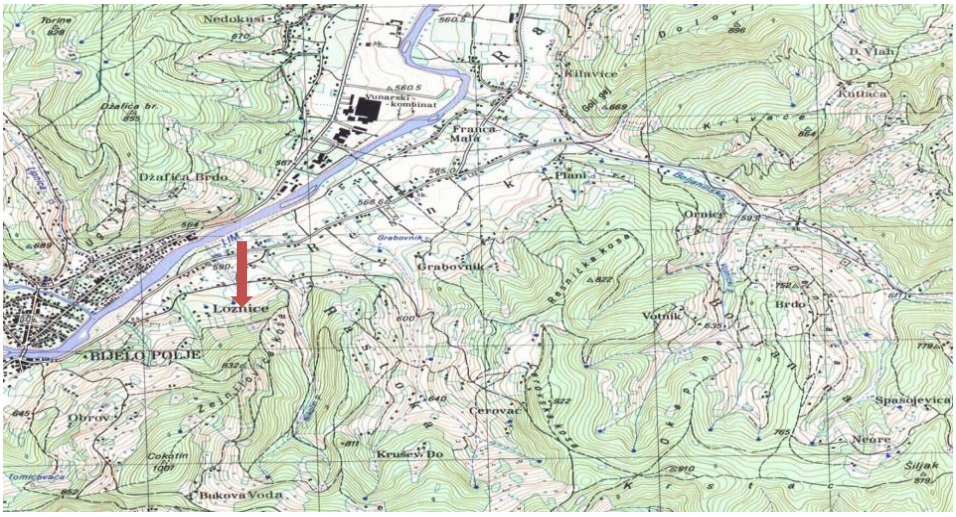

Figure 2: Location of the Raspberry nursery, Loznica, Bijelo Polje, Montenegro (Source: Topographic map 1: 25000, Bijelo Polje-East: 131-4-3, JNA, 1980)

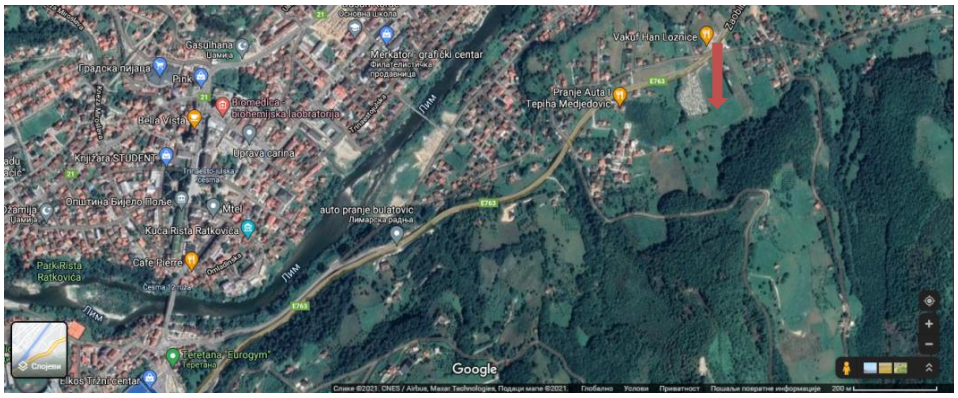

Figure 3: Nursery in Loznice, Bijelo Polje, (Source: Google earth, June 2021)

Figure 4: Nursery in Loznice, Bijelo Polje, (Source: Google earth, June 2021)

Preparatory works were performed during 2016-2017, and the organized process of production of "certified" planting material was carried out by the Private Institution Biotechnical Center, Bijelo Polje, following the Law on Planting Material (*Official Gazette of the Republic of Montenegro* N^{o}28/6, N^{o}73, N^{o}40/11, N^{o} 61/11, and 48/15) and constant control for food safety, veterinary and phytosanitary services from Podgorica and Phytosanitary Laboratories of the Biotechnical Faculty of the University of Montenegro. At the end of each of these years, the seedlings received the necessary phytosanitary documentation, certificate, label, and plant passport, and then marketed locally and internationally, which proves that the process was set up correctly and had the goal achieved, which is a healthy and well-developed seedling of raspberries.

Glen Ample is from Scotland (1994, SCRI - Scottish Crop Research Institute, Dundee). The varieties "Glen Prosen" and "Meeker" took part in their creation, and the hybrid is created from the same parents as the variety "Glen Rosa". It has been very common in the United Kingdom (Knight & Fernandez, 2008), and has been rapidly spreading to other European countries. The shoots are moderately lush and smooth, with very few thorns. It has high and stable fertility. The fruits have a very nice exposure on medium to long fruiting branches (Figures 5 and 6) with good quality. It is suitable for growing both in the open field and in various types of protected and semi-protected spaces. The primary purpose of the fruits of this variety is fresh consumption, but also for various types of processing. It has been moderately resistant to the most significant diseases, (Petrović *et al*., 2020).

The variety "Glen Ample" has been registered in Montenegro since November 2016, (Decision N^{o} 060-320 / 14-0422-1123 of 28.11.2016, license holder from Scotland James Hutton Limited, and authorized propagandist PU Biotechnical Center from Bijelo Polje, in Montenegro, agreed on the multiplication of the variety on December 2, 2016, when the legal conditions were met for it to be grown for the first time in a nursery in Montenegro).

Figure 5: Raspberry “Glen Ample” fruiting twig

Figure 6: Raspberry "Glen Ample" fruit

The precise assessment of the suitability of the site for the construction of the raspberry nursery was performed during the construction of the nursery.

Agrochemical analysis of soil samples was carried out at two depths of 0-30 cm and 0-50 cm before the establishment of nurseries in the laboratory of the Center for Soil Studies and Land Reclamation of the Biotechnical Faculty, University of Montenegro, Podgorica (Table 1).

Table. 1. Agrochemical analysis of soil samples from the site "Loznice I"

Depth (cm)	pH u H_2O	pH u KCL	$CaCO_3$ (%)	IDG (%)	Humus (%)	Available P_2O_5 (mg/100g)	Available K_2O (mg/100g)
0-30	4,78	4,1	0	0	4,22	5,7	4,6
0-50	4,63	4,05	0	0	2,61	3,7	2,7

The Table 1 shows that the soils are strongly acidic (pH in water is 4.78 and 4.73, pH in KCl 4.10 and 4.05), carbonate-free, poor in easily accessible phosphorus and potassium. In the layer 0-30 cm there is a lot of humus (4.22%), while in the layer of 0-50 cm the humus content is significantly lower (2.61%).

The soil was sampled and analyzed for the presence of nematodes. Report N^o 04-2913 dated of 8 July 2016 of the Phytosanitary Laboratory of the Biotechnical Faculty, University of Montenegro did not confirm the presence of nematodes in the soil. The performed analyses have shown that this location is suitable for the production of raspberry planting material. After assessing the suitability of the site for nursery production, the land was prepared for the nursery. First, the treatment with total herbicides was performed during the summer of 2016 (one month before tillage), to clear the land of weeds to make the optimal condition for raspberry growth. These measures included:

calcification (200 kg/ha), humus - the application of well-burned manure (20 t/ha), as well as the application of complex NPK fertilizer (10:20:30, 2 t/ha). After spreading lime, organic, and mineral fertilizers on the surface, they were ploughed to a depth of 30 cm. In the spring, before planting the parent plants, the soil was finely prepared by milling to a depth of 5-10 cm.

Planting of mother plants of the variety "Glen Ample" was done manually, in rows at a depth of about 10-15 cm in April 2017, using the planting material imported from the nursery Hengartner Pflanzen GmbH (Zurich, Switzerland).

The distance between the rows was 1.6 m and the distance between the rows in the row was 0.6 m. The amount of planted plants was 10,416 per hectare. The plant uptake index was measured in August 2017 by counting plants that did not have the potential for further growth. However, it was rather tall (97%). Having been planted, the plants were irrigated and fertilized with a system of dripping perforated strips "drop by drop" with a diameter of Ø16 ("Hirro 10"), whose droppers were perforated at a distance of 10 cm (dropper from a dropper). The row spacing was cultivated and milled 2 to 3 times with a motor cultivator, while the application of plant protection products was performed with a back petrol motor atomizer. The application of plant protection products was performed following the forecast and assessment of the possible occurrence of diseases and pests on average 6 to 7 treatments during the vegetation period (March, October) during 2017, 2018, 2019 and 2020.

During 2017, a system of 18 sprayers with a diameter of Ø 25.44 mm with a wetting operation of about R = 40 m per sprayer was used as a nursery watering system. Since herbicides are still not allowed to be used in the production of raspberry planting material, weeds were removed by hand (plucking) and taken out of the plot. The seedlings were taken out by hand in the autumn when the above-ground part of the plant's tree was woody and a large part of the leaf mass fell from the plant. After the seedlings were removed, they were processed. The seedlings were first shortened to a length of about 0.3 m, tied in bundles of 50 pieces each, labelled and as such traded on the market. Part of the seedlings was furrowed in a drained place so that they would be ready for the spring market offer. After the autumn removal of the seedlings, the nursery was cleaned of the remains of plants, leaves and branches, which were taken out of the plot and cut. In the spring of the following year, before the movement of vegetation (February-March), shallow tillage was started with a frost to a depth of 10 cm.

After controlling the percentage of the admission of mother plants in the nursery during 2017, it was found that it was rather high (97%). The production of new shoots was measured during the next three vegetation years, on two occasions: in summer during the vegetation (June / July) and in autumn before the end of vegetation (October, November). The procedure was such that the number of plants in the nursery in 2018, 2019, and 2020 was measured on a surface of 1 m^2 by the method of a random sample in 5 repetitions. The number of plants per ha was obtained by calculation. The tested plants had to have the prescribed height, the thickness of the root neck, properly branched aboveground part, and

without the presence of symptoms of diseases and pests on the tree and leaves. The control of the presence of diseases and pests in the nursery was performed by an expert from the Biotechnical Faculty, who was hired by the Phytosanitary Administration. The development of the aboveground part of the plant was analyzed by field observations following the valid UPOV TG/43/7 (April 9, 2003) descriptor.

The production of raspberry planting material was performed in accordance to the Law on Planting Material (Official Gazette of the Republic of Montenegro, No. 28/6, No. 73/10, No. 40/11, No. 61/11, and 48/15). The law stipulates that the raspberry seedlings should meet the following criteria: the length of the aboveground part should be at least 20 cm and have at least 2 well-developed buds and a diameter immediately above the root neck from 5 to 12 mm.

RESULTS AND DISCUSSION

Quality planting material is a key factor in the successful cultivation of all types of fruit, including raspberries. The Figures 7-22 present the most significant technological processes in the production of raspberry planting material of the "Glen Ample" variety.

The results of testing the number of plants per m^2 and per ha have been shown in the Tables 2 and 3. The number of plants per m^2 of the variety "Glen Ample" was measured in two terms. The first measurement was performed in the summer period (June-July), and the second in the autumn period (October-November). Measurement data have been presented by repetitions, years and as an average for three years.

Figure 7: Mother Plant planted in April 2017

Figure 8: Mother plant condition as of June 13, 2017

Figure 9: Mother Plant,
(July 6, 2017)

Figure 10: Inter row cultivation in the nursery, after planting (August 20, 2017)

Figure 11: Plant health control
(June 2018)

Figure 12: Plant health control
(September 2018)

Figure 13: After the autumn extraction of seedlings, the spring cultivation of the nursery (March 2019)

Figure 14: Manual weeding
(April 2018)

Figure 15: Nursery, condition of plants (September 2018)

Figure 16: Nursery, condition of plants (November 2018)

Figure 17: Application of plant protection products in the nursery

Figure 18: Manual extraction of raspberry seedlings from nurseries in Bijelo Polje

Figure 19: Seedlings after removal and tying

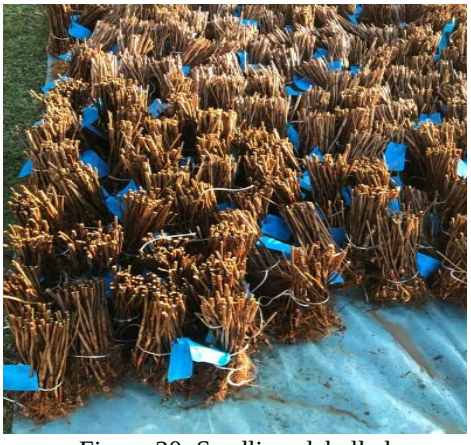

Figure 20: Seedlings labelled in bunches of 50 pieces

Figure 21: Seedlings in a dedicated box (November 2020)

Figure 22: Seedlings ready for delivery to the buyer (November 2020)

Table 2 indicates that the number of plants per m^2 in the summer period (June-July) was 19.3. By years small variations in this trait can be observed. The calculation determined the number of plants per ha, which in the summer period (June-July) amounted to 202,000. The lowest number of plants per ha was determined in 2019 (198,000), and the largest in 2020 (206,000).

Table 2. Number of plants per m^2 and ha in the summer period (June-July) in the nursery "Loznice I", Bijelo Polje (period 2018-2020)

Year	Number of plants per m^2					Average	Number of plants per ha					Average
2018.	18	19	19	20	20	**19,2**	180.000	190.000	190.000	200.000	200.000	**202.000**
2019.	19	17	19	21	20	**19,2**	190.000	170.000	190.000	210.000	200.000	**198.000**
2020.	17	18	20	22	20	**19,4**	170.000	180.000	200.000	220.000	200.000	**206.000**
Average						**19,3**						**202.000**

Analysis of the number of plants per m^2 in the autumn period (October-November) shows that it was higher and averaged 20.2 (Table 3). Conversion to ha showed that the number of plants averaged 202,000. The highest number of plants per ha was in 2020 (206,000), and the lowest in 2019 (198,000).

Table 3. Number of plants in autumn (October-November) in the nursery "Loznice I", Bijelo Polje (period 2018-2020)

Year	Number of plants per m2					Average	Number of plants per ha					Average
2018.	20	21	21	20	19	**20,2**	200.000	210.000	210.000	200.000	190.000	**202.000**
2019.	19	18	21	20	21	**19,8**	190.000	180.000	210.000	200.000	210.000	**198.000**
2020.	18	22	22	21	20	**20,6**	180.000	220.000	220.000	210.000	200.000	**206.000**
Average						**20,2**						**202.00**

As the raspberry variety "Glen Ample" is new in Montenegro only in this nursery is proliferated, and due to the fact that the situation is similar in the environment where there are only nurseries that produce older varieties "Willamette" and "Meeker", it is rather difficult to make a good comparison with yield of seedlings per unit area with other works. Depending on the variety and care conditions, a quality lemon balm can have an annual production of 200,000 or even 300,000 raspberry seedlings. In the Institute for Fruit Growing in Čačak, in the rootstock of certified material on the hill "Grad" near Kosjerić, near the variety "Villamette" in 2008, the production of 400,000 raspberry seedlings per 1 hectare was achieved (Leposavić 2016). Considering that "Glen Ample" gave an average of 202,000 pcs / ha in the examined three-year period, it can be stated that this is a satisfactory yield of seedlings and is close to the results found in practice.

Table 4 shows the data regarding the height of raspberry seedlings of the "Glen Ample" variety, measured in two terms: summer period (June-July) and autumn period (October-November).

Table 4. Height of seedlings (m) in the nursery "Loznice I", Bijelo Polje (period 2018-2020)

Year	Summer (June-July)					Average	Autumn (October-November)					Average
2018.	0.63	0.51	0.69	0.66	0.50	**0.60**	1.10	0.98	0.92	1.05	1.12	1.03
2019.	0.69	0.61	0.71	0.70	0.58	**0.66**	1.04	0.93	0.97	1.15	1.21	1.06
2020.	0.61	0.55	0.70	0.67	0.60	**0.63**	1.03	1.10	0.98	1.12	1.25	1.10
Average						**0.63**						**1.06**

By measuring the height of plants during the summer (June-July), it was determined that they had a good growth, which averaged 0.63 m, with a small variation over the years, from 0.60 m in 2018 to 0.66 m in 2019. However, concerning these measurements, the height of seedlings at the end of vegetation (October-November) was higher by about 40%. The average height of seedlings at the end of the vegetation was 1.06 m. The seedlings had the highest height in 2020 (1.10 m), and the lowest in 2018 (1.03 m). The height of the seedlings was following the Law on Planting Material.

Seedling diameter is one of the most important parameters for classifying seedlings. Table 5 shows changes in the diameter of seedlings, which is shown in two terms: summer period (June-July) and autumn period (October-November).

Table 5. Diameter of seedlings (mm) above the root neck in the nursery "Loznice I", Bijelo Polje (period 2018-2020)

Year	**Summer (June-July)**					**Average**	**Autumn (October-November)**					**Average**
2018.	5.0	4.0	4.0	6.0	4.0	**4.6**	7.0	7.0	9.0	12.0	10.0	**9.0**
2019.	6.0	4.0	6.0	7.0	6.0	**5.8**	7.0	8.0	12.0	13.0	11.0	**10.2**
2020.	6.0	5.0	7.0	6.0	4.0	**5.6**	8.0	6.0	11.0	12.0	9.0	**9.2**
Average						**5.3**						**9.5**

In summer, the diameter of seedlings above the root collar averaged 5.3 mm. The smallest diameter of seedlings was in 2018 (4.6 mm), and the largest in 2019 (5.8 mm).

Based on the data from Table 5, it can be seen that the diameter of the seedlings above the root collar at the end of the vegetation was about 45% higher compared to the summer period. This indicates that in the second part of the vegetation in raspberries, I express the growth of shoots in thickness. The diameter of the seedlings at the end of the vegetation was high. It ranged from 9.0 mm in 2018 to 10.2 mm in 2019. The average diameter of seedlings for all three examined years was 9.5 mm.

According to the prescribed standards on the categorization of planting material, seedlings were classified into three classes: Class I, Class II and class outside the category (Figure 23).

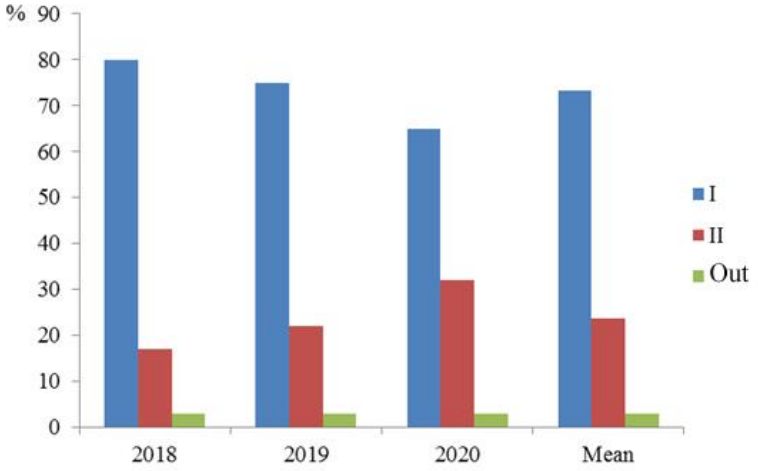

Figure 23: Class of raspberry planting material in the nursery "Loznice I", Bijelo Polje (period 2018-2020)

The obtained results indicate that the largest number of seedlings is those of class I (73%), then class II (24%), while only 3% of seedlings were out of class. Observed by the parameter *years*, the largest number of seedlings of class I was in 2018 (80%), and the lowest in 2020 (65%). In 2020, the largest number of Class II seedlings was obtained (32%), and the least in 2018 (17%). The number of seedlings outside the class was very small in all three examined years and amounted to 3%.

CONCLUSIONS

The production of raspberry planting material of the variety "Glen Ample" can be successfully organized in the municipality of Bijelo Polje and northern Montenegro due to the corresponding agro-ecological conditions. At the end of the season, the number of plants was 20.2 per m^2, or 202,000 per ha. The quality of the seedlings met the required standards and took place in accordance with the

Law and regulations. According to these criteria, the largest number of seedlings belonged to the category I class (73%), so it can be concluded that quality of planting material produced in local agro ecological conditions gives an advantage to future raspberry planters to establish new plantations faster, more efficiently and cheaper with such seedlings.

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