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SEED OF *Taxus baccata* L. FROM PARK TREES – MORPHOLOGICAL CHARACTERISTICS

SEME *Taxus baccata* L. SA PARKOVSKIH STABALA – MORFOLOŠKE KARAKTERISTIKE

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Abstract

Taxus baccata L. is a rare species in the forests of Serbia, holding the status of a protected species as a tertiary relic. Contrary to the distribution in forests, the species is represented in parks. Yew is a dioecious species that bears fruit every or every other year, and the seeds are surrounded by a fleshy red covering that is extremely attractive. Data on the morphological characteristics of yew seeds are limited to a few literature sources due to the infrequent collection of seeds and significantly more frequent propagation by vegetative means. Seeds were collected during the fall of 2021 from 13 yew trees (11 trees from Belgrade and one from Novi Sad and Vrdnik) to investigate their morphological characteristics. The morphological characteristics of the seeds (length and width of the seeds diameter and shape of the seed scar, as well as dry weight of the seeds) from these trees are within the limits of the values reported in the literature for yew seeds. Significant variability in seed characteristics between the observed trees was proven using analysis of variance, and then grouping was performed using post-hoc Tukey HSD. Individual trees that are spatially close to each other showed a higher degree of seed similarity than spatially distant trees, as confirmed by cluster analysis (Tree Clustering, Single Linkage-Euclidean distances).

Key words: seed length, seed morphological characteristics, seed variability, seed weight, seed width

1. INTRODUCTION / UVOD

The European yew (*Taxus baccata* L.) is a woody evergreen species which, like other non-European species belonging to the *Taxus* genus, grows as a lower tree up to 20 m high, often with intertwined trunks and a broadly rounded or conical crown (Ocokoljić & Ninić-Todorović, 2003; Thomas & Polwart, 2003). The natural distribution area includes western, central and southern Europe, northwestern Africa, and southwestern Asia to northern Iran (Rushforth, 1999). It is an autochthonous species in Serbia, which most often occurs singly in beech forests on the mountains: Tara, Prokletija, Kopaonik, Šar-Mountains, Mokra Mountains, Đerdap and Zlatibor (Vilotić, 2000). Yew is a dioecious species that reaches sexual maturity late in nature (about 70 years old), tolerates shade well, has no special requirements

for soil, grows on various types of soil, and is resistant to rot (Thomas & Polwart, 2003; Linares, 2013). According to some authors, it can reach an age of more than 2000 years (Igić & Vukov, 2000). A well-developed root system provides mechanical support even on the most inaccessible terrains, such as cliffs and rocky outcrops. In yew, throughout its life, the strengthening of the root system takes precedence over growth, which is one of the reasons for its durability and longevity (Hageneder, 2013). Slow growth, great regenerative power, the effective storage of resources, toxicity, and high-stress tolerance form a unique ecological strategy that has enabled it to survive for 15 million years and adapt to different environmental conditions.

There are indications that this species was once more present in European forests, but overuse (Clark, 1963), combined with unsuccessful regeneration, illegal logging, and a lack of appropriate management strategies (Svenning & Magård, 1999; Dhar et al., 2006), contributed to European yew classification as a rare and endangered species throughout Europe (Hageneder, 2007).

In Serbia, it is a tertiary relict (Banković et al., 2009). Accordingly, the forests where they grow require special attention. Numerous studies on efforts to conserve natural yew populations in Denmark (Svenning & Magård, 1999), Austria (Vacik et al., 2001; Dhar, 2006; Dhar, 2007; Dhar, 2008; Ruprecht et al., 2009; Klumpp & Dhar, 2011), Norway (Myking et al., 2009), Italy (Piovesan, 2009; Farris et al., 2012), Greece (Katsavou & Gantasas, 2012), Portugal (Vessella et al., 2013) and Ireland (Devaney et al., 2014) were published.

It is rare in forests. It is a common species cultivated in many horticultural forms in parks, (Cvjetićanin & Perović, 2010). The mass use of yew in urban areas resulted from its tolerance to different environmental conditions and modest requirements regarding light, especially tolerance to air pollution (Thomas & Polwart, 2003). Unlike most other conifers, this species reproduces well vegetatively. Yew has the ability of adventitious growth, resulting in many shoots developing at the tree base, a rare phenomenon among gymnosperms. Low-growing branches often descend to the ground and root, producing adventitious shoots that grow vertically and become independent plants. Fallen yew trees continue to grow until sufficient root contact is established, with apical shoots developing from lateral branches or the trunk. It is characteristic that old yew trees become hollow under the influence of some fungi, and in these hollows, from the vegetative bark at the top of the tree, new trees develop and take root. Over time, new trees take over the function of the old ones, which enables the complete renewal of the organism. This process is time-consuming and does not happen to all trees with equal success (Hageneder, 2013).

Yew is a dioecious plant and uses unisexual cones in reproduction. Seed embryos (inflorescences) of yew are single, located in the axils of the leaves, made of shield-shaped microsporophylls with 2 to 8 microsporangia, and covered with scaly leaves (Šilić, 1990). Yew seeds are distinguished by their specific morphology and are significantly different from the seeds of most other conifers (Fig. 1). Yew seeds are oval-shaped, 6-8 mm long and 4-5 mm wide, shiny, smooth and chestnut, dark brown. A red fleshy appendage, the arillus, covers the seed covered , on the upper side. It is worth noting that the whole yew contains the toxic alkaloid taxine. Therefore, yew seeds are not edible and require careful handling (Cvjetićanin & Perović, 2010). Yew seeds are slow and difficult to germinate, establishing double dormancy, originating from an impermeable seed coat and an immature embryo (Regent, 1980). The procedures described for eliminating the complex dormancy of yew seeds are mostly ineffective (Suszka, 1985). Therefore, nursery production of this species is mainly based on vegetative reproduction. Although yew prop-

agation is often done by cuttings or grafting, yew seeds are essential for preserving the biodiversity of the species. For the preservation of the biodiversity of this species and the seeds dispersal in nature, birds that feed on juicy arillus are extremely important, and they expel the whole seed through their digestive system and scatter it in flight.

The available data on the morphological characteristics of yew seeds are limited to several sources, and it is clear that the reason for this is the infrequent collection of seeds and significantly more frequent propagation by vegetative means. This research examines the variability of morphological characteristics of seeds from trees from urban areas of Belgrade, Novi Sad, and Vrdnik.

Figure 1. Cones with seeds of yew (*Taxus baccata* L.) / **Slika 1**. Šišarke sa semenom kod tise (*Taxus baccata* L.) (© Lj. Mijatović)

2. MATERIAL AND METHODS / MATERIJAL I METOD RADA

The research was conducted during the fall of 2021. Seeds were collected from 13 park yew trees, 11 from parks in Belgrade, and one tree from Novi Sad and Vrdnik (Fig. 2).

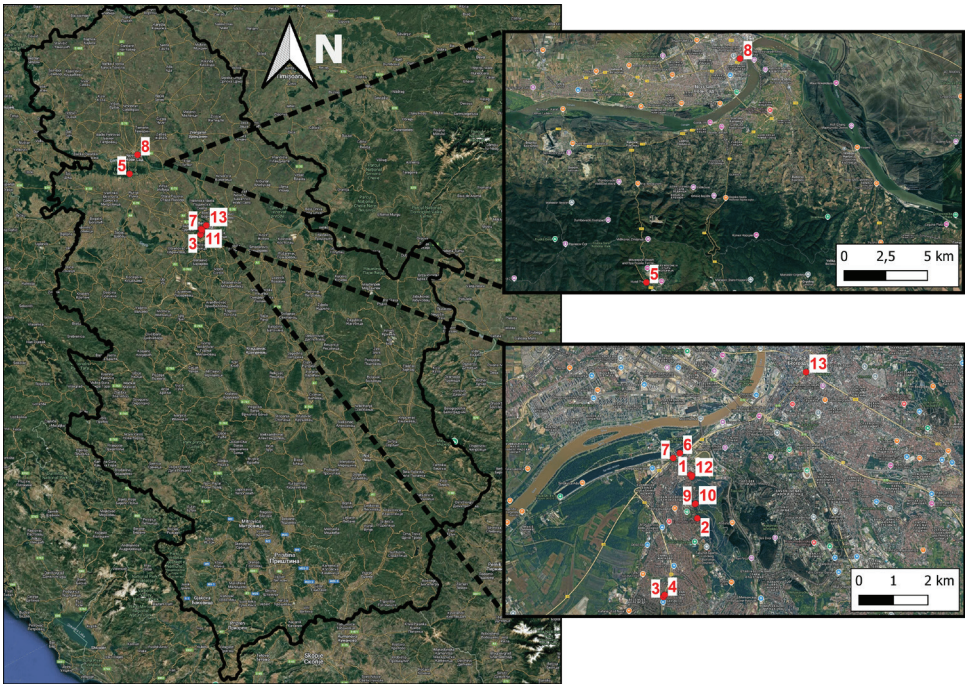

Figure 2. Locations of maternal yew trees / **Slika 2**. Lokaliteti stabala tise sa kojih je sakupljano seme

The collected seeds were tested in the Laboratory for Testing Seeds and Seedlings at the Faculty of Forestry, University of Belgrade. The following morphological characteristics of the seeds were measured: the length and width of the seeds, and the shape and diameter of the scar on the seeds. Measurements were carried out on a sample of 100 seeds per tree using a digital vernier with an accuracy of 1/10 mm. The average value of the sample standard deviation (Sd), as well as the minimum (min) and maximum (max) measured values, was determined for the seed length (D), seed width (W), and scar diameter (O). The distribution for the descriptive characteristic scar shape (triangular, square, round, and elliptical) was given according to the number of seeds in the observed sample. It was measured at the place of the largest scar diameter. Seed mass (m) was determined on a sample of 100 air-dried seeds per tree, using a scale with a precision of 1/1000 g. The degree of difference/similarity between seeds from different trees was tested by one-factor analysis of variance (OneWay ANOVA $p<0.05$)., Their grouping was performed using post-hoc Tukey HSD. Cluster analysis (Tree Clustering, Single Linkage-Euclidean distances) examined the degree of closeness of different yew trees depending on the seeds' morphological characteristics . Statistica 7.0 program was used for the statistical processing of the collected data.

3. RESULTS AND DISCUSSION / REZULTATI I DISKUSIJA

The measurement results showed that the seed length, seed width, and seed scar diameter are within the limits of the values recorded in the literature for yew seeds. The average values of yew seed length range from 5.5 mm to 7.4 mm. The smallest measured value

Table 1. Seed length and width, diameter of seed scar, and mass of seeds from different *Taxus baccata* trees: (T1-T13 = Tree 1 - Tree 13; D (Sd) = seed length (standard deviation); D min-max = seed length minimum-maximum value; W (Sd) = seed width (standard deviation); W min-max = seed width minimum-maximum value; O (Sd) = seed scar diameter (standard deviation); O min-max = seed scar diameter minimum-maximum value; m = mass of 100 air-dried seeds) / **Tabela 1**. Dužina i širina semena, prečnik ožiljka na semenu i masa semena sa različitih stabala tise: (T1-T13 = Stablo 1 - Stablo 13; D (Sd) = dužina semena (standardna devijacija); D min-max = dužina semena minimalna-maksimalna vrednost; W (Sd) = širina semena (standardna devijacija); W min-max = širina semena minimalna-maksimalna vrednost; O (Sd) = prečnik ožiljka semena (standardna devijacija); O min-max = prečnik ožiljka semena minimalna-maksimalna vrednost; m = masa 100 vazdušno suvih semena)

	D (Sd) (mm)	**D** min-max (mm)	**W (Sd)** (mm)	**W** min-max (mm)	**O (Sd)** (mm)	**O** min-max (mm)	**m** (g)
T1	6,35^{a} (0,30)	5,50-7,10	4,52^{a} (0,19)	4,00-5,00	2,11^{a} (0,22)	1,50-2,50	8,212
T2	7,40^{b} (0,28)	6,80-8,10	4,48^{b} (0,17)	4,00-4,90	2,20^{a} (0,19)	1,80-2,70	4,283
T3	6,99^{c} (0,33)	5,90-7,60	4,06^{bc} (0,19)	3,60-4,40	1,93^{a} (0,22)	1,30-2,40	6,464
T4	7,01^{c} (0,32)	6,00-8,10	4,07^{bc} (0,39)	3,50-7,30	1,76^{ab} (0,29)	1,10-2,40	4,271
T5	6,45^{cd} (0,26)	5,80-7,40	4,11^{bc} (0,15)	3,80-4,40	2,06^{bc} (0,21)	1,50-2,60	4,966
T6	6,39^{de} (0,40)	5,60-7,50	4,76^{c} (0,30)	3,80-5,40	2,47^{cd} (0,20)	1,90-2,90	6,878
T7	7,09^{e} (0,33)	6,00-7,90	4,62^{d} (0,24)	4,00-5,20	2,15^{de} (0,20)	1,70-2,70	7,531
T8	6,62^{e} (0,40)	4,60-7,50	4,47^{d} (0,35)	3,60-6,40	2,15^{def} (0,31)	1,40-2,80	7,581
T9	6,62^{f} (0,37)	5,30-7,50	3,99^{d} (0,22)	3,40-4,80	1,75^{efg} (0,19)	1,40-2,60	5,585
T10	6,55^{f} (0,39)	5,60-7,30	3,78^{de} (0,24)	3,10-4,40	1,81^{efg} (0,19)	1,40-2,50	5,790
T11	5,79^{fg} (0,15)	5,50-6,10	4,48^{e} (0,21)	4,00-4,90	2,02^{fg} (0,23)	1,70-2,50	6,154
T12	5,50^{g} (0,23)	5,10-6,30	4,07^{f} (0,18)	3,80-4,80	1,84^{g} (0,24)	0,70-2,20	7,973
T13	7,23^{h} (0,32)	6,40-8,10	4,81^{f} (0,18)	4,10-5,20	2,24^{h} (0,24)	1,80-2,90	5,840

of seed length is 5.1 mm, while the maximum measured seed length is 8.1 mm (Table 1). Kamczyc & Suszka (2022) presented similar results reporting the length of yew seeds ranging from 5.72 mm to 6.8 mm, as well as Zarek (2007) whose results show an average seed length of 5.58 mm. Visdal-Johnsen (2006) reports similar results in which seed length ranges between 5.91-6.92 mm, with an average value of 6.53 mm.

The average value of yew seed width ranges from 3.78 mm to 4.76 mm.The smallest measured seed width is 3.1 mm while the maximum measured value is 7.3 mm (Table 1). These valuesare slightly lower thanthose reported by Pers-Kamczyc & Suszka, (2022) and Visdal-Johnsen (2006). Pers-Kamczyc & Suszka (2022) report a yew seed width result that is in the range of 4.13-4.73 mm, while the results of Visdal-Johnsen (2006) indicate a slightly wider seed of 4.71-5.35 mm. The results obtained during this research are most similar to the results published by Zarek (2007) for Poland, whose results show an average seed width of 4.42 mm.

The measured mass of 100 seeds varies from a minimum value of 4.271 g to a maximum value of 8.212 g, while the average mass of 100 air-dried seeds is 6.271 g. This is in the same range of values reported for a seed from different yew trees in England by Melzack & Watts (1982), and about 2 g more than the mass reported by Zarek (2007). Regent (1980) stands out among local authors, , stating that there are 10,000 to 18,000 seeds in a kilogram of yew seeds. We cannot fully confirm this research, since the range of weight variation between trees is somewhat wider.

The average measured values of scar diameter ranged from 1.75 mm to 2.47 mm, The largest number of seeds from trees 2, 6, 7, 9, 10, and 13 have a square-shaped scar (Fig. 3). Trees 9 and 10 are particularly significant since 88 seeds have a square scar.

Significant variability between all trees was confirmed, through the analysis of variance. Using post hoc Tukey HSD and cluster analysis, it was determined that spatially close trees have a greater degree of similarity in the mor-

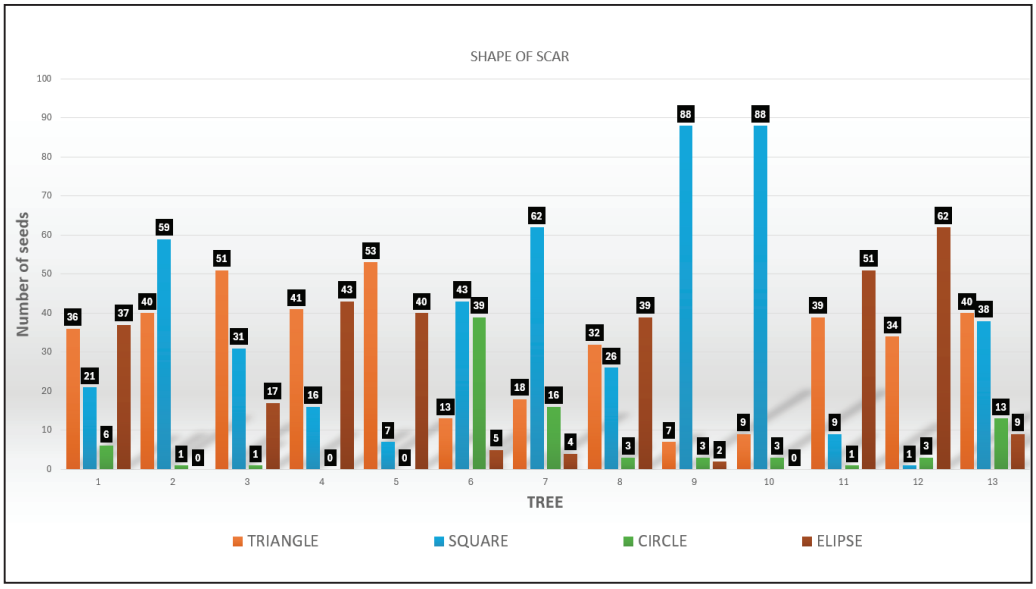

Figure 3. Shape of seed scar (%) for different yew trees / **Slika 3**. Oblik ožiljka semena (u %) tise za svako stablo

phological characteristics of seeds than spatially distant trees. Trees T3 and T4 showed the highest degree of similarity according to seeds characteristics and at the same time, they are positioned in the same park, as well as T9 and T10. Trees T11 and T12 are close to each other and at the same time, they are separated from other trees according to cluster analysis (Fig. 4). The origin of maternity trees for seed collection is unknown, so this similarity can be affected by vegetative reproduction and tree clones used for planting in parks. On the other hand, it can be the result of the same pollinator for female trees on short distances. Without information about the origin of mother trees, this question cannot be answered precisely.

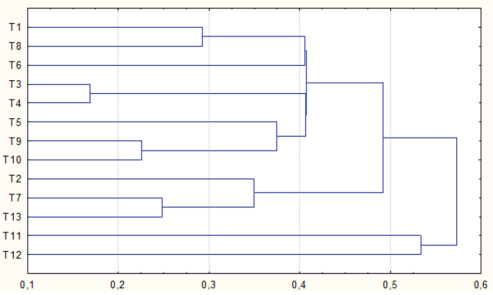

Figure 4. Cluster analysis of the degree of closeness of different yew trees depending on the morphological characteristics of their seeds / **Slika 4**. Klaster analiza stepena bliskosti različitih stabala tise u zavisnosti od morfoloških karakteristika njihovog semena (Tree Clustering, Single Linkage-Euclidean distances)

4. CONCLUSION / ZAKLJUČAK

Morphological characteristics of yew seeds originating from park trees are found in the frameworks specified for seeds of this species in available literature sources. A significant degree of variability in seed characteristics was present among the 13 yew trees growing in the parks. The degree of similarity in the morphological characteristics of seeds between yew trees is determined by the spatial arrangement on the field and the mutual distance between the trees. This research contributes to the knowledge about morphological characteristics of *Taxus baccata* seed, especially for the region of the Balkan Peninsula.

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Sažetak

Evropska tisa (*Taxus baccata* L.) je zimzeleno drvo niskog rasta, obično dostiže do 20 m visine. U Srbiji je autohtona i raste u bukovim planinskim šumama širom Srbije. Tisa je rijetka u šumama Srbije i uživa status zaštićene vrste kao tercijarni relikt (Banković et al. 2009), ali je izuzetno česta u parkovima gdje se gaji u vidu različitih hortikulturnih sorti i varijeteta (Cvjetićanin & Perović, 2010). Prilagodljivost različitim uslovima sredine i minimalni zahtjevi za svetlošću čine ovu vrstu podobnom za široku upotrebu u hortikulturne svrhe. Ova vrsta pokazuje izuzetnu vegetativnu reprodukciju, za razliku od većine četinara. Morfologija sjemena tise je karakteristična, značajno se razlikuje od ostalih sjemena četinara. Predložene metode za prevazilaženje mirovanja sjemena tise su često neefikasne, što dovodi do vegetativnog razmnožavanja u rasadnicima, ali sjeme tise je ključno za održavanje biodiverziteta vrsta. Dostupni podaci o morfološkim karakteristikama sjemena su veoma loši i ograničeni na mali broj istraživača, vjerovatno kao rezultat češćeg vegetativnog razmnožavanja u odnosu na generativnu reprodukciju. U cilju istraživanja morfoloških karakteristika sjemena, tokom jeseni 2021. godine sakupljeno je sjeme sa 13 parkovskih stabala tise (11 u Beogradu, 1 u Novom Sadu i 1 u Vrdniku). Morfološke karakteristike sjemena (dužina i širina sjemena, oblik i prečnik ožiljka sjemena i suva sjemena masa dobijeni u ovom istraživanju slični su dostupnim literaturnim podacima za sjeme tise. Značajna varijabilnost uočenih karakteristika između stabala primijećena je korišćenjem ANOVA (jednosmjerni) i post-hoc testa (Tukey HSD). Dužina sjemena tise je u prosjeku između 5,5 mm i 7,4 mm, sa ekstremima od 5,1 mm i 8,1 mm, što potvrđuju različiti autori. Pers-Kamczyc & Suszka (2022) navode opseg od 5,72 mm do 6,8 mm, dok Zarek (2007) navodi u prosjeku 5,58 mm; Visdal (2006) na sličan način pruža opseg od 5,91-6,92 mm sa prosjekom od 6,53 mm. Širina sjemena tise je u prosjeku između 3,78 mm i 4,76 mm, sa ekstremima od 3,1 mm i 7,3 mm, što je niže od nekih ranije prijavljenih vrijednosti. Pers-Kamczyc & Suszka (2022) pronašli su opseg širine od 4,13-4,73 mm, dok je Visdal-Johnsen (2006) primijetio širi opseg od 4,71-5,35 mm, dok je Zarek (2007) naveo u prosjeku 4,42 mm. Masa 100 sjemena osušenih na vazduhu kreće se od 4,271 g do 8,212 g, sa prosjekom od 6,271 g, što je u skladu sa nalazima Melzecak & Watts (1982), ali je približno 2 g teže od Zareka (2007). Regent (1980) tvrdi da postoji 10.000 do 18.000 sjemena po kilogramu, što ovo istraživanje ne može u potpunosti da potvrdi zbog širih varijacija mase uočenih među drvećem. Prečnik ožiljaka je u prosjeku između 1,75 mm i 2,47 mm. Drveće 2, 6, 7, 9, 10 i 13 sa najvećom učestalošću ožiljaka kvadratnog oblika. Najznačajnija su stabla 9 i 10, koja imaju 88 sjemena sa ožiljcima kvadratnog oblika. Prostorna distribucija ispitanih stabala ima značajan uticaj na stepen sličnosti između sjemena sa različitih stabala, što je potvrđeno klaster analizom (Tree Clustering, Single Linkage-Euclidean distances).

Ključne reči: dužina sjemena, masa sjemena, morfološke karakteristike sjemena, širina sjemena, varijabilnost sjemena