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Distribution of Service Tree in Kocaeli-Marmara Area: Phenological, Morphological and Chemical Properties

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Abstract

Service tree is a less-known species that its conservation and breeding has a priority. There is small population of the service tree in Kocaeli city-Kartepe area in Turkey. In this study, growing habitat of the service tree, tree habitus, flowering phenology, fruit characteristics (morphological and chemical) was investigated. Service trees were determined on the southern slopes, grown as multi-stemmed trees and has less or severe suckers. Flowering period occurred in April and there were averagely 30.5 flowers per bud and 3.1 fruits per cluster. Fruits were apple shaped; the average weight, length and width of fruits were calculated as 7.28 g, 17.1 mm and 19.9 mm, respectively. Soluble solid contents, titratable acidity, and pH were measured as 20.2%, 0.42% and 4.0, respectively. Seed number per fruit was 1.4 and it was a well-developed seeds. This is the first report distribution of service tree in the Kocaeli city and has an importance as a genetic resource for the breeding.

Key words: *Sorbus domestica* L., ecology, phenology, morphological characteristics, chemical characteristics

INTRODUCTION

One of the economically valuable but less known and used fruit species [1] is the service tree (*Sorbus domestica* L.; 2n=34) which belong to section *Cormus* that has been grown for its fruits for the over two thousand years in the Mediterranean Region [2]. It typically grows on calcareous soils. Wild populations are apparently widespread in southern Europe from Spain to the Balkans [3] and also in Turkey [4]. In Turkey, the service tree spreads mostly in the Marmara Region, Central and Western Black Sea region and Central Anatolia regions, while rarely grows in the Aegean and Mediterranean Regions [5]. The majority of the service tree localities occurred up to the altitude of 400 m while vertical limit of distribution is at the altitude of 610 m [6]. There is not a commercial service tree orchard established; it is mostly situated in the forest areas only small groups of a few trees and sometimes in the field or farmer orchards. There is a little about the trees of service tree. Service tree can live for 200-400 years [7] and periodically re-grown from basal shoots of from suckers after the death and decay of an older main trunk [8]. The large areas of natural distribution with different ecological conditions allow the assumption that may exist in various ecological types.

Service trees have a lot benefits. It is an important forest fruit bearing species, very valuable for the rural areas human nutrition and fruits play a major role in fall and winter providing a valuable stock of vitamins, organic acids, fibers, tannins and natural sugars [9, 10]. The nutritional value of the fruits is excellent. There are three to four times more potassium and calcium than in apples or pears [11] and contain strong natural antioxidants [12]. It has possible benefits in reducing complications of diabetes mellitus [13] and in the folk medicine, it use against dysentery and kidney diseases, to improve memory and concentration [14]. The fruits of service tree are suitable for fresh consumption or for processing in different products, as canned fruit or jam or can be preserved by drying [14, 15, 16, 17] as well as brandy produced via formation or distillation [14]. In the propagation experiments, it was proved that there is a compatibility with quince and pear [11, 18]. It has also a valuable timber quality in Europe [10, 14] and is gaining importance as an ornamental plant recent days [19].

In the natural habitat, trees propagated by seed [20, 21], and there is considerable morphological variability among the self-propagated seedlings. Investigation of geographical distribution area properties of service tree [6, 8] and selecting good quality types was undergoing in the recent years [14, 15, 17, 22, 23, 24, 25]. Research is undertaken on the breeding and conservation of service tree [26] and improvement of methods for vegetative mass propagation including cutting propagation [23] and *in vitro* methods [19, 27, 28, 29]. Service trees grow very slow and reach productive maturity after twenty years old and produce non-uniform yields [14]; so needs to selection and breeding for commercially production.

Very little is known about the service tree so there is no report about this species before in the Marmara Region and the natural tree population has decreased by afforestation and over exploitation. The objective of this study was to determine the morphological description, evaluation of fruit quality and functional-nutritional properties of the Service tree naturally grown in flora of Kocaeli city in Turkey.

MATERIAL AD METHODS

The study was conducted in 2012-2013 years in the Kocaeli city-Kartepe region forest area.

Determination of the study area properties

Geographical localization and altitude of service tree types has been done by GPS equipment. The other plants growing in dense forest area together with service trees and general properties of the area were also observed.

Tree habitus characteristics

Tree height (m) and trunk diameter (cm) was measured. In addition, suckering characteristics of the types was determined as less (1 or 2 stem), moderate (3 to 4 stem) and severe (more than 4) suckering.

Leaf characteristics

Leaflet number per leaf was determined and leaflet length (cm) and width (cm) was measured in the middle leaflet of 20 pinnate leaves for each replicate.

Flowering phenology and flower characteristics

First flowering (10 to 15 % of flowers opened), full flowering (80 to 90% of flowers opened), and end of flowering (petals of flowers turned from white to brown and 80-90% of flowers fall off) was determined. Fruit harvested when skin color turned to yellow and were recorded as the day of harvest. Flower number per pedicel, flower number per flower bud, peduncle length (main stem length of the inflorescence; as cm) were determined from 20 buds for each replicate. Flower stalk length (mm), stamen and pistil number was investigated in 20 flowers for each replicate.

Fruit characteristics

Fruit morphological characteristics such as fruit weight (g), fruit length and width (mm), fruit shape, fruit stalk length (mm) and fruit number per cluster was determined from 20 fruits for each replicate. Fruit chemical characteristics including total soluble solid contents (TSS, %), titratable acidity (TA) as malic acid (%) and pH of fruits was determined too.

Seed characteristics

Seed number per fruit, seed weight (g), seed length and width (mm) was determined from 20 seeds per replicate.

Experimental design and statistical analysis

The experiment was conducted in a completely randomized plot design with three replicate. The arcsine square root transformation was applied to the data to provide a normally distributed data set for the ANOVA. Statistical analysis was performed with Minitab 17 statistical program and the means were separated by Duncan's Multiple Range Test ($P< 0.05$).

RESULTS AND DISCUSSION

Characteristics of the study area and the mixed population in the flora in Kocaeli-Kartepe area

In the study area, climatically conditions are generally warm with a few frozen days in winter and hot and dry summers. In some years, late spring frost may occur. According to Kocaeli Meteorological Station long years temperature records, average temperature is 14.8 ºC; while the hottest month is July (23.8 ºC) and the coldest month is January (6.2 ºC). As an average of 60 years, annual rainfall is 771.7 mm [30].

In the analyzed forest location, there is a little population of service trees grown in different parts near 10 to 15 meters each other in the forest flora. The forest flora includes the mixture of too many plants species together with Service tree, like as *Quercus spp., Arbutus unedo* L., *Mespilus germenica* L., *Rubus fructicosus* L., *Corylus colurna* L., *Salix alba* L., *Prunus domestica* L., *Spartium junceum* L. It was reported that occurrence of service tree is connected with communities of oak forests at the lower altitudes [6].

In the records of the Turkey Ministry of Forestry and Water Affairs, service tree distributed between 100-1000 m, in the central and west part of Black Sea region, Marmara Region and around the Hatay City, in the Turkey forest areas [31]. In our study, service trees distributed between 100-120 m altitudes above the sea level, on the 40º42´11´´-40º44´54´´ north latitude and 29º59´28´´-29º62´59´´ east longitude; on the warm south-facing ledges. Place of the trees was near the edge of the high places, and to reach and measuring them was very difficult. In agreement with our findings, service tree occurs on the lower and warmer stands in the south regions and the vertical distribution of this plant is mentioned from the altitude 109 m up to 610 m by the other researchers [6, 32] too. Service tree superior genotypes was selected at the 40º north latitude but 36 º east longitudes in the Tokat city (Turkey) [25] too.

Service tree is given as a threatened species due to overall reduction of tree population, lack of natural regeneration and disturbance of the natural population structure due to human impact [33, 34]. We observed that, the forest area has undergone severe damage over the time to open field and settlement, building new roads, and tree populations was decreased dramatically (Figure 1 A.).

Characteristics of the tree habitus

Investigated service trees grow as multi-stemmed trees (Figure 1 B), branching from the basal part and grow up to 15.3 m (T4) in height while the thick trunk was recorded as 54.0 cm for again T4 (Table 1). Tree height was determined between 5.0 to 23.0 m in Slovakia [1]. In our study, the trees which grown in more densities place had a bigger dead and broken trunks depends on trunk decay and new suckers occurred from the basal part of trees. Severe suckering was observed in T2 and T3. After the death of the older trunks of service tree, new shoots has grown from

Figure 1. (A) Degraded forest lands by the human effects (June, 2014) where service trees observed; **(B)** Service tree branched from the basal parts with 6 trunks

Table 1. Tree habitus and leaf morphological properties of the service trees types

Type number	Tree height (m)	Trunk diameter (cm)	Suckering	Leaf number	Leaf length (cm)	Leaf width (cm)
T1	11.0	25.0	medium	14.3	5.2	1.9 a
T2	13.7	39.0	severe	14.0	4.0	1.0 b
T3	9.0	20.3	severe	15.0	4.8	1.7 a
T4	15.3	54.0	less	17.0	5.1	1.8 a
T5	11.0	30.0	less	17.0	4.3	1.6
Average	12.0	33.7	-	15.5	4.7	1.6

Values in the same column with different lower-case letters are significantly different (P<0.05).

suckering in Britain forests too [8]. Service tree is definitely regarded as a light demanding woody plant [6] and in early young age of plant is intolerant to shading so it falls quickly without a minimum light supply.

Leaf characteristics

The winter buds were in green color while the fresh leaves were silver color at the first opening stage (Figure 2 A) and turned to green later with dense grey-white pubescence on the back side of leaf (Figure 2 B and C**)**. The pinnate leaf occurred from leaflet and number of the leaflets varied from 14.0-17.0. The leaflet length and width was ranged from 4.0-5.2 cm and 1.0-1.9 cm respectively (Table 2). None of the observed data for the leaf characteristics of the types was not exhibited a statistical importance. In the research on leaflet morphometric variation of service tree was recognized that the leaflet length is the least variable character, and leaflet length and width was changed from 12.19 mm to 14.94 mm and from 44.60 to 46.10 mm respectively [35]. Our results are in agreement with founding's of other study [10], that leaflet numbers changed between 11.7-17.0.

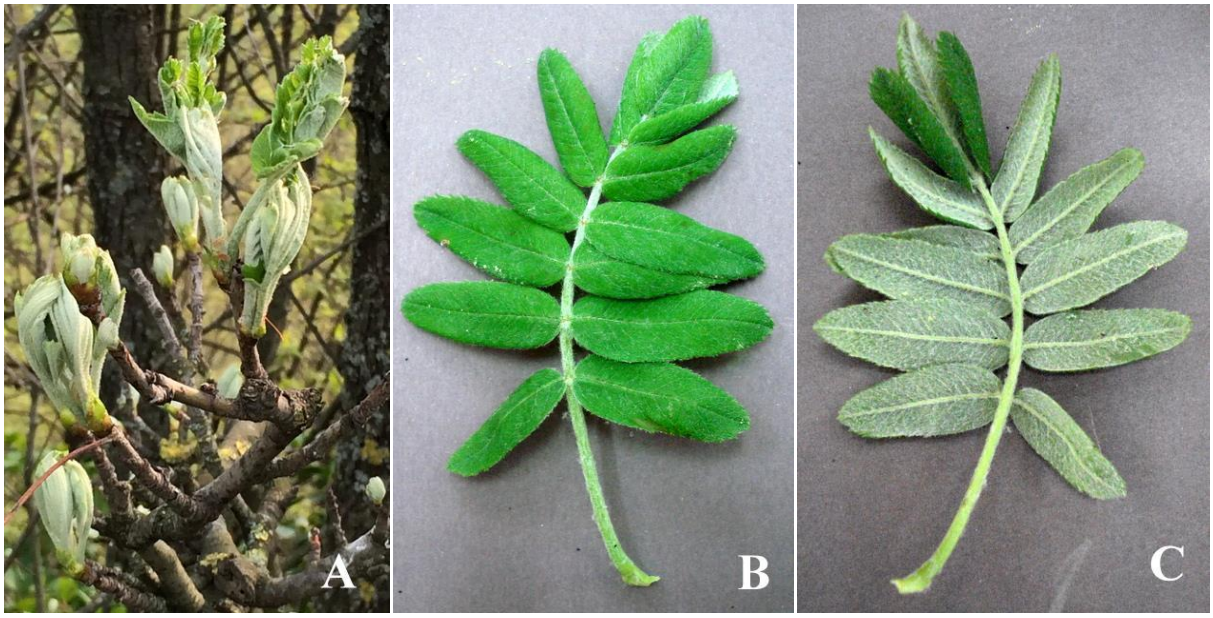

Figure 2. (A) Leaf buds of service tree at the first opening stage; **(B)** The front side of the leaf **(C)** The back side of the leaf

Table 2. Flowering dates of the service tree types in Kocaeli conditions

Types	Years	Flowering Periods			
		First Flowering	Full Flowering	End of Flowering	Harvesting Time*
T1	2012	16 April	22 April	28 April	25 September
	2013	11 April	17 April	25 April	29 September
T2	2012	17 April	21 April	28 April	23 September
	2013	11 April	16 April	25 April	27 September
T3	2012	20 April	25 April	30 April	29 September
	2013	14 April	19 April	26 April	25 September
T4	2012	16 April	23 April	29 April	25 September
	2013	09 April	15 April	26 April	27 September
T5	2012	18 April	25 April	30 April	27 September
	2013	15 April	21 April	28 April	29 September

*Tree maturity stage

Flowering phenology and flower structure

Flowering has started in the second or third week of April in 2012 and 2013. The phenology has become full flowering period in 5-7 days and ended in the last week of April in both of the experimental years (Table 2). Flowering period was observed between third week of April and second week of June in Tokat ecology [25] that this region is colder than our ecology. Service tree types showed differences for the flower numbers per peduncle and per pedicel. T2 has the highest number of flowers with 36.7 flowers. Total numbers per bud was changed from 57 to 162 in the other study [25]. This amount was too high than in our ecology. Peduncle length was changed between 6.3 to 7.5 cm, and exhibited statistical differences among the types. Pedicel numbers also important statistically too and changed from 5.3 to 8.3 per peduncle between the types (Figure 3 A, B, C; Table 3). Service tree flower structure is perfect and contains both female and male structures. We counted 5 sepals, 5 petals, 20.1 stamens averagely. There was one pistil which has 5 styles and one inferior ovary in each flower (Figure 3 C, Table 3). 5-6 styles in each flowers was reported in service tree [3] and the style numbers was expressed as a character, used to distinguish *Sorbus domestica* (with 5-6 styles) from *Sorbus aucuparia* (has 3-4 styles) [8].

Table 3. Flower characteristics of service tree types

Types	Flower number per pedicel	Flower number per bud	Peduncle length (cm)	Flower stalk length (mm)	Stamen number	Pistil number
T1	4.9 ab	31.0 ab	7.2 a	2.3	20.0	1
T2	5.2 ab	36.7 a	6.7 b	1.6	20.3	1
T3	2.8 c	32.3 ab	6.3 b	1.3	19.3	1
T4	4.2 b	29.3 bc	7.5 a	2.1	20.0	1
T5	5.4 a	23.3 c	6.7 b	2.0	20.7	1
Average	4.5	30.5	6.9	1.9	20.1	1

Values in the same column with different lower-case letters are significantly different (P<0.05).

Figure 3. (A) Flower buds of service tree; **(B)** Opened flowers of service tree; **(C)** Flower structure of service tree

Fruit morphological and chemical characteristics

Fruit weight showed significant variation among examined service tree types, and ranged from 4.55 to 9.69 g, while the length of fruit was between 14.87-18.60 mm and fruit width was between 17.67-21.72 mm (Figure 4 A, B and Table 4). The results on fruit weight, fruit length and fruit width content comply with those reported by the other authors. In different part of the same country, fruit weight was measured in different ranges. One of the researchers determined 4.91-18.64 g fruit weight, 19.8-36.3 mm fruit length and 18.8-32.6 mm fruit width in the Slovakia service tree populations [1] while the others [23] measured the fruit weight as 4.9-21.8 g in the same country. Fruit weight, length and width of selected service tree genotypes between were measured between 9.69-20.07 g, 22.02-28.38 mm and 25.20-34.35 mm respectively in the Tokat city of Turkey [25]. In the light of this study we can say, selection of the superior types will support the spread of service tree cultivation because it will allow to production of bigger and valuable fruit. It was also suggested that superior trees can play an important role in further service tree collection and propagation work and promising selections service tree fruits weight presented as 14.2-25.6 g [14]. Service tree has apple or pear –shaped fruits but apple-shaped fruit is more common. All of the trees have apple-shaped fruit in our study too. Fruit stalk has been assigned from 3.3 mm to 8.3 mm in our study, while was measured from very short (0.5 mm) to very tall (14.1 mm) in the other study [1]. Again, it was measured as 1.8-3.7 mm [14] and our results are comparable to those of them. Fruit number per cluster was significantly important criteria and changed from 1.33 (T1) to 4.0 (T4) (Figure 4 B). In the selected trees, there was more fruit in a cluster and changed from 5.50 to 18.40 per cluster (bud) [25]. Service tree fruits were yellow color with a very little reddish color on the sun-exposed side of the fruit at the tree maturity stage. The mesocarp of over-ripe fruits was become soft, sweet and delicious, offering a pleasant taste.

Service tree samples were analyzed for soluble solid contents, titratable acidity, and pH of fruits. Only titratable acid variation was found statistically important in these observed parameters. Soluble solid contents of types indicated minimum for T1 (18.5%) and maximum for T4 (21.93%) (Table 5). These results were in agreement with the findings of others [14] who determined the soluble solid contents between 15.7-21.8% for small fruit class of service tree. On the other hand, total soluble solid contents of service tree fruits presented between 18.9%- 31.8% [10] that this is very high than in our ecology. Titratable acidy of fruits changed from 0.38% to 0.45% according to our results. In the other study, the titratable acidy changed in a wider range from 0.045% to 0.33% and was found as 0.044 averagely in the promising types [10]. When we compare our types, we recognized that our types have ten times more acidity, and this has been strongly affected their fruit taste.

Figure 4. (A) Immature green fruit of service tree; **(B)** Harvested service tree fruits

Seed Characteristics

Results for the seed characteristics are presented in Table 6. Seed weight was changed slightly from 0.044 g to 0.055 g, and there were 0.7-2.0 seeds per fruit. Seed length and width was measured between 6.48-8.17 mm and 5.48-6.31 mm and seed length was determined as statistically important. In the previous studies, 1000 seed weight was determined from 12.5 g to 34.9 g [23] that it was in contrast with our results. Seed length and width was determined as 6.0-8.3 mm and 3.9-5.4 mm ranges respectively in the previous studies [1, 17], and we could say that the results was in a harmony with ours.

Table 4. Fruit morphological characteristics of the service tree types

Type number	Fruit weight (g)	Fruit length (mm)	Fruit width (mm)	Fruit shape	Fruit Stalk length (mm)	Fruit number per cluster
T1	7.97a	17.60	20.46	Apple	5.0	1.33 c
T2	9.69a	17.98	21.61	Apple	7.7	2.67 bc
T3	5.28b	14.87	17.67	Apple	5.7	3.67 ab
T4	4.55b	16.40	18.08	Apple	3.3	4.00 a
T5	8.89a	18.60	21.72	Apple	8.3	3.67 ab
Average	7.28	17.09	19.91	Apple	6.0	3.07

Values in the same column with different lower-case letters are significantly different (P<0.05).

Table 5. Fruit chemical properties of the service tree types

Type number	Soluble solid contents (%)	Titratable acidity (%)	pH
T1	18.50	0.38 b	4.05
T2	19.10	0.43 a	4.11
T3	20.93	0.44 a	4.36
T4	21.93	0.41 ab	3.61
T5	20.27	0.45 a	3.71
Average	20.15	0.42	3.97

Values in the same column with different lower-case letters are significantly different (P<0.05).

Table 6. Fruit seed characteristics of the service tree types

Seed number per fruit	Seed weight (g)	Seed length (mm)	Seed width (mm)
1.7	0.046	8.17 a	6.31
1.3	0.055	6.48b	5.48
0.7	0.047	7.82 a	5.96
1.3	0.049	6.95 ab	5.97
2.0	0.044	7.74 a	6.00
1.4	0.048	7.43	5.94

Values in the same column with different lower-case letters are significantly different (P<0.05).

CONCLUSION

Today, natural resources and forest lands have destroyed by the people and there is an uncontrolled use. Difficulties on the usage of natural resources, efficiently, will affect humans in future thus make survival harder for them. Service tree is a valuable genetic resource for the future of humanity as a multipurpose tree with its delicious fruits, timber and medicinal properties, and suitable for the agroforestry applications.

Development of the cultivation of the service tree will be only successful and sustainable if growers find a good quality reproductive material and knowledge on the cultural treatment of the species is available. Really interested to grow this species and long-term use will depend on the economic desirability as a fruit and timber product.

In Kocaeli-Kartepe area, this species have small, strongly astringent fruits and are only edible after over ripening so that there are somewhat difficult to appreciate for the modern consumer in contrast to the attractive and tasty fruits on the market. Increasing the quality and taste of this fruit will be possible by the selection studies. In addition, service tree is one of the native species of the region and global changes will improve the importance of this fruit in future. This is the first report distribution of service tree in the Kocaeli city and therefore, the establishment of modern orchards with the selected types in the Kocaeli region or in the other regions and also use the true cultural treatments will contribute to grow of the service tree.

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