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Identification of Sainfoin Species (*Onobrychis* spp.) from Morphologic Characters and Flower Colour by L*a*b*, RGB and HSV Colours by Principle Component Analysis

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Abstract

The aim of this study, to determine similarities/dissimilarities of *Onobrychis* species for morphologic characters (flower diameter, days to flowering, main stem length and width, number of stem, leaflet length and width), and colour values (L*, a*, b*, R, G, B, H, S and V) by using principle component analysis. Plant materials, belonging to *Onobrychis* species; *Onobrychis hypargyrea* Boiss. (O_1), *Onobrychis viciifolia* Scop. (O_2), *Onobrychis montana* subsp. *cadmea* P.W.Ball (O_3), *Onobrychis armena* Boiss. (O_4), *Onobrychis gracilis* Besser (O_5), *Onobrychis hajastana* Grossh. (O_6), *Onobrychis lasiostachya* Boiss. (O_7) *Onobrychis oxyodonta* Boiss. (O_8) and *Onobrychis podperae Širj.* (O_9) were collected from different locations (grassland, arable area and forest area) in Eskişehir province. According to these explanations; morphologic characters, main stem length, leaflet width and days to flowering; Lab colours, L and b; RGB colours, R and B, HSV colours, H and S were determined as best contributors. *Onobrychis* species, O_3, O_4 and O_9; morphologic characters, main stem length and width leaflet length and width; colours; L, b, R, B S and V were determined as stabile species/characters. *Onobrychis viciifolia* Scop. (O_2) with *Onobrychis hajastana* Grossh. (O_6) and *Onobrychis montana* subsp. *cadmea* P.W.Ball (O_3) with *Onobrychis lasiostachya* Boiss. (O_7) were found as similar species.

Keywords: *Onobrychis* spp., fodder crops, morphologic characters, Lab, RGB, HSV colours, principal component analysis.

INTRODUCTION

Sainfoin (*Onobrychis sp.*), consisting of the combination of the French words sain and foin, comes to mean as healthy food [36]. Sainfoin (*Onobrychis sp.*), cultivated since ancient times, is a common crop in the Near East flora including Turkey that is also one of the micro gene centres for sainfoin, alfalfa, lentil, vetch etc [9; 17; 18; 20; 23; 24; 29]. Sainfoin with large number of erect or semi-erect plant structure, is known perennial crop, and grows a length of 30-60 cm under normal conditions and 90 cm in good soil conditions. The sainfoin flower as a typical leguminous flower is raceme, having pink colours of the petals. There are dark pink shorts on the flag corolla leaf; the corolla came from five crown leaves with bright rose-red colour and dark coloured lines. Because of foreign pollination, flowers attract bugs [1; 16; 29; 39-41]. These genetic resources in sainfoin consisting of a number of species, and adapted to various environmental conditions such as temperature, precipitation, drought, salinity, diseases and pests, are very rich in genetic diversity [2; 19; 37]. Sainfoin is an important plant for the evaluation of calcareous and arid soils, drought conditions [22; 38]. There are almost 900 leguminous plants in Turkey and 46 of them belong to *Onobrychis* species. There are many sainfoin species comprising commercially used cultivars and natural species having high potential potency. In sainfoin species; *Onobrychis hajastana* Grossh., *Onobrychis hypargyrea* Boiss., *Onobrychis oxyodonta* Boiss., *Onobrychis viciifolia* Scop., *Onobrychis podperae* Širj., *Onobrychis lasiostachya* Boiss., *Onobrychis montana* subsp. *cadmea* P.W.Ball, *Onobrychis armena* Boiss., *Onobrychis gracilis* Besser are natural plants of vegetation grow in most parts of areas in Turkey [10; 17].

The species and variety diagnosis in plants is very important in plant breeding and different methods are used for species identification. In flowering plants, especially in forage plants, flower colour is very important in terms of its structure and its content representing the plant. Therefore, variety or plant identification from flowers is very important in plant identification [1; 13; 30]. It is possible to make plant identification from the flower, and the flower colour gives an important clue to this. Many studies have revealed that flower colour, fleshy shape and structure have an important place in defining the plant [3; 6; 29]. In the same way, our study was based on diagnosis of sainfoin species with flower colours by using different colour methods. There are a lot of methods in the world about colours, and Lab, RGB and HSV colour measurement methods are the three of the most used methods. Lab colour medium is the system, comprising a 3-axis colour system, L for lightness and a and b for the colour dimensions. It consists of all colours in the spectrum. The Lab colour space shows means of colour spectrum and mostly used in different activities including agriculture. L assigns lightness from zero (no lightness) and 100 (maximum lightness). Other a shows positive values +60 red colour and negative values -60 green colour. The other b shows positive value positive values +60 yellow colour negative values -60 blue colour. RGB colour system creates all of colours from the combination of the red, green and blue colours. RGB is the image model revealing colour combination model. Colour densities vary from zero (black) to 255 (white) for each RGB (red, green, blue) component. 255 denotes pure white, and zero is pure black. The image is defined on the red, green, blue colour codes r, g, b. Each pixel receives intermediate values according to these colour codes. The HSV (Hue, Saturation, Value) colour space defines colours as colour essence, saturation and brightness, respectively. S, saturation, determines the "vitality" of the colour. High saturation results in vibrant colours, while low likelihood causes the colour to approach grey shades. It changes within 0-100. V, the brightness, determines the lightness of the colour, that is, the white ratio within it. It varies from 0-100. H, hue, colour essence determines the dominant wavelength of the colour, for example yellow, blue, green, etc. It ranges from 0Â° to 360 Â°. The brightness determines the lightness of the colour, that is, the white ratio within it. Both Lab, RGB and HSV methods can be used safely and reliably in determining the colour characteristics of an object [7; 25; 44]. On the other side, flower colour and flower characteristics are the way of recognizing plants in forage plants [1; 3; 6; 13; 29; 30]. From here, plant identification can be made according to flower colours using these methods. The aim of this study, to determine similarities/dissimilarities of *Onobrychis* species for morphologic characters (flower diameter (cm), days to flowering, main stem length and width (cm), number of stem, leaflet length and width (cm)), and colour values (L, a, b, R, G, B, H, S and V) by using principle component analysis in sainfoin species.

MATERIALS AND METHOD

The study was carried out in the field of Transitional Zone Agricultural Research Institute in Eskişehir province in 2015-1016. Plant materials, belonging to *Onobrychis* species; *Onobrychis hypargyrea* Boiss. (O_1), *Onobrychis viciifolia* Scop. (O_2), *Onobrychis montana* subsp. *cadmea* P.W.Ball (O_3), *Onobrychis armena* Boiss. (O_4), *Onobrychis gracilis* Besser (O_5), *Onobrychis hajastana* Grossh (O_6), *Onobrychis lasiostachya* Boiss. (O_7), *Onobrychis oxyodonta* Boiss. (O_8) and *Onobrychis podperae Širj.* (O_9) were collected from different locations (grassland, arable area and forest area) in Eskişehir province. The seeds of total 387 plants were germinated in pots in glasshouse, seedlings of sainfoin species were transferred to field as a single plant in 1 m x 1 m plot size (10 plants in each row) and allowed to grow. Soil characteristics of experimental area were; 7,16 pH, 1,12 EC (dS/m), 0,075 total salt (%), 2,03 lime (%), 1,62 Organic Matter (%), 97,21 Phosphorus (P_2O_5, kg/ha) and 742,23 (Potassium, K_2O). Fertilizers as 30 kg/ha and 60kg/da P_2O_5 were applied before plants were transferred to field to allow plant growth. Precipitations and average temperature were 328,4 mm and 8,2 °C in 2015-2016 and 421,3 mm and 8,9 °C in long-term years (1970-2016). The map, showing *Onobrychis*-genotype-gather locations was given in Figure 1.

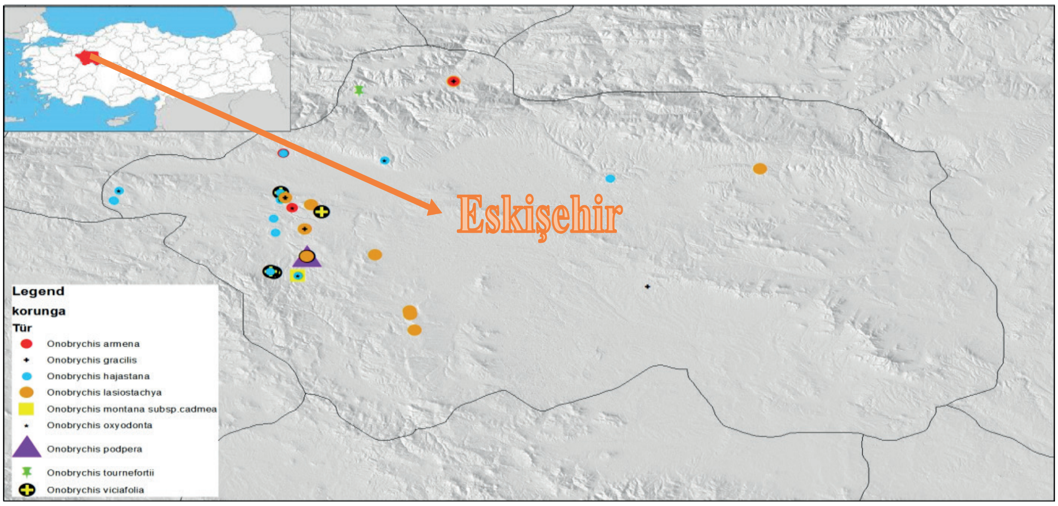

Figure 1. Locations related to gathering areas of *Onobrychis* species in Eskişehir province.

Flower diameter (cm), days to flowering, main stem length and width (cm), number of stem, leaflet length and width (cm) as morphologic characters [5; 6]; L, a, b, R, G, B, H, S and V as colour values [12; 32; 43; 45] were measured. Both morphologic characters and colour values were taken when plants reached flowering stages. Colour values were measured from corollas of flowers on medium with light intensity of 550-600 mmol / m^2 in *Onobrychis* species by Mobile Colour Grab Program for R, G, B, H, S and V colour measurements. Konica Minolta Cr-5 Model Colour Measurement Device for L, a b was used. Colour values and morphologic parameters were taken with two and five replicates, and means of replicates were evaluated and analysed. Analyses of the data obtained to reveal the similarities/differences of *Onobrychis* species were evaluated in the MINITAB 17 package program.

RESULTS AND DISCUSSION

Sainfoin is a perennial fodder crop in the leguminous family and could be cultivated for 5-6 years. It shows well grow and adaptation to arid conditions/climates. It is also very promising plant to help the meeting the animal feed demand in arid conditions. Protein is rich and the quality of the bait is good, the sapwood is rich in calcium, phosphorus and other mineral substances. It can be used as a good pasture plant because it is resistant to grassing. Sainfoin can also be fed to the animals with fresh, dry grass or silage. When dairy cattle are given a certain amount of sainfoin every day, digestive system disorders are rarely encountered. It ensures the growth of all animals, increases their yield. Besides, sainfoin is a very good honey-making plant in the bees because it gives plenty of flowers [19; 37; 39; 40]. Demand in animal foods geometrically increases, so has world population. To help to meet demands in animal food, it is vital to increase the use of high yielding fodder crops including sainfoin. This phenomenon could only be accomplished by successful breeding programs in which vast and rich genotypic variations are used. Definition of plants, determination of their distinguishing characteristics will help to determine different plant genotypes in breeding programs [5; 6]. The flower type and colour are different for each sainfoin type. By using this feature, it is possible to distinguish the sainfoin species and the sainfoin can be successfully distinguished from the flower type and colour characteristics [37]. The flower type and colour characteristics of *Onobrychis* species were given in Figure 2.

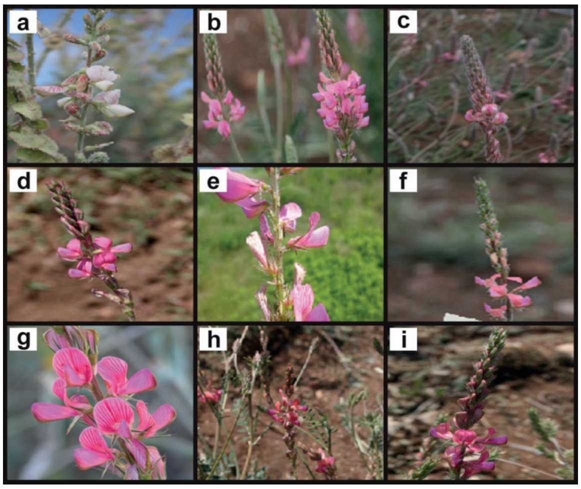

Figure 2. The flower type and colour characteristics of *Onobrychis* species (**a:** *O. hypargyrea* Boiss., **b:** *O. viciifolia* Scop., **c:** *O. montana* subsp. *cadmea* P.W.Ball, **d:** *O. armena* Boiss., **e:** *O. gracilis* Besser, **f:** *O. hajastana* Grossh., **g:** *O. lasiostachya* Boiss., **h:** *O. oxyodonta* Boiss., **i:** *O. podperae Širj.*).

Onobrychis hypargyrea **Boiss. (O_1)** is a multi-year herbaceous crop, growing environment and altitude: rocky and calcareous slopes, grassland, step forest clearance, resistant to cold and drought. It could be used as green fertilizer because it fixes nitrogen to the soil. In deserted areas and in hilly areas such as slopes, seeding enriches the soil by preventing desertification and erosion. Flowers attract bouquets and birds and increase biodiversity [14; 35; 42]. ***Onobrychis viciifolia*** **Scop. (O_2)** is perennial, erect and the most cultivated crop in the world. This crop could be recognized with bright pink flowers, 50-50 cm crop height and 5-8 paired leaflets. Though it has lots of cultivated and released types, native types could be seen in fallow areas, roadsides, sandy, clay soils. It grows in 200-2000 altitude in most parts of Anatolia [1; 6; 26]. If sainfoin seeds are contaminated with bacteria nitrogen is added to the soil by nodosity bacteria. Sainfoin could be fed to the animals green or dry. It is an important fodder crop in terms of its high mineral content [4]. ***Onobrychis montana*** **subsp. cadmea P. W. Ball (O_3)** is a herbaceous multi-year-old plant known as hemicryptophyte, the majority of which are dead buds, and whose body surface is located on the soil, so that it is not damaged in the cold cycle. Sainfoin is ideal plant for ruined mine sites in terms of soil amelioration etc. It binds nitrogen to the soil to provide nitrogen reserves, it can be used as green fertilizer because it fixes nitrogen. Sainfoin enriches the soil by preventing desertification and erosion. Flowers attract bees and birds and increase biodiversity [42]. **O*nobrychis armena*** **Boiss. (O_4)** is a species widely found in the arid and salty areas of Anatolia where rainfall is low. In these adverse climatic and geographic conditions. *Onobrychis armena* Boiss., winter resistant, is a preferred plant in arid conditions compared to other plants. *Onobrychis armena*, winter resistant, is a preferred plant in arid conditions compared to other plants in meadows of Central Anatolia and Eastern Anatolia.

Onobrychis gracilis **Besser (O_5)** is perennial plant with herbaceous body that is vertical or raised, 40-70 cm hairless. It has 5-8 pairs of leaves and leaflets are linear. Having pink colour, the flower is narrow and long. This plant is found in temperate areas and up to 1500 altitude, and could not show well growth over this altitude. *O. gracilis* is not as resistant as other *Onobrychis* species against drought, cold and over grazing [1; 35; 42]. ***Onobrychis hajastana*** **Grossh. (O_6)** is well adapted to grows stony and limy-clay soils, in steppes or sloppy arid pastures of Eastern Anatolia having more than 1500 m altitude. It is also perennial and endangered crop having prostrate, semi prostrate and semi erect types, almost 60 cm stem height, 6-8 paired leaflets, it is resistant to crushing, drought grazing and flowers from June to August [31]. ***Onobrychis lasiostachya*** **Boiss. (O_7)** is a perennial with 80-120 cm plant height and a pale pink form of flower. This plant has a wide adaptation ability including Central and Eastern Europe, Turkey, the Caucasus and the southern territory of Siberia. This plant, which is very resistant to drought, cold and frost, can grow in sandy and clayey soils, rocky regions, shortly all kinds of soil types. [1; 8; 11; 26]. ***Onobrychis oxyodonta*** **Boiss. (O_8)** is perennial crop with erect, semi erect and medium crop types, 50-60 cm crop height, 5-8 paired leaflets. It grows lime steppes, fallow areas, sandy soils with fallow fields, Cedrus-Pinus woods, sandy slopes, 400-2000 m altitude in many parts of Anatolia. It flowers July, august with pink, dark pink flower [4; 33]. ***Onobrychis podperae*** *Širj*. **(O_9)** is perennial plant with subterranean substructure. The body of the vertical structure can be extended up to 20-60 cm and has a clear light green line. The base leaves are 5-10 pairs and the upper leaves 3-9 pairs. With pink colour, the flower state is sparse, very flowering and lengthening in the fruit period. This plant grows in altitudes of 300-1300 m consisting of limestone rocks, slopes and steppes. It is resistant to drought and could be seen in Turkey, Iran, Russia etc. [21; 46].

Correlation is a statistical method used to determine if there is a linear relationship between two numerical measurements, and if so, what the direction and severity of this relationship is. If the correlation coefficient is negative, there is an inverse relationship between the two variables, that is, one of the variables is increasing while the other is decreasing [15; 27]. Maximum, minimum values and means in Morphologic parameters and colour values of *Onobrychis* species were given in Table 1.

Table 1. Maximum, minimum values and means in Morphologic parameters and colour values of *Onobrychis* species.

	Flower Colour	Variable	Mean	Minimum	Maximum
Onobrychis hypargyrea **Boiss. (O_1)**	Careys pink	**Flower Dia.**	102,6±31,80	35,01	122,91
Onobrychis viciifolia **Scop. (O_2)**	Pink flare	**Days to Flow.**	140,91±2,51	138,0	147,22
Onobrychis montana **subsp.** ***cadmea*** **P. W. Ball (O_3)**	Pink flare	**Main St.Len.**	57,67±5,07	44,60	60,84
Onobrychis armena **Boiss. (O_4)**	Pale violet red	**Main St.Wİd.**	0,77±0,21	0,40	1,06
Onobrychis gracilis **Besser (O_5)**	Vanilla ice	**No.Stem**	34,63±1,16	32,32	36,37
Onobrychis hajastana **Grossh. (O_6)**	Pink	**Leaflet Le.**	7,22±0,28	6,70	7,58
Onobrychis lasiostachya **Boiss. (O_7)**	Pale violet	**Leaflet Wid.**	2,88±0,98	1,20	4,21
Onobrychis oxyodonta **Boiss. (O_8)**	Indian red	**L**	49,50±7,68	44,64	69,46
Onobrychis podperae **Širj. (O_9)**	Pale violet red				

Variable	Mean	Minimum	Maximum	Variable	Mean	Minimum	Maximum
a	17,86±6,80	1,76	23,32	**b**	163,34±44,92	96,00	232,00
b	9,47±5,60	3,29	20,64	**H**	294,36±109,64	4,0	348,0
R	221,67±13,12	194,00	240,00	**S**	38,33±18,55	14,00	62,00
G	123,6±38,60	72,0	187,0	**V**	85,89±6,85	70,00	94,00

Correlations between morphologic characters and colour values in *Onobrychis* species were given in Table 2. Negative/positive significant correlations between characters are determined as; **negative and significant at 5 %/1 %:** between days to flowering and a, days to flowering and H, number of stem and a, L and a, L and H, a and b, b and H, G and S, B and S.

Table 2. Correlations between morphologic characters and colour values in *Onobrychis* species.

	Flower Dia.	Days to Flow.	Main St.Len.	Main St.Wİd.
Days to Flow.	-0,185ns			
Main St.Len.	0,731*	0,518ns		
Main St.Wİd.	0,608ns	0,231ns	0,776*	
No.Stem	0,282ns	0,751*	0,709*	0,390ns
Leaflet Le.	0,688*	0,172ns	0,747*	0,663*
Leaflet Wid.	0,655*	0,130ns	0,701*	0,784*
L	-0,489ns	0,923**	0,210ns	0,026ns
a	0,313ns	-0,908**	-0,347ns	-0,135ns
b	-0,086ns	0,838**	0,494ns	0,331ns
R	0,125ns	-0,195ns	-0,020ns	0,123ns
G	-0,063ns	0,393ns	0,242ns	0,097ns
B	0,461ns	0,153ns	0,514ns	0,437ns
H	0,473ns	-0,947**	-0,246ns	-0,074ns
S	-0,134ns	-0,338ns	-0,398ns	-0,403ns
V	0,031ns	-0,150ns	-0,087ns	0,002ns

	No.Stem	Leaflet Le.	Leaflet Wid.	L
Leaflet Le.	0,202ns			
Leaflet Wid.	0,315ns	0,887**		
L	0,517ns	0,019ns	-0,001ns	
a	-0,686*	-0,088ns	-0,071ns	-0,916**
b	0,697*	0,285ns	0,307ns	0,788*
R	-0,038ns	-0,119ns	-0,021ns	-0,123ns
G	0,122ns	0,025ns	-0,117ns	0,399ns
B	0,202ns	0,473ns	0,367ns	0,089ns
H	-0,556ns	0,016ns	0,036ns	-0,989**
S	-0,080ns	-0,471ns	-0,362ns	-0,393ns
V	-0,018ns	-0,207ns	-0,120ns	-0,056ns

	a	b	R	G
b	-0,929**			
R	0,124ns	-0,148ns		
G	-0,257ns	0,018ns	0,492ns	
B	-0,197ns	0,259ns	0,724*	0,532ns
H	0,919**	-0,797*	0,160ns	-0,392ns
S	0,384ns	-0,335ns	-0,584ns	-0,706*
V	0,060ns	-0,110ns	0,989**	0,494ns

	B	H	S
H	-0,057ns		
S	-0,862**	0,340ns	
V	0,692*	0,098ns	-0,556ns

Positive and significant at 5 %/1 %: between flower diameter and main stem length, flower diameter and leaflet length, flower diameter and leaflet width, days to flowering and number of stem, days to flowering and L, days to flowering and b, main stem length and main stem width, main stem length and number of stem, main stem length and leaflet length, main stem length and leaflet width, main stem width and leaflet length, main stem width and leaflet width, number of stem and b, leaflet length and leaflet width, L and b, a and H, R and B, R and V, B and V. Yield components are important in investigating high yielding genotypes and increase the success of breeding programs. Determining correlations between yield components helps to understand relationship between components and what effects yield components in *Onobrychis sativa* L. [1; 28; 34]. Moreover, relationship between plant characters could be explained by different statistical methods and principle component analysis analyse mutual effects of characters and reduce these relations in characters to lesser components and determines the factor structure formed by variables. This method determines the variance explained by the sum of each of the factors and their factors. In other word, this method provides recognition, classification, size reduction and interpretation. Table 3 showed eigen values and cumulative variances of morphologic characters and colour values by principal component analysis in *Onobrychis* species.

Table 3. Eigen values and cumulative variances of morphologic characters and colour values by principal component analysis in *Onobrychis* species.

Eigen analysis of the Correlation Matrix for Morphologic Characters					
	PC_1	**PC_2**	**Days to Flowering**	**PC_1**	**PC_2**
Eigenvalue	4,2482	1,6672	**Main Stem Length**	0,189	0,679
Proportion	0,607	0,238	**Main Stem Width**	0,464	0,138
Cumulative	0,607	0,845	**Number of Stem**	0,416	-0,087
Variable	**PC_1**	**PC_2**	**Leaflet Length**	0,414	0,542
Flower Diameter	0,371	-0,342	**Leaflet Width**	0,425	-0,217
Eigen analysis of the Correlation Matrix for Lab Colour					
	PC_1	**PC_2**	**Variables**	**PC_1**	**PC_2**
Eigenvalue	2,7567	0,2119	**L**	0,566	0,725
Proportion	0,919	0,071	**a**	-0,596	0,032
Cumulative	0,919	0,990	**b**	0,569	-0,687
Eigen analysis of the Correlation Matrix for RGB Colour					
	PC_1	**PC_2**	**Variables**	**PC_1**	**PC_2**
Eigenvalue	2,1719	0,5549	**R**	0,596	-0,433
Proportion	0,724	0,185	**G**	0,526	0,847
Cumulative	0,724	0,909	**B**	0,607	-0,309
Eigen analysis of the Correlation Matrix for HSV Colour					
	PC_1	**PC_2**	**Variables**	**PC_1**	**PC_2**
Eigenvalue	1,6112	1,0870	**H**	0,307	0,856
Proportion	0,537	0,362	**S**	0,728	0,071
Cumulative	0,537	0,899	**V**	-0,613	0,512

In morphologic characters and Lab colour; first factor showing the highest eigenvalues, covered almost 4,2482-60,7 % and 2,7567- 91,9 % of the total variance, respectively. The second factor explained eigenvalues of 1,6672-23,8 % and 0,2119-7,1 %, respectively. In morphologic characters, main stem length (0,464), leaflet width (0,425) in Factor 1, days to flowering (0,679) in Factor 2 had higher contribution. In Lab colour, L (0,566) and b (0,569) in Factor 1 gave higher contribution. In RGB and HSV colours; the first factor showed the highest eigenvalues as 2,1719-72,4 % and 1,6112-53,7 % of the total variance, respectively. The second factor assigned eigenvalues of 0,5549-18,5 % and 1,0870-36,2 %, respectively. In RGB colour, R (0,596) and B (0,607) in Factor 1 showed higher contribution. In HSV colour, S (0,728) in Factor 1 and H (0,856) in Factor 2 gave higher contribution. Main stem length, leaflet width and days to flowering in morphologic characters; L and b in Lab colour were found as the best contributors. R and B in RGB colour, H and S in HSV colour were found as best contributors (Table 3). A biplot graph representing a part of the principle component analysis was given in Figure 3.

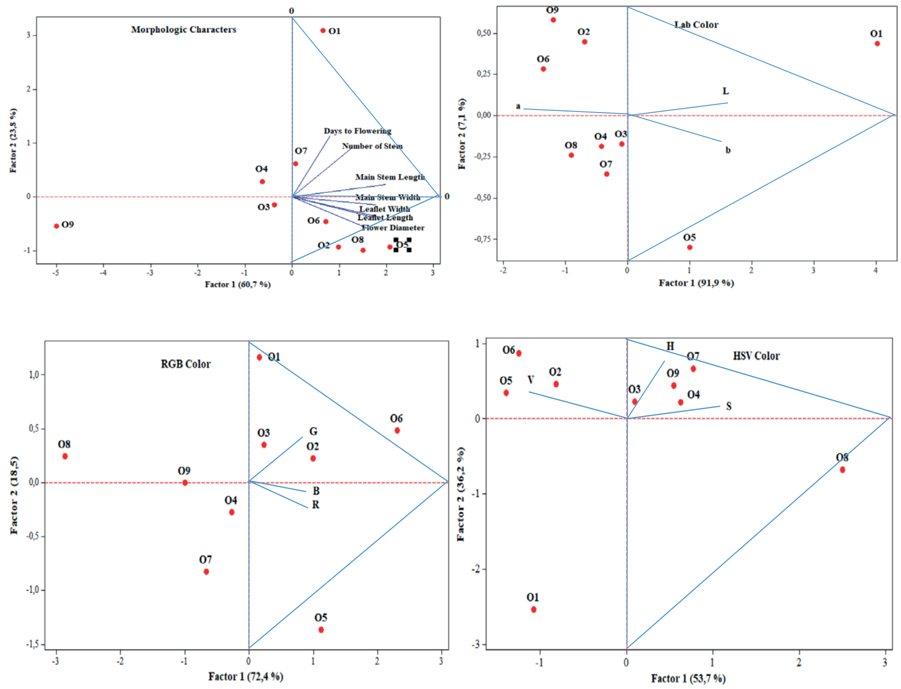

Figure 3. Biplot graph representing relationship between *Onobrychis* species, morphologic characters and colour values.

In morphologic characters, days to flowering and number of stem created in one group, while flower diameter, main stem length and width, leaflet length and width participated same group. O_3, O_4 and O_7 were in same group; O_2, O_6, O_5 and O_8 joined in same group. O_1, O_5 and O_9 have formed separate, singular groups (Figure 3). In lab colour, two groups occurred; L an b in one group and a in the other. O_3, O_4, O_7 and O_8 had same group, while O_2, O_6 and O_9 created one group. O_1 and O_5 were alone. *Onobrychis* species and R, G, B, H, S, V colours drew different behaviours in RGB and HSV analyses. B and R were in same group, while G was alone. O_1, O_2, O_3 and O_6 participated in same group, were O_4, O_7 and O_9 were found in one group. O_5 and O_8 were alone in RGB colour. In HSV colour, O_3, O_4, O_7 and O_9 joined in same group; while O_2, O_5, and O_6 created one group. O_1 and O_8 were alone (Figure 3).

According to these explanations; morphologic characters, main stem length, leaflet width and days to flowering; Lab colours, L and b; RGB colours, R and B, HSV colours, H and S were determined as best contributors (Table 3). *Onobrychis* species, O_3, O_4 and O_9; morphologic characters, main stem length and width leaflet length and width; colours; L, b, R, B, S and V were determined as stabile species/characters (Figure 3). A model denoting similarities/dissimilarities of *Onobrychis* species for morphologic characters and colour values was shown in Figure 4.

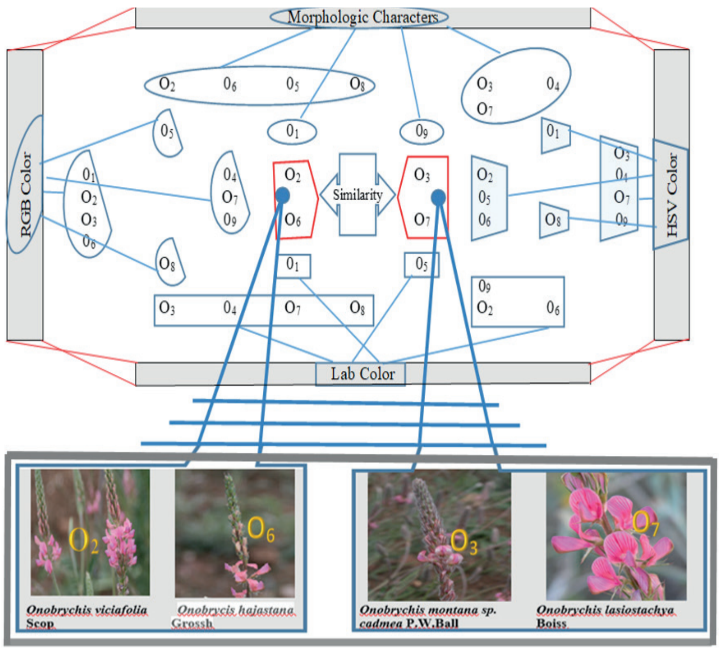

Figure 4. A model denoting similarities/dissimilarities of *Onobrychis* species for morphologic characters and colour values.

Similarities/dissimilarities of *Onobrychis* species; *Onobrychis* species; *Onobrychis hypargyrea* Boiss. (O_1), *Onobrychis viciifolia* Scop. (O_2), *Onobrychis montana* subsp. *cadmea* P.W.Ball (O_3), *Onobrychis armena* Boiss. (O_4), *Onobrychis gracilis* Besser (O_5), *Onobrychis hajastana* Grossh. (O_6), *Onobrychis lasiostachya* Boiss. (O_7), *Onobrychis oxyodonta* Boiss. (O_8) and *Onobrychis podperae Širj.* (O_9) were evaluated for morphologic characters and colour values in the model. *Onobrychis viciifolia* Scop. (O_2) with *Onobrychis hajastana* Grossh. (O_6) and *Onobrychis montana* subsp. *cadmea* P.W.Ball (O_3) with *Onobrychis lasiostachya* Boiss. (O_7) were found as similar species.

Sainfoin (*Onobrychis* spp.) is one of the most valuable plants among leguminous fodder crops. With its high protein content and durability to drought, the sainfoin with its wide range of richness has an important potential to close off the increasing animal feed need in the future. Therefore, revealing the similarities/dissimilarities of the *Onobrychis* species in terms of different characteristics will enhance the success of sainfoin breeding programs. The use of different light reflectance values in addition to the morphological properties will contribute to this distinction of *Onobrychis* species.

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