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Research Article

DETERMINATION OF MINERAL CHANGES ON CROP GROWTH TYPES AND GENOTYPES IN *ONOBRYCHIS* Mill. SPECIES BY TWO STATISTICAL METHODS

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ABSTRACT. The aim of this study was to determine changes, similarities/dissimilarities in crop growth types and *Onobrychis hajastana* Grossh, *Onobrychis hypargyrea* Boiss, *Onobrychis oxyodonta* Boiss and *Onobrychis viciafolia* Scop in sainfoin by conditional formatting and principal component analysis. Sainfoin is known as resistant crop to drought and cold and can be successfully grown in arid conditions including unproductive and barren places. In addition, soil selectivity of it is not high. Sainfoin is not only nutritious crop for cows, calves and goats etc., but also it is well source of nectar for beekeeping. In the light of this explanations, high yield in sainfoin depends on genotypic performance and depends on the activity of metabolic activity. In this activity, the mineral level of the plant is of great importance. Results showed that medium crop growth type gave higher mineral levels. Relatively *O. oxyodonta* Boiss having higher mineral levels in this study had higher dry matter production and crop yield, it could be said as higher yielding crop. So, P, K, Na, B, Fe, Zn, Ca in minerals were determined as stabile and best contributors to high yield. *O. oxyodonta* Boiss with medium crop growth types is the best crop for high crop production.

Keywords: *Onobrycis species, fodder crops, minerals, conditional formatting and principal component methods*

INTRODUCTION

Being long-lived, perennial, nutrient-resistant crop, sainfoin (*Onobrychis sativa* Lam.) is a so resistant to cold and drought. It develops well in barren and limy soils and more efficiently grows in limestone and non-irrigated soils than alfalfa. The hay of sainfoin is as nutritious as alfalfa, it is so rich in protein and mineral content. Unlike alfalfa, hay of sainfoin does not cause tympani ties in animals and it can be fed to animals in abundance [1, 2]. Sainfoin increases yield and quality of milk and butter in milk cows. In addition to be a nutrient source for animals, it is well known as nectar crop [2, 3]. Around 160 species of sainfoin known in the world. Wild sainfoin species have extended over the areas from the Baltic Sea to the Mediterranean, Asia and Siberia. It is especially concentrated and diversified Especially in Anatolia, Iran and Caucasia including Türkiye [4, 5]. These genetic resources, which consist of species that have been adaptable for centuries to various environmental conditions such as temperature, precipitation, drought, salinity, diseases and pests, are very rich in gene diversity [6, 7] Despite the fact that Turkey has

a very rich variety of species, the most common varieties of sainfoin were found as *O. hajastana* Grossh., *O. hypargyrea* Boiss., *O. oxyodonta* Boiss. and *O. viciifolia* Scop. [4]. Sainfoin silage has a beneficial effect on dry matter intake, dry matter digestibility and cellulose digestibility in sheep [8, 9] as well as duodenally utilisable crude protein and metabolizable energy [10]. It is also a good source of macro and micro-minerals, except for Cu, Zn and Mg which need to be supplemented. The nitrogen digestibility of sainfoin silage is lower than that of other legume silages [11]. In comparison with grasses sainfoin is rich in mineral, except its calcium and sodium contents which are generally lower than in other forage legumes [12] [13]. Besides the stage of growth, soil moisture level has also a variable effect on mineral concentrations in the forage of sainfoin [14, 15, 16, 17]. Minerals play vital role in the crop metabolic processes and growth [18, 19]. Effectiveness and level of minerals are influenced from generally genotype x environment interaction, but considerably under genotypic influence [20, 21]. Effectiveness of minerals are similar in many metabolic activities and integrative effects of minerals could mainly be seen. Besides, level of minerals changes with genotypic differences, environmental conditions, availability and amount of minerals in soil, crop growth stage and habit, crop type [22]. Genotypic differences and crop characters affect crop metabolic contents including crop mineral content in sainfoin. Pasture type and forage crop differ in the crop growth and characteristics, this phenomenon must be determined and identified accordingly [23, 4, 24]. The aim of this study was to determine changes, similarities/dissimilarities in crop growth types and *O. hajastana*, *O. hypargyrea*, *O. oxyodonta* and *O. viciifolia* in sainfoin by conditional formatting and principal component analysis.

MATERIALS AND METHODS

Plant materials, belonging to *Onobrycis* species, *Onobrychis hypargyrea*, *O. oxyodonta*, *O. hajastana*, *O. viciifolia*) were collected from grassland, arable area, forest area in Eskişehir province. The seeds of total 387 plants were germinated in pots in glasshouse and seedlings of sainfoin species were transferred to field as a single plant in 1 m X 1 m plot size. Soil characteristics of experimental area was given in Table 1.

Table 1. *Soil characteristics of experimental area.*

Soil Depth (cm)	pH	EC dS/m	Total Salt %	Lime %	Organic Matter %	Phosphorus (P_2O_5) kg/ha	Potassium (K_2O) kg/ha
0-30	7.26	1.04	0.025	1.07	1.53	100.04	820.95
30-60	7.30	0.52	0.028	3.57	1.17	70.17	600.30

Fertilizers as 30kg/ha. and 60kg/da P_2O_5 were applied before plants were transferred to field to allow plant growth. Total 387 plants of *Onobrycis* species were described and classified according to methods of Variety Registration and Seed Certification Center (lit). used and criterion of *Onobrycis* species was given in Fig 1.

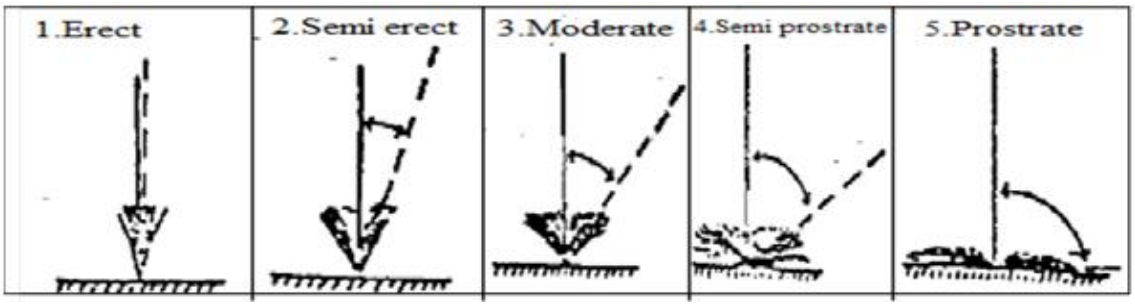

Fig. 1*. Description criterion of Onobrycis species.*

Four Onobrycis species, *Onobrychis hajastana*, *O. hypargyrea*, *O. oxyodonta* and *O. viciifolia* were used in the study. *Onobrycis hajastana* is well adapted to grow 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 [4, 23, 24]. *O. hypargyrea* is a multi-year herbaceous crop, growing environment and altitude: rocky and calcareous slopes, grassland, step forest clearance, resistant to cold and drought. It can 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 [25, 26, 27]. *O. oxyodonta* 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. Its flowers July, august with pink, dark pink flower [28, 29]. *O. viciifolia* 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 [30, 31, 32]. 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. If fed green, it doesn't cause swelling in animals. On the other hand, the content of mineral matter is as high as or higher than other quality feed crops. It is an important fodder crop in terms of its high mineral content [29]. 1-5 scale was used (1. Erect, 2. Semi erect, 3. Moderate, 4. Semi prostrate and 5. Prostrate). Total 387 plants in *Onobrycis* species (*O. hypargyrea, O. oxyodonta, O. hajastana, O. viciifolia*) were described and classified by this criterion and shown in Table 2.

Table 2*. The number of described and classified a Onobrycis species.*

***Onobrycis* Species**	**Erect**	**Semi Erect**	**Moderate**	**Semi Prostrate**	**Prostrate**	**Total**
Onobrychis hajastana	5	19	20	117	121	282
Onobrychis oxyodonta	4	4	6	12	18	44
Onobrychis viciifolia	6	2	6	3	17	34
Onobrychis hypargyrea	27	-	-	-	-	27

N, P, K, Ca, Mg, S, Fe, Mn, Zn and Cu [33] were evaluated. Minerals were determined in bread wheat seeds. The Kjeldahl method and a Vapodest 10 Rapid Kjeldahl Distillation Unit (Gerhardt, Konigs winter, Germany) were used to determine the total N content [34,

35]. The Ca, Mg, K, P, Fe, Cu, Mn, Zn contents in genotypes were determined by using an Inductively Coupled Plasma spectrometer (Perkin-Elmer, Optima 2100 DV, ICP/OES, Shelton, CT 06484-4794, USA [33]. Conditional formatting and principle component analyses were made in Excel and Minitab 17 software programs [36, 37, 38].

RESULTS AND DISCUSSION

Area, yield and quality of pastures has tremendously decreased in last five decades. Due to overgrazing, mismanagement, pastures have turned into lower quality pastures, away from the required quality level. The purposes of technical studies are to increase the quantity and quality of crops produced in pastures and create opportunity to arrange optimum use of animals from pastures [39]. Being a valuable fodder crop with high protein content, sainfoin is an important crop in the remediation of deteriorated pastures and improves the soil conditions and reduces the amount of erosion by taking place in the fallow-cereal rotation system in dryland conditions.

In the present study, minimum, maximum, mean values of minerals in sainfoin genotypes were given in Table 3.

***Table 3**. Minimum, maximum, mean values of minerals in sainfoin genotypes.*

Variable	Minimum	Maximum	Mean	Variable	Minimum	Maximum	Mean
N	2,4	2,9	2,6±0,2	Zn	24,7	32,5	29,3±2,4
P	2443,1	3011,4	2640,5±190,1	Fe	103,1	149,6	127,9±18,2
K	25785,1	31045,2	27617,4±1693,3	Mn	32,7	46,0	39,1±4,4
Ca	8803,5	9615,5	9010,3±275,9	Cu	21,8	40,5	32,0±7,4
Mg	1380,3	1534,8	1449,8±54,9	B	14,3	16,2	15,1±0,7
Na	577,3	708,8	626,0±43,6	Minerals (Erect Genotypes)			
Variable	Minimum	Maximum	Mean	Variable	Minimum	Maximum	Mean
N	2,4	2,7	2,6±0,1	Zn	28,2	30,3	28,9±1,1
P	2414,4	2772,2	2625,7±187,3	Fe	96,7	136,2	121,0±21,3
K	27164,3	28524,6	27900,5±687,4	Mn	34,3	39,1	37,3±2,5
Ca	8560,8	9571,3	9203,6±323,1	Cu	25,1	31,0	28,2±2,9
Mg	1445,4	1467,4	1458,4±11,6	B	14,3	15,6	14,9±0,6
Na	598,0	631,3	613,7±16,7	Minerals (Semi Erect Genotypes)			
Variable	Minimum	Maximum	Mean	Variable	Minimum	Maximum	Mean
N	2,4	2,6	2,6±0,1	Zn	28,1	30,3	29,2±1,0
P	2754,3	2814,4	2794,3±34,7	Fe	131,1	147,9	141,7±9,2
K	29491,6	29571,3	29543,2±45,3	Mn	38,7	43,8	41,3±2,5
Ca	9201,2	9335,4	9257,0±69,9	Cu	22,3	36,1	27,2±7,7
Mg	1421,1	1485,5	1442,6±37,1	B	15,2	16,4	15,9±0,6
Na	612,9	662,4	634,4±25,4	Minerals (Medium Genotypes)			
Variable	Minimum	Maximum	Mean	Variable	Minimum	Maximum	Mean
N	2,3	2,5	2,4±0,04	Zn	24,7	30,4	27,0±2,9
P	2367,0	2454,1	2399,8±47,4	Fe	105,0	116,6	109,2±6,4
K	25732,7	28428,4	26641,4±1548,2	Mn	33,6	34,6	34,0±0,5
Ca	8802,6	9378,3	8998,8±329,5	Cu	22,3	23,2	22,8±0,4
Mg	1383,6	1419,1	1401,4±17,7	B	9,4	14,0	12,3±2,5
Na	621,0	648,6	630,5±15,6	Minerals (Semi Prostrate Genotypes)			
Variable	Minimum	Maximum	Mean	Variable	Minimum	Maximum	Mean
N	2,3	2,9	2,6±0,1	Zn	23,4	29,5	26,4±2,3
P	2470,9	2972,6	2699,8±170,7	Fe	100,8	132,8	117,1±11,2
K	26892,4	32777,1	28507,4±2141,2	Mn	32,3	39,7	35,0±2,4
Ca	8852,3	9452,6	9010,0±193,3	Cu	29,5	49,0	36,5±6,8
Mg	1384,9	1464,4	1430,0±26,3	B	13,9	15,2	572,7±0,4
Na		678,5	619,6±31,5	Minerals (Prostrate Genotypes)			
Variable	Minimum	Maximum	Mean	Variable	Minimum	Maximum	Mean
N	2,5	2,8	2,6±0,1	Zn	26,5	30,2	28,2±1,6
P	2632,0	2752,0	2665,8±57,9	Fe	113,0	133,9	123,9±9,6
K	27400,7	28542,6	28081,4±484,2	Mn	35,7	41,0	37,8±2,4
Ca	9018,9	9213,4	9076,9±91,7	Cu	28,9	35,0	31,7±2,5
Mg	1428,3	1452,6	1444,1±11,1	B	14,3	16,0	15,1±0,7
Na	614,7	653,2	627,3±17,8	Minerals (Mean)			

Like other crops sainfoin requires significant quantities of minerals for metabolic activities and dry matter production [40]. Minerals play an important role in biochemical events. In this way, revealing level of minerals, similarities/dissimilarities in the and activities of minerals in both genotypes and crop growth types in *Onobrycis* sp. could give great opportunity to develop new varieties in breeding programs [41, 42, 43]. Acts of minerals are formed by genotype x environment interaction. While specific effects of minerals on specific metabolic events are known, it is evident that minerals act together in metabolic events, in other words integrative effects of minerals occur in many metabolic events [18, 19]. N, P and K and major minerals and they act vital role in crop growth. Nitrogen in activities of enzymes, organic and amino acids, nucleic acids, photosynthesis; phosphorus in dry matter production and photosynthesis, energy transfer, potassium in movement of stomata, CO2 uptake, ATP production are necessary [41, 44].

Photosynthetic processes relatively dry matter production, enzyme activity related protein synthesis and crop growth are triggered and regulated by manganese, zinc magnesium, sulfur, iron, copper and Zinc [45, 46]. Here is the situation to be emphasized that minerals occupy very important place in almost all the metabolic activities and the co-action of minerals affects the speed and level of metabolic events. Each mineral is necessary and valuable for the crop, although the minerals are similar in their effect on metabolic events in crops. The lack of a mineral causes the growth retardation to occur in the crop during these events [47, 48]. In the light of these explanations, minerals are of vital importance for crop growth. This is more important for the fodder crops, involving sainfoin. Because, the upper parts of the fodder crops are being used by harvesting and/or grazing. In this case, the more crop metabolic activity is, the more the upper parts of crops occur and the importance of minerals for crop growth in metabolic processes in sainfoin arises. In fodder crops, crop growth type is very important for purpose of crop use. Once some types could suitable/resistant to one/some purpose(s), the other may complies with another purpose(s). Sainfoin could be classified in five crop growth type; prostrate, semi prostrate, medium, semi erect and erect. Prostrate types are cold resistant and suitable to be crushed and grazing; semi erect/erect ones are susceptible to are cold, grazing and to be crushed, but suitable to cut or harvest. In Türkiye, sainfoin is used both by being harvested and being grazed. So, the crop to be used must be durable and suitable for both situations. In both cases, medium crop type will be suitable for both grazing, harvesting and productive and rational crop production. In the present study, by evaluating five crop growth type and four *Onobrycis* species, changes and similarities/dissimilarities in minerals were examined by conditional formatting and principal component analyses.

Conditional Formatting Method

The aim of conditional formatting method is to explain effective variants in Excel A number of conditional formatting procedures are used in range of cells, by the order of priority from top to bottom in the process area [38]. Evaluation of minerals for crop growth type in Figure 2, conditional formatting of crop growth types in Table 4 were given.

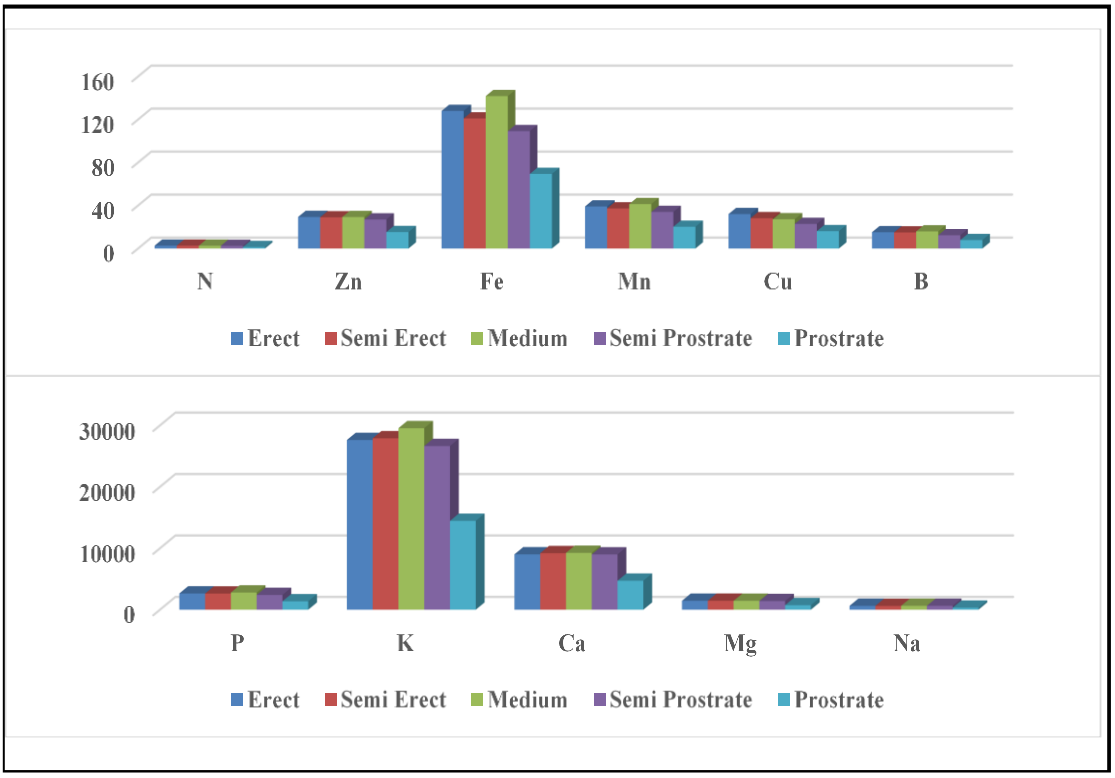

***Fig. 2**. Evaluation of minerals for crop growth type in sainfoin.*

Medium type crops had the higher mineral values then the other types; erect and prostrate types had lowest values (Fig 2). Besides, conditional formatting analysis of crop growth types revealed that medium type in Fe, Mn, K and P; erect, semi erect prostrate types in N; semi erect, medium and semi prostrate types in Ca; erect, medium and semi prostrate types in Mg; erect and medium types in Na; erect, semi erect, medium and semi prostrate types in Zn; and prostrate type in Cu had the highest values. Medium type in N, semi erect type in P, erect type in K prostrate type in Ca, Mg, Zn, Fe, Mn and B, semi erect type in Na, medium type in Cu gave the lowest values (Table 4).

***Table 4**. Conditional formatting of crop growth types in sainfoin.*

	N	P	K	Ca	Mg	Na	Zn	Fe	Mn	Cu	B
Erect	2,65	2664,94	27765,69	9017,33	1451,93	629,80	29,32	125,96	39,44	30,95	15,11
Semi erect	2,65	2624,51	27899,73	9202,87	1458,42	613,72	29,00	121,03	37,31	28,24	14,95
Medium	2,60	2794,32	29543,07	9256,95	1442,65	634,42	29,29	141,76	41,34	27,22	15,92
Semi prostrate	2,63	2694,59	28402,83	9159,05	1451,00	625,98	29,20	129,58	39,36	28,80	15,33
Prostrate	2,64	2699,77	28506,94	9009,97	1430,02	619,59	26,47	117,13	35,01	36,54	14,67

Results showed that medium crop growth type gave higher mineral levels. It has been stated that the plants with medium growth type are more resistant to lodging and being cruched (lit). They have high mineral levels, high yield potential and good adaptability to the current conditions. Accordingly, in this study, plants with medium growth type have the highest mineral values. The medium growth types of sainfoin will contribute in fodder crop production. Evaluation of minerals for *Onobrycis* species in Fig 3, conditional formatting minerals for *Onobrycis* species in Table 5 were shown.

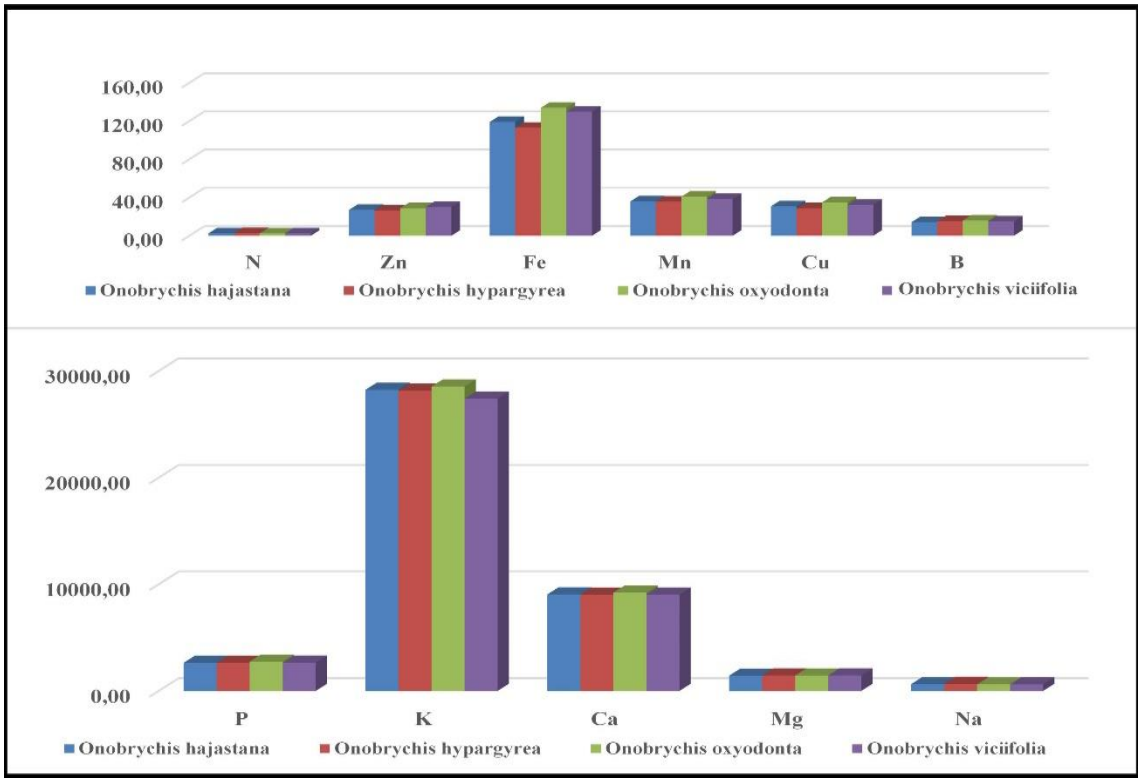

Fig. 3*. Evaluation of minerals for Onobrycis species.*

O. oxyodonta had the higher mineral values then the other types; *O. hypargyrea* and *O. hajastana* types had similar values, *O. viciifolia* gave lowest value (Fig 1). Table 3 showed that *O. hypargyrea* in N, *O. oxyodonta* in P, K, Ca, Fe, Mn, Cu and B; *O. hypargyrea* and *O. viciifolia* in Mg; *O. hypargyrea* in Na; and *O. viciifolia* in Zn had the lowest mineral values. Moreover, *O. oxyodonta* in *N*; *O. hajastana* and *O. hypargyrea* in P; *O. viciifolia* in K; *O. hypargyrea* and *O. viciifolia* in Ca; *O. hajastana* in Mg; *O. oxyodonta* and *O. viciifolia;* in Na; *O. hypargyrea* in Zn, Fe, Mn and Cu; and *O. hajastana* in B had the lowest values (Table 5).

Table 5*. Conditional formatting of Onobrycis species.*

Crop Varieties	N	P	K	Ca	Mg	Na	Zn	Fe	Mn	Cu	B
O. hajastana	2,60	2631,98	28227,94	9046,30	1428,28	625,06	27,20	119,12	35,98	30,88	14,30
O. hypargyrea	2,87	2633,07	28152,68	9018,85	1450,81	653,20	26,51	113,04	35,77	28,90	15,28
O. oxyodonta	2,56	2752,04	28542,01	9213,44	1444,73	616,40	28,90	133,92	41,00	35,02	16,02
O. viciifolia	2,60	2646,05	27400,21	9028,98	1452,58	614,78	30,20	129,87	38,65	32,35	14,98

Mineral levels are mostly under genotype x environment interaction and significant variations occur among crop genotypes [45, 46]. Species having higher mineral levels could have higher genotypic performance in metabolic processes including dry matter production [18]. Relatively *O. oxyodonta* having higher mineral levels in this study had higher dry matter production and crop yield, it could be said as higher yielding crop.

Principal Component Analysis

Principal component analysis (PCA) as a statistical method explains multi variations in variables with lower variables and helps to assign covariance values in variables [49,

50]. Having graphic analysis, this method gives information to classify variables [51, 52]. Principal component analysis of crop growth types, bi-plot analysis of crop growth types on minerals in *Onobrycis* species were given in Table 6 and Fig 4.

***Table 6**. Principal component analysis of crop growth types on minerals in Onobrycis species*

Eigenanalysis of the Correlation Matrix					
	PC_1	**PC_1**		**PC_1**	**PC_1**
Eigenvalue	6,884	3,086	**Proportion**	0,626	0,280
Cumulative	0,626	0,906			
Variable	**PC_1**	**PC_1**	**Variable**	**PC_1**	**PC_1**
N	0,338	-0,126	**Zn**	0,250	-0,416
P	0,288	0,173	**Fe**	0,379	0,028
K	0,278	0,159	**Mn**	0,349	-0,151
Ca	0,284	-0,152	**Cu**	-0,289	0,354
Mg	0,057	-0,563	**B**	0,381	-0,003
Na	0,292	0,140	**Minerals (Crop Type)**		

PC_1 gave the highest largest eigenvalue (6,884) and covered almost 62,6 % of the total variance. PC_2 denoted the eigenvalue of 0,626 and had 28,0 % of the total variance. With 90,6 % of cumulative variance, PC_1 and PC_2 revealed most of total variance in the study. N (0,338), P (0,288), K (0,278), Ca (0,284), Na (0,292), Fe (0,379), Mn (0,349) and B (0,381) in PC_1; Mg (-0,563) and Zn (-0,416) in PC_2 had the highest contributions. N, P, K, Ca, Fe, Mn, Na, Fe, Mn and B in PC_1; Mg and Zn in PC_2 were determined as the best contributors (Table 6).

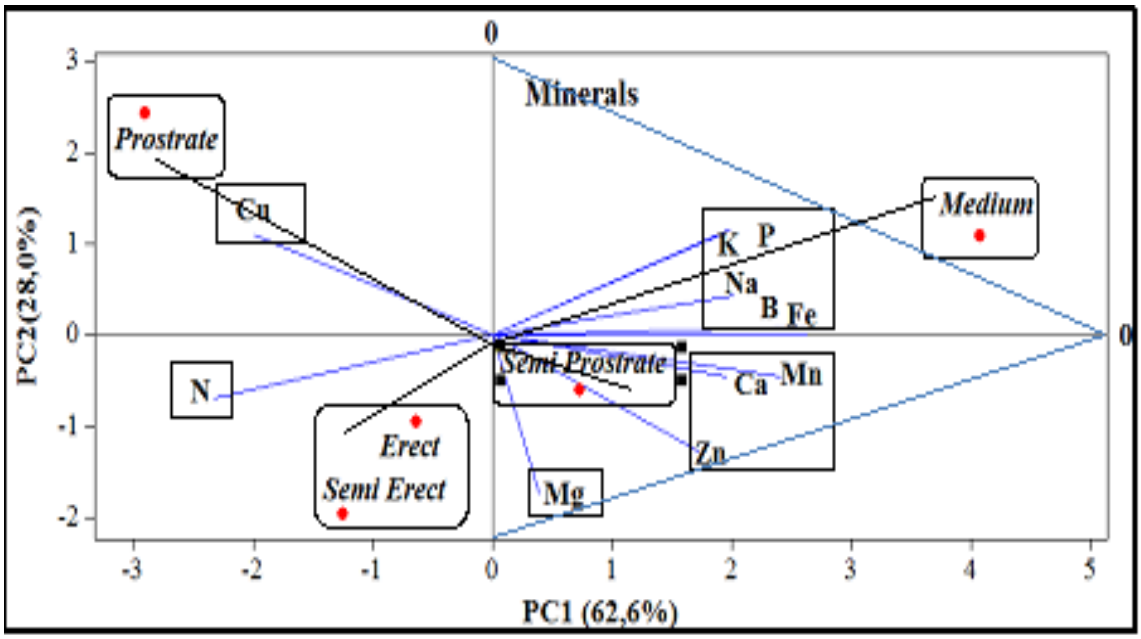

***Fig. 4**. Bi-plot analysis of crop growth types on minerals in Onobrycis species.*

Bi-plot analysis revealed that semi erect and erect growth types occupied same group and the other crop growth types created their separate own groups. Besides, K, P, Na, B, Fe joined one group; Zn, Ca and Mn take part in one group. Mg, N and Cu created separate

groups. P, K, Na, B, Fe, Zn, Ca in minerals; semi prostrate and medium crop growth type were determined as stabile and best contributors (Fig. 4). Principal component and bi-plot analyses of *Onobrycis* species in minerals were shown in Table 7 and Fig 5.

Table 7*. Principal component analysis of Onobrycis species in minerals.*

Eigenanalysis of the Correlation Matrix					
	PC₁	**PC₁**		**PC₁**	**PC₁**
Eigenvalue	6,616	2,455	**Proportion**	0,601	0,223
Cumulative	0,601	0,825			
Variable	**PC₁**	**PC₁**	**Variable**	**PC₁**	**PC₁**
N	-0,297	0,255	**Zn**	0,288	-0,394
P	0,344	0,296	**Fe**	0,378	-0,144
K	0,064	0,572	**Mn**	0,381	0,037
Ca	0,330	0,325	**Cu**	0,387	0,001
Mg	0,046	-0,048	**B**	0,240	0,362
Na	-0,315	0,321	**Minerals (Sainfoin Genotypes)**		

In Table 7, PC_1 had the highest largest eigenvalue (6,616) and occupied almost 60,1 % of the total variance. PC_2 showed the eigenvalue of 0,601 and had 22,3 % of the total variance. With 82,5 % of cumulative variance, PC_1 and PC_2 gave most of total variance in the study. P (0,344), Fe (0,378), Mn (0,381) and Cu (0,387) in PC_1; K (0,572) and Zn (-0,394) in PC_2 had the highest contributions. P, Fe, Mn and Cu in PC_1; K and Zn in PC_2 were determined as the best contributors.

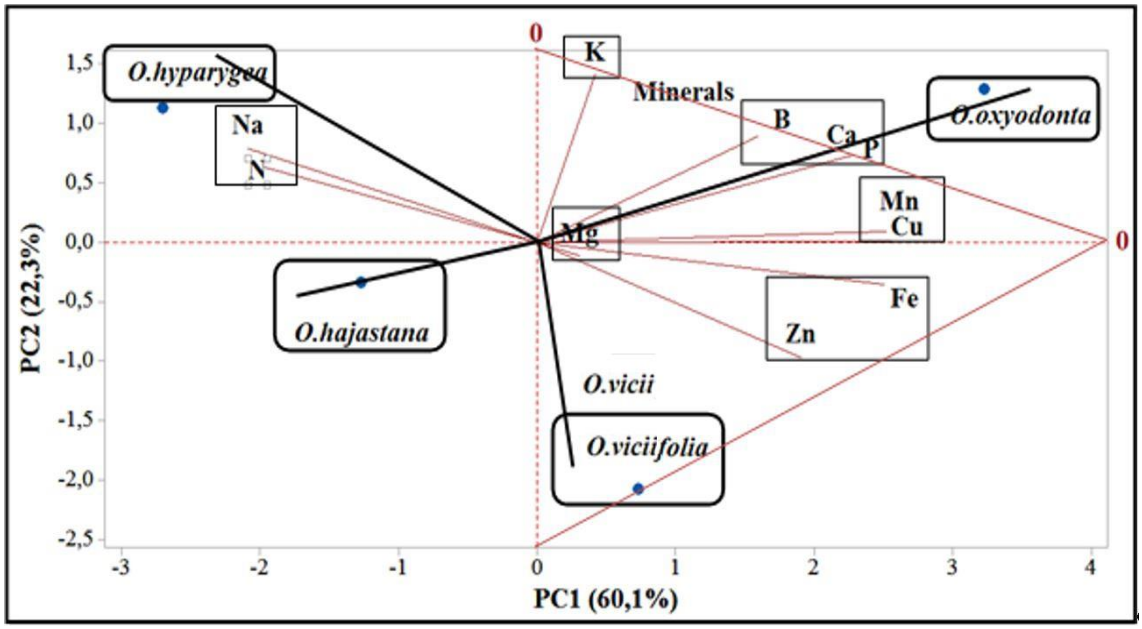

Fig. 5*. Bi-plot analysis of Onobrycis species in minerals.*

All *Onobrycis* species occupied separate groups. B, Ca and P, Na and N, Mn and Cu, Zn and Fe joined same groups. So, B, Ca, P, Mn, Cu, Fe and Zn in minerals; *O. oxyodonta* were found as stabile and best contributors (Fig. 5). Sainfoin is known as resistant crop to drought and cold and can be successfully grown in arid conditions including unproductive and barren places. In addition, soil selectivity of it is not high. Sainfoin is

not only nutritious crop for cows, calves and goats etc., but also it is well source of nectar for beekeeping. In the light of this explanations, high yield in sainfoin depends on genotypic performance and depends on the activity of metabolic activity. In this activity, the mineral level of the plant is of great importance. Results showed that medium crop growth type gave higher mineral levels. Relatively *O. oxyodonta* having higher mineral levels in this study had higher dry matter production and crop yield, it could be said as higher yielding crop. So, P, K, Na, B, Fe, Zn, Ca in minerals were determined as stabile and best contributors to high yield. *O. oxyodonta* with medium crop growth types is the best crop for high crop production.

CONCLUSION

In this study, conditional formatting and principal component analyses were used to identify changes and similarities/dissimilarities in mineral contents of five crop growth types and four *Onobrycis* species for the first time. According to the obtained data from conditional formatting method, plants with medium growth type have the highest mineral values. The medium growth types of sainfoin will contribute in fodder crop production. Between four *Onobrychis* species, *O. oxyodonta* has higher dry matter production and crop yield, it could be said as higher yielding crop.

Principle component analysis clearly showed that P, K, Na, B, Fe, Zn, Ca in minerals were determined as stabile and best contributors to high yield. *O. oxyodonta* with medium crop growth types is the best crop for high crop production.

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