

STATISTICAL COMPARISON ON NUMERICAL ANATOMICAL VALUES OF *CROCUS* L. TAXA

ALİ ÖZDEMİR^{1*} AND YURDANUR AKYOL²

¹Celal Bayar University, Faculty of Art and Science, Department of Mathematic, Manisa, Turkey

²Hasan Türek Anatolian High School, Manisa, Turkey

*Corresponding author's email: acaozdemir@gmail.com

Abstract

This study aims to statistically compare the numerical values of root and scape anatomy of 13 *Crocus* taxa. Anatomical variations in 13 *Crocus* L. taxa have been investigated by means of numerical methods (Analysis of variance and Pearson correlation). By the analysis of the investigated taxa from ten anatomy related characters, it has been determined that endodermis width, pericycle length and trache cell diameter are the best character pairs which represent the variations in them. It has been also found that the results from numerical analysis of the anatomy characters can provide additional anatomical evidences for recognition of the taxa.

Key words: Statistical analysis, *Crocus*, Numerical anatomy.

Introduction

The genus *Crocus* L. belongs to the large family Iridaceae. It is a systematically problematic genus and consist of about 200 recognized species occurring from western Europe and northwestern Africa to western China with the center of species diversity on the Balkan Peninsula and Turkey (Mathew, 1982; Halevy, 1990; Gul *et al.*, 2016., Harpke *et al.*, 2016). Many taxon of the family Iridaceae are grown in parks and gardens as ornamental plants due to their beautiful flowers (Baytop, 1984). Some *Crocus* species were used for making dye, perfume and medicaments since 1600 B.C (Rudall & Mathew, 1990; Abdullaev, 2003; Özdemir & Akyol, 2005) pointed out that the saffron could be useful in cancer chemoprevention in near future. Different studies on some *Crocus* species has been found in the literature (Dainauskaite *et al.*, 2001; Özdemir *et al.*, 2004, 2006, 2011, 2013, 2016; Akan *et al.*, 2013; Yetişen *et al.*, 2013). Recently a similar numerical study was carried out on the onosmataxon (Binzet *et al.*, 2018). Some researchers have reported that the extract of *Crocus* has antitumor, antimetastatic and cytotoxic activities and inhibits nucleic acid synthesis in human malignant cells (Fatehi *et al.*, 2003; Sivanesan *et al.*, 2014., Milajerdi *et al.*, 2016). The aim of this study was to investigate the anatomical structures and to evaluate statistical of anatomical characters of 13 *Crocus* taxa growing in Turkey.

Material and Methods

Plant samples were collected from natural areas between 2012-2016. Morphological and taxonomical descriptions of the plants was made according to Mathew (1982) and Davis (1984). For numerical analysis 10 characters of the root and scape were selected (Table 1). This selection was based on the variations of the anatomical data. Characters were coded as 1-10 and the taxa were coded as A-M. Significance of the differences between the taxa and characters were evaluated by Analysis of variance (Regression Analysis) and Pearson's correlation at levels of * $p < .05$ and ** $p < .01$. Statistical analysis were performed using the MINITAB software package.

Results and Discussion

Anatomical findings

***C. biflorus* Miller subsp. *tauri* (Maw) Mathew:** A metaxylem, 4 xylem strands were present in root vascular tissue. There were 7-8 big, 6-14 small vascular bundles in the scape.

***C. biflorus* Miller subsp. *Pulchricolor* (Maw) Mathew:** A big metaxylem and 4-5 xylem strands were present on the median part of the root. Different sized vascular bundles were located in three circles.

***C. fleischeri* Gay:** Metaxylem was single in root vascular cylinder. Vascular bundles were present in periphery and central part of scape.

***C. flavus* Weston subsp. *flavus* Weston:** Single metaxylem was present in the root centre. There were 4 xylem strands. The number of vascular bundles 5-8 in the scape.

***C. olivieri* Gay subsp. *istanbulensis*:** A big metaxylem and 3-4 xylem strands were present in the root . There are 4-5 big and 6-8 small vascular bundles in the scape.

***C. chrysanthus* (Herbert) Herbert:** 1 or 2 metaxylem was present on the median part of vascular cylinder. There were 5 big vascular bundles in the center part of scape.

***C. danfordiae* Maw:** Metaxylem was single in root vascular cylinder. Xylem strands were 7-8, There were 3-4 big and 7-14 small vascular bundles as **2 circle** in the scape.

***C. speciosus* Bieb. subsp. *ilgazensis*:** Endodermal thickening was three sided. Single metaxylem was located in the centre of the root. Scape vascular bundles were located two circles.

***C. speciosus* Bieb. subsp. *speciosus*:** There were 2 metaxylem and 8 xylem strands in the centre of root. Scapevascular bundles were two circled. Big vascular bundles are 5-6.

Table 1. Numerical values of Anatomical properties of the *Crocus* taxa.

Taxon	1		2		3		4		5	
	Epidermis width (µm)		Epidermis length (µm)		Cortex cell (µm)		Endodermis width (µm)		Endodermis length (µm)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
A <i>C. biflorus</i> subsp. <i>pulchricolor</i>	11.5 ± 2.51		12.9 ± 1.70		22.3 ± 3.79		9.2 ± 10.6		5.0 ± 0.19	
B <i>C. chrysanthus</i>	10.5 ± 4.78		9.7 ± 4.44		28.3 ± 3.95		10.7 ± 5.06		3.0 ± 0.26	
C <i>C. flavus</i>	9.0 ± 2.77		8.9 ± 3.01		56.6 ± 3.58		15.3 ± 3.17		10.3 ± 4.5	
D <i>C. fleischeri</i>	21.9 ± 1.22		24.0 ± 4.88		30.1 ± 4.18		15.9 ± 2.78		7.2 ± 3.21	
E <i>C. danfordiae</i>	13.0 ± 3.29		9.1 ± 7.14		40.5 ± 2.51		25.0 ± 4.83		19.0 ± 0.1	
F <i>C. asumaniae</i>	16.6 ± 4.09		11.5 ± 4.14		37.5 ± 5.21		13.0 ± 12.2		7.90 ± 0.8	
G <i>C. mathewii</i>	17.2 ± 6.51		15.5 ± 1.86		23.1 ± 3.34		12.0 ± 10.9		7.0 ± 0.19	
H <i>C. olivieri</i> subsp. <i>istanbulensis</i>	18.3 ± 1.98		16.2 ± 3.03		32.0 ± 3.97		22.4 ± 4.96		13.0 ± 0.1	
I <i>C. pulchellus</i>	9.00 ± 11.9		7.5 ± 3.28		31.3 ± 5.28		10.0 ± 15.0		9.0 ± 0.11	
J <i>C. biflorus</i> ssp. <i>tauri</i>	20.0 ± 3.16		7.3 ± 3.45		30.1 ± 3.21		15.0 ± 14.09		5.0 ± 0.12	
K <i>C. speciosus</i> ssp. <i>speciosus</i>	15.0 ± 2.35		12.5 ± 1.76		25.9 ± 2.79		6.30 ± 12.9		17.1 ± 3.8	
L <i>C. speciosus</i> ssp. <i>ilgazensis</i>	25.3 ± 4.87		15.9 ± 1.23		22.2 ± 4.62		9.60 ± 2.79		15.2 ± 9.3	
M <i>C. speciosus</i> ssp. <i>xantholaimos</i>	18.5 ± 6.30		23.0 ± 3.94		21.4 ± 4.07		8.60 ± 12.4		15.8 ± 5.9	

Taxon	6		7		8		9		10	
	Pericycle width (µm)		Pericycle length (µm)		Metaxylem diameter (µm)		Cortex cell (µm)		Trachea cell (µm)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
A <i>C. biflorus</i> subsp. <i>pulchricolor</i>	5.3 ± 2.510		4.9 ± 1.70		14.3 ± 3.79		22.2 ± 10.6		12.0 ± 0.19	
B <i>C. chrysanthus</i>	5.2 ± 4.780		2.7 ± 4.44		22.3 ± 3.95		28.7 ± 5.06		13.0 ± 0.26	
C <i>C. flavus</i>	7.5 ± 2.770		4.9 ± 3.01		35.6 ± 3.58		37.3 ± 3.17		15.3 ± 4.53	
D <i>C. fleischeri</i>	10.2 ± 1.20		4.0 ± 4.88		22.1 ± 4.18		30.9 ± 2.78		12.2 ± 3.21	
E <i>C. danfordiae</i>	7.0 ± 3.290		10.1 ± 7.14		18.5 ± 2.51		38.0 ± 4.83		10.0 ± 0.13	
F <i>C. asumaniae</i>	7.6 ± 4.090		2.50 ± 4.14		20.5 ± 5.21		25.0 ± 12.2		12.9 ± 0.80	
G <i>C. mathewii</i>	3.2 ± 6.510		2.50 ± 1.86		13.1 ± 3.34		35.0 ± 10.9		13.0 ± 0.19	
H <i>C. olivieri</i> subsp. <i>istanbulensis</i>	11.3 ± 1.90		5.20 ± 3.03		20.0 ± 3.97		29.4 ± 4.96		18.0 ± 0.19	
I <i>C. pulchellus</i>	12.0 ± 110		4.70 ± 3.28		23.3 ± 5.28		40.0 ± 15.0		12.0 ± 0.11	
J <i>C. biflorus</i> ssp. <i>tauri</i>	5.0 ± 3.160		2.30 ± 3.45		14.1 ± 3.21		32.0 ± 14.09		11.0 ± 0.12	
K <i>C. speciosus</i> ssp. <i>speciosus</i>	15.0 ± 2.30		5.50 ± 1.76		28.9 ± 2.79		36.3 ± 12.9		17.1 ± 3.80	
L <i>C. speciosus</i> ssp. <i>ilgazensis</i>	8.3 ± 4.870		7.90 ± 1.23		40.2 ± 4.62		22.4 ± 2.79		9.20 ± 9.30	
M <i>C. speciosus</i> ssp. <i>xantholaimos</i>	10.5 ± 6.30		6.00 ± 3.94		24.4 ± 4.07		27.6 ± 12.4		12.8 ± 5.90	

SD: Standart deviation, 1-10: Character codes, A-M: Characters codes

C. speciosus Bieb. subsp. xantholaimos: Root endodermal thickening was three sided. 2-4 metaxylem were located centre of the root. Scape vascular bundles were 2-3 circle.

C. pulchellus Herbert: 1-2 metaxylem and 4-5 xylem strands were present in the root vascular cylinder. Scape vascular bundles were located as two ring at the scape.

C. asumaniae: B. Mathew & T. Baytop: There was a single metaxylem on the median part of root vascular cylinder. Form of scape was polygonal. Vascular bundles were numerous and more scattered.

C. mathewii Kernd. & Pasche: A large metaxylem and 3-4 xylem strands was present in the vascular tissue of root. Vascular bundles of the scape were located as 2 - 3 ring at the scape.

Statistical analysis

Significance of the differences between the investigated taxawas evaluated by analysis of variance (Regression Analysis) and Pearson's correlation

(Correlation). The statistical analysis of the results are shown in Tables 2, 3 and 4. According to Table 2, based on the Pearson's correlation method (Correlation), there are important correlations among (A-B, C, D, E, G, I, L; B-E, L, M; C-D, G, H; D-E, L; E-F, G, I, K; F-G, I, M; G-H, J; I-K, L; J-K; K-L, M; L-M) the investigated taxa at levels of 0.01 and 0.05 (Table 3). According to Table 3, based on the Pearson's correlation method (Correlation), there are important correlations among (1-2, 4; 2-10; 3-4, 5, 7; 4-9; 5-6, 7; 6-7, 8; 7-10; 9-10) the anatomical characters of the investigated taxa at levels of 0.01 and 0.05 (Table 3). According to Table 4, based on Analysis of variance (Regression Analysis), there are important correlations among (A-B, C, D, J, M; B-L, M; C-E, D, H; D-E, K, M; E-F, I; F-I, M; J-M; K-M; L-M) the investigated taxa at levels of 0.01 and 0.05 (Table 4). As shown in Table 2 and Table 4, there are correlations between *C. speciosus* ssp. *speciosus*, *C. speciosus* ssp. *ilgazensis* and *C. speciosus* ssp. *xantholaimos*. It is mentioned that there are close relationships between *C. chrysanthus* and *C. danfordia* (Davis, 1984; Güner, 2000). According to the statistical results, there is a considerable relation between the two taxa, at the level of $p < 0.01$ (0.003). On the other hand, there are no important

differences between *C. biflorus* subsp *pulchricolor* and *C. asumaniae*; *C. biflorus* subsp *pulchricolor* and *C. olivieri* subsp. *istanbulensis* which are not close systematically. Also, there are no important differences *C. chrysanthus* and *C. olivieri* subsp. *istanbulensis* (Tables 2, 4). In the present study, 13 *Crocus* taxa were compared statistically regarding anatomical characters. We aimed to find statistical and anatomical differences in addition to morphological characters to distinguish these taxa. The results of the study show that there are big metaxylem, 4-5 xylem strands in roots of *C. biflorus* subsp. *tauri* and subsp. *pulchricolor*. On the other hand, the vascular bundles are located two circles in the scape of *C. speciosus* subsp. *ilgazensis*, subsp. *Speciosus* and *xantholaimos* which are close taxa as systematically. Also,

according to the statistical results, there is a considerable relation between the these taxa. Özdemir *et al.*, (1999, 2001, 2010) showed the importance of numerical analysis of the anatomical characters of the leaf in the some *Crocus* species. By the analysis of investigated taxa from anatomical related characters, it has been determined that endodermis width, pericycle length and trache cell diameter are the best characters pairs which represent the variations in them. Since *Crocus* is systematically a problematic genus, it is necessary to use alternative methods to distinguish its taxa. Numerical anatomical features and statistical evaluations of taxa can be used to distinguish these taxa. It has been also found that the results from can provide additional anatomical evidences for the recognition of the taxa.

Table 2. Pearson's correlation (Correlation) based on 13 investigated *Crocus* taxa.

	A	B	C	D	E	F	G	H	I	J	K	L
B	0,969 0,004**											
C	0,759 0,003**	0,857 0,060										
D	0,900 0,040*	0,870 0,070	0,701 0,008**									
E	0,700 0,007*	0,749 0,003**	0,845 0,070	0,629 0,021*								
F	0,892 0,073	0,912 0,070	0,909 0,063	0,884 0,070	0,805 0,001**							
G	0,738 0,040*	0,725 0,065	0,637 0,019*	0,831 0,070	0,680 0,011*	0,770 0,002**						
H	0,914 0,080	0,906 0,090	0,801 0,041*	0,845 0,700	0,834 0,090	0,899 0,100	0,711 0,006**					
i	0,898 0,020*	0,942 0,060	0,821 0,051	0,776 0,052	0,804 0,001**	0,833 0,002**	0,701 0,080	0,852 0,090				
J	0,925 0,050*	0,912 0,200	0,758 0,053	0,851 0,060	0,815 0,051	0,904 0,058	0,796 0,011*	0,923 0,080	0,879 0,054			
K	0,876 0,876	0,890 0,890	0,659 0,659	0,726 0,726	0,617 0,617	0,713 0,713	0,585 0,585	0,759 0,759	0,897 0,897	0,796 0,796		
L	0,561 0,046*	0,644 0,018*	0,512 0,074	0,576 0,039*	0,290 0,336	0,530 0,063	0,228 0,453	0,506 0,077	0,593 0,033*	0,507 0,077	0,883 0,010**	
M	0,838 0,060	0,777 0,002*	0,444 0,128	0,801 0,051	0,410 0,164	0,621 0,024*	0,506 0,078	0,691 0,059	0,730 0,600	0,687 0,053	0,709 0,007**	0,702 0,006**

*Significant at the level of 0.05, **Significant at the level of 0.01 and A-M: taxa codes

Table 3. Pearson's correlation (Correlation) based on anatomical characters of the investigated *Crocus* taxa.

	1	2	3	4	5	6	7	8
2	0,579 0,038*							
3	0,463 0,111	0,456 0,117						
4	0,005** 0,988	0,112 0,714	0,524 0,049*					
5	0,165 0,589	0,159 0,604	0,050* 0,871	0,236 0,438				
6	0,400 0,176	0,254 0,402	0,134 0,662	0,085 0,782	0,494 0,046*			
7	0,083 0,787	0,114 0,712	0,044* 0,888	0,369 0,214	0,874 0,001**	0,495 0,036*		
8	0,138 0,652	0,054 0,861	0,227 0,457	0,276 0,361	0,431 0,141	0,710 0,007**	0,319 0,287	
9	0,178	0,373	0,176	0,029*	0,111	0,359	0,309	0,102

*Significant at the level of 0.05, **0.01 and 1-10: Anatomical characters codes

Table 4. Correlation between 13 investigated *Crocus* taxa (Regression Analysis).

	MS	F-value	Probability	Significance
A-B	47.848	382.7	0,040	*
A-C	52.200	17.57	0,050	*
A-D	47.134	382.2	0,040	*
A-E	44.250	12.70	0,050	*
A-F	47.000	598.6	0,060	NS
A-H	57.600	14.32	0,080	NS
A-İ	46.670	2.530	0,020	*
A-J	47.980	598.0	0,030	*
A-L	50.920	5,040	0,050	*
A-M	103.11	40.54	0,020	*
B-F	92.200	1.539	0,540	NS
B-H	99.570	51.18	0,100	NS
B-L	117.57	17.18	0,010	**
B-M	1414,6	11,95	0,041	**
C-D	1383,0	15,85	0,028	**
D-E	1417,2	18,68	0,023	*
D-K	1565,8	59,43	0,005	**
E-F	1868,4	48,47	0,006	**
E-İ	944,03	18,30	0,023	**
F-İ	1073,3	126,4	0,002	**
G-K	838,29	9,650	0,050	*
J-M	220,03	21,45	0,019	**
K-L	106,56	9,340	0,010	**
K-M	1041,1	24,38	0,010	**
L-M	892,64	9,680	0,013	*

MS: Mean square *p<.05, **p<.01, A-M: Taxon codes, NS: Not significant

References

- Abdullaev, F. 2003. *Crocus sativus* against cancer. *Archives Med. Res.*, 34(4): 354.
- Akan, H., M. Aydoğdu, M. Korkut and M. Balos. 2013. An ethnobotanical research of the Kalecik mountain area. *Biol. Divers. & Conser.*, 6(2): 84-90.
- Akyol, Y., C. Durmuskahya, O. Kocabaş, S. Pekönür and C. Özdemir. 2014. The morphological and anatomical investigation of two endemic crocus (Iridaceae) species of Turkey. *Pak. J. Bot.*, 46(3): 833-839.
- Akyol, Y., K. Yetişen, C. Özdemir, B. Bozdağ and O. Kocabaş. 2012. Türkiye'deki *Crocus biflorus* Miller subsp. *tauri* (Maw) Mathew (Iridaceae) Üzerine Morfolojikve Anatomik Bir Çalışma, *Iğdir Univ. J. Inst. Sci. & Tech.*, 2(2): 15-20.
- Baytop, T. 1984. Türkiye'de Bitkilerle Tedavi. *İstanbul: Üniv. Yay.* (Serie, 3255).
- Binzet, R., I. Kandemir and N. Orcan. 2018. Numerical taxonomic study of the genus *Onosma* L. (Boraginaceae) from eastern mediterranean region in Turkey. *Pak. J. Bot.*, 50(2): 561-573.
- Dainauskaite, D., G. Indrisiunaite and J. Varkuleviciene. 2001. Investigation evaluation and conservation of genetic resources of flower varieties released by Lithuanian breeders. *Biologia*, 4: 97-100.
- Davis, P.H. 1984. *Flora of Turkey and East Aegean Islands*, Vol.8. Edinburgh Univ. Press, UK.
- Fatehi, M., T. Rashidabady and F.H. Zahra. 2003. Effects of *Crocus sativus* petals extract on rat blood pressure and on responses induced by electrical field stimulation in the rat isolated vas deferens and guinea-pig ileum. *J. Ethnopharmacol.*, 84: 199-203.
- Gul, I, U. Nissar and Z. Abdin. 2016. Molecular authentication and quality control of crocus sativus and aloe barbadensis in raw material source and polyherbal medicine employing scar markers. *Pak. J. Bot.*, 48(3): 1091-1098.
- Güner, A., N. Ozhatay, T. Ekim and K.H.C. Baser. 2000. *Flora of Turkey and The East Aegean Islands* (vol. 11). Edinburgh: Edinburgh University Press.
- Halevy, A.H. 1990. Recent advances in control of flowering and growth habit of geophytes. *Acta Hort.*, 266: 35-42.
- Harpke, D., H. Kerndorff, E. Pasche and L. Peruzzi. 2016. Neotypification of the name *Crocus biflorus* Mill. (Iridaceae) and its consequences in the taxonomy of the genus. *Phytotaxa*, 260(2): 131-143.
- Mathew, B. 1982. *The Crocus*. A revision of the genus *Crocus* (Iridaceae). Batsford, B.T. Ltd., London
- Milajerdi, A., K. Djafarian and H. Hossein. 2016. The toxicity of saffron (*Crocus sativus* L.) and its constituents against normal and cancer cells, *J. Nutr. & Intermed. Metabol.*, 3: 23-32.
- Özdemir, A., Y. Akyol, A.Y. Özdemir and C. Özdemir. 2016. Response of *Crocus* L. Iridaceae to ecological characteristics. *Bangladesh J. Bot.*, 45(3): 533-539.
- Özdemir, A.Y., A. Özdemir and C. Özdemir. 2010. Statistical comparative leaf anatomy of some *Crocus* L. Taxa. *Asian J. Math. & Statistics*, 3(1): 16-24.
- Özdemir, C, Y. Akyol and E. Alçitepe. 2004. Morphological and anatomical studies on two endemic *Crocus* species of Turkey area. *Pak. J. Bot.*, 36(1): 103-113.
- Özdemir, C. and Y. Akyol. 2005. The morphological and anatomical studies on *Crocus pulchellus* Herbert (Iridaceae) in Turkey. *J. Econ. Taxon. Bot.*, 29: 237-245.
- Özdemir, C., E. Alçitepe, B. Bozdağ and B. Baran. 2011. An anatomical study on *Crocus olivieri* Gay subsp. *olivieri* (Iridaceae) *J. Econ. Taxon. Bot.*, 35: 1.
- Özdemir, C., P. Baran and Y. Akyol. 2006. The morphology and anatomy of *Crocus flavus* Weston subsp. *flavus* (Iridaceae). *Turk. J. Bot.*, 30: 175-180.
- Özdemir, C., Y. Akyol, K. Yetişen and B. Bozdağ. 2013. *Crocus chrysanthus* (herbert) herbert (Iridaceae) üzerinde morfolojik ve anatomik bir çalışma. *Iğdir Univ. J. Inst. Sci. & Tech.*, 3(1): 25-30.
- Rudall, P. and B. Mathew. 1990. Leaf anatomy in *Crocus* (Iridaceae). *Kew Bulletin*, 45(3): 535-545.
- Sivanesan, H.I., S. Jana and B.Y. Jeong. 2014. *In vitro* shoot regeneration and microcorm development in *Crocus vernus* (L.). *Pak. J. Bot.*, 46(2): 693-697.
- Yetişen, K., U. Şen, T. Yıldırım and C. Özdemir. 2013. Morphological and anatomical study on endemic *Crocus olivieri* Gay subsp. *Istanbulensis* Mathew (Iridaceae). *Technol. Life Sci. & Biotechnol.*, 3(1): 31-37.

(Received for publication 17 July 2017)