Article

Agro-Morphological Characterization and Some Seed Characteristics of Wild *Crambe* (*Brassicaceae*) Species in Turkey

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Abstract: The seeds of wild *Crambe* species have potential to be used as a source of industrial oil and animal feed. In this study, 48 genotypes of three *Crambe* species collected from the flora of Turkey were grown under field conditions in Ankara/Turkey in 2014–2016. The seed protein ratio, plant height, number of branches per plant, number of seeds per plant, seed yield per plant, thousand seed weight and hullless/hulled seed ratio (H/H) were determined. The highest protein ratio was determined as 26.02% in the t18 accession of *Crambe tataria* species. Variations in the characteristics were analyzed using principal component analysis. In the factor analysis of *Crambe maritima*, *Crambe orientalis*, *Crambe tataria* and the mean of these three species, the first two principal components accounted for 100%, 58.06%, 59.93% and 100% of the total variations, respectively. There were positive correlations between the plant height and number of seeds per plant, seed yield per plant for *C. orientalis*, and number of branches per plant for *C. tataria*. Although seed yield per plant was high in *C. tataria* and *C. orientalis*, they are not suitable for conventional agriculture due to shell thickness, inhomogeneous plant emergence and shooting. Conventional cultivation of wild *Crambe* species can be made possible by eliminating these negative features with breeding and agronomic studies.

Keywords: wild *Crambe*; agro-morphology; protein ratio; crop wild relatives; genetic resources

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1. Introduction

The genus *Crambe*, which is a member of the family Brassica, comprising 338 genera and 3709 species, has approximately 35 taxa worldwide [1]. The flora of Turkey includes six species and four infraspecific taxa [2], comprising *Crambe alutacea* Hand.-Mazz., *C. tataria* Sebeök var. *tataria*, *C. grandiflora* DC., *C. hispanica* L., *C. maritima* L., *C. orientalis* L. subsp. *orientalis* var. *dasycarpa* O. E. Schulz, *C. tataria* Sebeök var. *parviflora* Hedge and Hub.-Mor., *C. orientalis* L. subsp. *orientalis* var. *orientalis*, *C. orientalis* L. subsp. *sulphurea* Prina, and *C. tataria* Sebeök var. *aspera* Boiss [3,4].

Like many members of the family Brassica, the genus *Crambe* is a new potential plant that could be a source of industrial oil [1]. The majority of *Crambe* species can easily be cultivated to provide high crop yields. They can also be used as melliferous, starch-bearing green fodder, or as decorative plants [5]. The oil obtained from *Crambe abyssinica* has high erucic acid content and has been used as an antiadhesion in the nylon and plastics industries. *Crambe abyssinica* Hochst, an annual *Crambe* species, has widespread industrial use and has been widely studied. As with many other wild *Crambe* species, those investigated herein were perennial.

Wild relatives have the potential to improve the beneficial characteristics of the crop, such as its resistance to biotic and abiotic stresses, enriching the gene pool and enhancing the yield, maturity period and quality [6]. Many agronomic characteristics, such as cytoplasmic and nuclear male sterility, resistance to disease, insects and nematode pests, intermediate C3-C4 photosynthetic activity, and tolerance to cold, salt and drought conditions, have been transferred from wild plant species to cultivated plants [1]. Morphological characterization is the first stage in the definition and classification of genetic resources [7].

The collection and characterization of a wide range of genetically diverse crops are essential for beginning a successful breeding program [7–9].

It is important to determine the agromorphological characteristics and some seed characteristics in order to determine the potential of wild *Crambe* species to be cultivated, and brought into the economy. The aim of this study is to determine the yield and some agromorphological characteristics of wild *Crambe* species in Turkey, under conventional farming conditions.

2. Materials and Methods

2.1. Plant Material and Crop Sowing

The plant material consisted of 48 accessions belonging species of *C. orientalis*, *C. tataria*, and *C. maritima*. The species of *Crambe* used in the field experiment were previously collected in Turkey. This is the most comprehensive study ever made, covering all species of *Crambe* and their accessions in Turkey. In this study, 3 accessions for *C. maritima*, 22 accessions for *C. orientalis*, and 23 accessions for *C. tataria* were used. The localities and altitudes of the studied wild *Crambe* accessions are given in Table 1.

Table 1. List of investigated *Crambe* germplasm accessions and localities.

Code	Species	Origin	Code	Species	Origin
<i>Crambe maritima</i> (2n = 30; 60)			<i>Crambe tataria</i> (2n = 30; 60; 120)		
m1	<i>C. maritima</i>	Sinop	t1	<i>C. tataria</i> var. <i>aspera</i>	Aksaray
m2	<i>C. maritima</i>	Kastamonu	t2	<i>C. tataria</i> var. <i>tataria</i>	Aksaray
m3	<i>C. maritima</i>	Kastamonu	t3	<i>C. tataria</i> var. <i>tataria</i>	Aksaray
<i>Crambe orientalis</i> (2n = 30)			t4	<i>C. tataria</i> var. <i>tataria</i>	Kırşehir
o1	<i>C. orientalis</i> var. <i>orientalis</i>	Kayseri	t5	<i>C. tataria</i> var. <i>tataria</i>	Afyon
o2	<i>C. orientalis</i> var. <i>orientalis</i>	Nevşehir	t6	<i>C. tataria</i> var. <i>tataria</i>	Kırşehir
o3	<i>C. orientalis</i> var. <i>orientalis</i>	Kahramanmaraş	t7	<i>C. tataria</i> var. <i>tataria</i>	Kırıkkale
o4	<i>C. orientalis</i> var. <i>orientalis</i>	Aksaray	t8	<i>C. tataria</i> var. <i>tataria</i>	Ankara
o5	<i>C. orientalis</i> var. <i>orientalis</i>	Kahramanmaraş	t9	<i>C. tataria</i> var. <i>tataria</i>	Bilecik
o6	<i>C. orientalis</i> var. <i>orientalis</i>	Sivas	t10	<i>C. tataria</i> var. <i>aspera</i>	Eskişehir
o7	<i>C. orientalis</i> var. <i>orientalis</i>	Nevşehir	t11	<i>C. tataria</i> var. <i>tataria</i>	Ankara
o8	<i>C. orientalis</i> var. <i>orientalis</i>	Kayseri	t12	<i>C. tataria</i> var. <i>tataria</i>	Kırıkkale
o9	<i>C. orientalis</i> var. <i>orientalis</i>	Nevşehir	t13	<i>C. tataria</i> var. <i>tataria</i>	Eskişehir
o10	<i>C. orientalis</i> var. <i>orientalis</i>	Afyon	t14	<i>C. tataria</i> var. <i>tataria</i>	Eskişehir
o11	<i>C. orientalis</i> var. <i>orientalis</i>	Çankırı	t15	<i>C. tataria</i> var. <i>aspera</i>	Ankara
o12	<i>C. orientalis</i> var. <i>orientalis</i>	Ankara	t16	<i>C. tataria</i> var. <i>tataria</i>	Eskişehir
o13	<i>C. orientalis</i> var. <i>orientalis</i>	Ankara	t17	<i>C. tataria</i> var. <i>tataria</i>	Kırıkkale
o14	<i>C. orientalis</i> var. <i>orientalis</i>	Adıyaman	t18	<i>C. tataria</i> var. <i>tataria</i>	Ankara
o15	<i>C. orientalis</i> var. <i>orientalis</i>	Malatya	t19	<i>C. tataria</i> var. <i>tataria</i>	Sivas
o16	<i>C. orientalis</i> var. <i>sulphurea</i>	Kahramanmaraş	t20	<i>C. tataria</i> var. <i>tataria</i>	Ankara
o17	<i>C. orientalis</i> var. <i>orientalis</i>	Kahramanmaraş	t21	<i>C. tataria</i> var. <i>tataria</i>	Eskişehir
o18	<i>C. orientalis</i> var. <i>sulphurea</i>	Kahramanmaraş	t22	<i>C. tataria</i> var. <i>tataria</i>	Kayseri
o19	<i>C. orientalis</i> var. <i>orientalis</i>	Kayseri	t23	<i>C. tataria</i> var. <i>aspera</i>	Ankara
o20	<i>C. orientalis</i> var. <i>dasycarpa</i>	Adana			
o21	<i>C. orientalis</i> var. <i>orientalis</i>	Kahramanmaraş			
o22	<i>C. orientalis</i> var. <i>orientalis</i>	Kayseri			

Field experiments were conducted during the 2014–2016 crop season at the research and implementation area of the Central Research Institute for Field Crops, in Ankara, Turkey (39°55′59″ N; 32°81′49″ E).

Within the scope of the field studies, seeds collected from the localities were sowed in October of 2014 at a plant density of 70 cm × 30 cm and 5 m row length. The emergence of the plants was observed in the spring of 2015. Since the *Crambe* species studied are perennial, no flowering was observed in 2015. All observations within the scope of the study were recorded in the summer of 2016. Each parameter was determined as the mean

of 10 plant measurements in each row. For each accession, morphological and agronomical properties were recorded, comprising the seed protein ratio (PR), plant height (PH), seeds per plant (SPP), yield per plant (YPP), thousand seed weight (TSW), hullless/hulled seed ratio (H/H), and number of branches per plant (BPP). Data were measured and recorded according to International Plant Genetic Resources Institute procedures. The average height of 10 plants, measured from ground level to the top of the plant, was recorded as the PH. The BPP was calculated with the mean values of the number of branches of 10 plants. The TSW was obtained by weighing 4 replicates of 100 seeds. The SPP was calculated as the average of the number of seeds of 10 plants taken from each row.

2.2. Climate and Soil Properties of the Test Field

Total precipitation was 490 mm during 2014, 467 mm in 2015, and 388 mm in 2016. The lowest and highest temperatures were recorded in 2014 as -8.8°C in February and 37.8°C in August; in 2015 as -15.5°C in January and 37.7°C in July; and in 2016 as -16.4°C in January and 38.2°C in July. The test field in which the research was conducted consisted of well-drained, loamy–clayey soil. The soil pH was 7.97, the percentage of salt was 0.015%, organic matter was 1.36%, and lime was 7.02%. The altitude of the trial area was 846 m.

Statistical analyses: Statistical analyses were performed with JMP Pro 11 (SAS Institute, Cary, NC, USA). Correlation among the properties was calculated using the Pearson correlation procedure. Trait mean values were used to perform principal component analysis (PCA).

3. Results

Among the *Crambe* species, the average PH was highest in *C. orientalis* (132.33 cm) and lowest in *C. maritima* (79.05 cm). The average BPP was highest in *C. orientalis* (14.57 branches) and lowest in *C. maritima* (9.17 branches). The average SPP was highest in *C. tataria* (12,806.34 seeds) and lowest in *C. maritima* (1397.87 seeds). The average yield per plant was the highest in *C. tataria* (215.00 g) and lowest in *C. maritima* (75.75 g). The average TSW was the highest in *C. maritima* (58.53 g) and the lowest in *C. orientalis* (10.05 g). The average H/H was highest in *C. orientalis* (54.73%) and lowest in *C. maritima* (31.00%). The average PR was highest in *C. orientalis* (22.66%) and lowest in *C. maritima* (16.84%) (Table 2).

Table 2. Average values of the seed protein ratio and plant characteristics of *Crambe* species grown under field conditions.

Species		Plant Height (cm)	Branches per Plant (number)	Seeds per Plant (number)	Yield per Plant (g)	Thousand Seed Weight (g)	Hullless/Hulled Seed Ratio (%)	Seed Protein Ratio (%)
<i>C. maritima</i>	Min	75.00	8.71	581.18	38.82	48.35	30.00	15.88
	Max.	85.00	9.80	2472.68	119.55	66.80	32.00	18.20
	Mean	79.05	9.17	1397.87	75.75	58.53	31.00	16.84
	SD	5.27	0.56	971.81	40.80	9.37	1.00	1.21
	CV	6.66	6.16	69.52	53.87	16.01	32.25	7.18
<i>C. orientalis</i>	Min	80.00	8.29	2264.17	37.54	5.93	40.00	19.92
	Max.	205.56	38.70	26,820.15	266.19	18.66	79.00	25.25
	Mean	132.33	14.57	9958.57	86.02	10.05	54.73	22.66
	SD	30.80	6.26	5692.41	62.12	3.30	7.41	1.56
	CV	23.28	43.01	57.16	72.22	32.88	13.53	6.90
<i>C. tataria</i>	Min	80.00	6.00	2777.90	53.44	5.95	36.00	18.39
	Max.	160.00	16.00	52,157.43	497.18	41.15	60.00	26.02
	Mean	104.08	9.70	12,806.34	215.00	21.91	51.61	22.33
	SD	21.66	2.78	9938.25	130.53	9.44	5.44	8.59
	CV	20.81	28.69	77.60	60.71	43.09	10.54	8.59

The means, coefficients of variation (CV), and ranges of the quantitative plant characteristics of the 48 *Crambe* accessions are presented in Table 2. Considering each *Crambe* species, the intraspecies *Crambe* accessions had very high variations in the numbers of SPP, YPP and TSW. The variation levels of the agronomic characteristics were evaluated based on species. A high level of variation was observed among the accessions of *C. orientalis* and *C. tataria* for the TSW and in *C. maritima* for the H/H. Moderate variation was observed for the PH in the *C. orientalis* and *C. tataria* accessions. *C. maritima* exhibited the lowest variations for PH and BPP (Table 2; Figures 1–3).

Figure 1. Biplot diagram of the protein ratio (PR) and agro-morphological properties (plant height (PH), number of seeds per plant (SPP), yield per plant (YPP), thousand seed weight (TSW), hull-less/hulled seed ratio (H/H), and number of branches per plant (BPP)) of *C. maritima*.

Figure 2. Biplot diagram of the protein ratio and agro-morphological properties (protein ratio (PR), plant height (PH), number of seeds per plant (SPP), yield per plant (YPP), thousand seed weight (TSW), hull-less/hulled seed ratio (H/H), and number of branches per plant (BPP)) of *C. orientalis*.

Figure 3. Biplot diagram of the protein ratio and agro-morphological properties (protein ratio (PR), plant height (PH), number of seeds per plant (SPP), yield per plant (YPP), thousand seed weight (TSW), hulless/hulled seed ratio (H/H), and number of branches per plant (BPP)) of *C. tataria*.

For the germplasm accessions, multivariate analyses were used to determine the relative contributions of the characteristics for the total variability [10]. These analyses enabled the germplasm accessions to be classified with similar characteristics. PCA was used to decrease the number of descriptors associated with the data set. Thus, the maximum amount of variability in the data could be explained. Table 3 shows the principal components (PCs) generated from the three *Crambe* species (*C. maritima*, *C. orientalis*, and *C. tataria* intraspecies accessions) and their average agro-morphological characteristics and seed PRs.

In the *C. maritima* data set, PC1 had the highest Eigenvalue, at 5.37, and accounted for 76.7% of the variability, while PC2 had an Eigenvalue of 1.63 and accounted for 23.3% of the variability. PCs (PC2 to PC7) with an Eigenvalue of less than 1 were not considered due to Kaiser's rule [11]. Considering the data sets of *C. maritima*, *C. orientalis*, *C. tataria* and the means of the species, PC1 accounted for 76.7%, 35.82%, 35.87% and 76.23% of the variability, and PC2 accounted for 23.30%, 22.23%, 24.01% and 23.77% of the variability, respectively.

Table 4 shows the correlation matrices for the studied *Crambe* species independently. For *C. maritima*, there were significant positive correlation between BPP and SPP, but significant negative correlations between TSW and both of SPP and YPP. In *C. orientalis*, significant positive correlations were observed between PH and both of YPP and SPP, and also between SPP and YPP. For *C. tataria*, there were significant positive correlations between BPP and both of PH and SPP, but a significant negative correlation between BPP and H/H (Table 4).

The biplot analysis shows interrelationships among the *Crambe* traits visually. Figures 1–4 depict the score plots of the seed PR and agro-morphologic characteristics in three *Crambe* species and the means of three *Crambe* species, generated by comparing PC1 and PC2 axes.

Table 3. Eigen analysis of the correlation matrix loadings of the significant PCs.

Species	Characters	PC1	PC2	PC3	PC4	PC5	PC6	PC7
<i>C. maritima</i>	PH	−0.530	0.848	-	-	-	-	-
	BPP	0.996	0.090	-	-	-	-	-
	SPP	0.993	0.122	-	-	-	-	-
	YPP	0.979	0.206	-	-	-	-	-
	TSW	−0.984	−0.176	-	-	-	-	-
	H/H (%)	0.938	0.347	-	-	-	-	-
	PR (%)	−0.554	0.832	-	-	-	-	-
	Eigenvalue	5.37	1.63	-	-	-	-	-
	Variability (%)	76.7	23.3	-	-	-	-	-
	Cumulative (%)	76.74	100.00	-	-	-	-	-
<i>C. orientalis</i>	PH	0.485	0.005	−0.265	−0.147	−0.310	0.739	-
	BPP	−0.064	0.462	−0.477	0.735	0.020	0.048	-
	SPP	0.549	−0.294	−0.170	0.021	0.243	−0.143	-
	YPP	0.548	−0.195	−0.028	0.272	0.003	−0.459	-
	TSW	0.274	0.335	0.666	0.226	−0.506	−0.052	-
	H/H (%)	0.260	0.512	0.289	−0.124	0.724	0.178	-
	PR (%)	−0.132	−0.536	0.382	0.545	0.254	0.431	-
	Eigenvalue	2.508	1.557	0.989	0.796	0.596	0.485	0.071
	Variability (%)	35.825	22.235	14.123	11.371	8.507	6.927	1.012
	Cumulative (%)	35.825	58.06	72.183	83.553	92.06	98.988	100
<i>C. tataria</i>	PH	0.363	−0.224	0.475	−0.100	0.717	−0.209	0.160
	BPP	0.551	−0.130	0.055	0.345	−0.102	0.739	0.042
	SPP	0.457	0.428	−0.057	−0.289	−0.299	−0.203	0.625
	YPP	0.320	0.576	0.292	0.196	−0.075	−0.226	−0.621
	TSW	−0.386	0.273	0.363	0.669	0.027	−0.025	0.442
	H/H (%)	−0.214	0.586	−0.203	−0.267	0.523	0.474	0.017
	PR (%)	−0.243	−0.015	0.714	−0.480	−0.327	0.305	−0.026
	Eigenvalue	2.511	1.684	1.185	0.720	0.582	0.210	0.107
	Variability (%)	35.868	24.059	16.928	10.290	8.320	3.002	1.531
	Cumulative (%)	35.868	59.927	76.856	87.146	95.466	98.469	100.000
Means of 3 species	PH	0.399	−0.300	-	-	-	-	-
	BPP	0.302	−0.556	-	-	-	-	-
	SPP	0.400	0.297	-	-	-	-	-
	YPP	0.180	0.705	-	-	-	-	-
	TSW	−0.432	0.058	-	-	-	-	-
	H/H (%)	0.431	0.069	-	-	-	-	-
	PR (%)	0.430	0.087	-	-	-	-	-
	Eigenvalue	5.336	1.664	-	-	-	-	-
	Variability (%)	76.229	23.771	-	-	-	-	-
	Cumulative (%)	76.229	100	-	-	-	-	-

Protein ratio (PR), plant height (PH), number of seeds per plant (SPP), yield per plant (YPP), thousand seed weight (TSW), hullless/hulled seed ratio (H/H), and number of branches per plant (BPP).

In the biplot diagram of *C. maritima* (Figure 1), H/H, YPP, SPP and BPP showed a positive correlation. The genotype m2 had a higher PH and PR with respect to the other genotypes. While the m1 genotype stood out in terms of TSW, the m3 genotype had a higher BPP, SPP, YPP and H/H with respect to the other genotypes.

Figure 2 shows a biplot diagram of the *C. orientalis* accessions. The positive axis of PC1 contained H/H, TSW, PH, YPP and SPP, and was comprised of o6, o10, o17, o11, o2, o8 and o4 accessions. The negative axis of PC1 and PC2 contained PR, and was comprised of o14, o7, o15, o9, o1, o19 and o13 accessions.

Figure 3 shows the biplot diagram of *Crambe tataria* accessions. The positive axis of PC1 contained YPP, SPP, BPP and PH, and was comprised of t6, t5, t4, t21, t23, t13, t8, t7, t20 and t22 accessions. The negative axis of PC1 and PC2 contained H/H, TSW and PR, and was comprised of t15, t19, t18, t16, t3, t9, t14, t17, t2, t11, t12 and t10 accessions.

Table 4. Pearson's correlation coefficient analysis for the different plant characteristics of *Crambe* species (protein ratio (PR), plant height (PH), number of seeds per plant (SPP), yield per plant (YPP), thousand seed weight (TSW), hulless/hulled seed ratio (H/H), and number of branches per plant (BPP)).

	PH	BPP	SPP	YPP	TSW	H/H (%)	PR (%)
<i>Crambe maritima</i>							
PH	1.000						
BPP	−0.452	1.000					
SPP	−0.423	0.999 *	1.000				
YPP	−0.344	0.993	0.996	1.000			
TSW	0.372	−0.999	−0.998 *	−0.996 *	1.000		
H/H (%)	−0.203	0.965	0.973	0.989	−0.984	1.000	
PR (%)	0.999 *	−0.477	−0.449	−0.371	0.399	−0.231	1.000
<i>Crambe orientalis</i>							
PH	1.000						
BPP	−0.023	1.000					
SPP	0.602 **	−0.203	1.000				
YPP	0.482 *	−0.071	0.854 **	1.000			
TSW	0.206	0.010	0.058	0.305	1.000		
H/H (%)	0.190	0.130	0.158	0.134	0.388	1.000	
PR (%)	−0.220	−0.213	0.013	−0.005	−0.109	−0.311	1.000
<i>Crambe tataria</i>							
PH	1.000						
BPP	0.483 *	1.000					
SPP	0.139	0.452 *	1.000				
YPP	0.193	0.351	0.703	1.000			
TSW	−0.278	−0.407	−0.384	0.145	1.000		
H/H (%)	−0.313	−0.461 *	0.136	0.242	0.267	1.000	
PR (%)	0.070	−0.338	−0.196	−0.028	0.296	−0.033	1.000

*, ** Indicate significance at the 5% and 1% levels, respectively.

Figure 4. Biplot diagram of the protein ratio and agro-morphological properties (protein ratio (PR), plant height (PH), number of seeds per plant (SPP), yield per plant (YPP), thousand seed weight (TSW), hulless/hulled seed ratio (H/H), and number of branches per plant (BPP)) among the species (*Crambe maritima*, *Crambe orientalis* and *Crambe tataria*).

Figure 4 shows the biplot diagram of *Crambe* species (mean of the accessions of intraspecies). *C. maritima* had the highest TSW among the species. While *C. tataria* had higher YPP and SPP, *C. orientalis* had higher PH and BPP than the other species.

4. Discussion

The minimum, maximum, and mean values of wild *Crambe* accessions examined in this study are shown in Table 2. Davis [12], Keskiner [13], Comlekcioglu et al. [14], Gökçe [15] and Köybaşı [16] reported the maximum and minimum PHs in *C. orientalis* as 40 and 120 cm, 35 and 110 cm, 71 and 120 cm, and 95.21 and 31.6 cm, respectively. In this research, the minimum and maximum PHs of *C. orientalis* were 80 and 205 cm, and the average was 132.33 cm, which was higher than the above-mentioned values. For *C. tataria*, a higher PH (80–160 cm) was determined than that reported by Comlekcioglu et al. [14] (73–116 cm), Davis [12] (90–100 cm), Gökçe [15] (89.31) and Köybaşı [16] (37.5 cm). The BPP values obtained in the current research for *C. tataria* (6–16 branches) and *C. orientalis* (8.29–38.7 branches) were higher than those reported by Comlekcioglu et al. [14] (2–15 and 1–10 branches, respectively), Gökçe [15] (2.94 and 1.56 branches, respectively) and Köybaşı [16] (15.1 and 12 branches, respectively). For *C. orientalis* and *C. tataria*, the TSW values were determined to be between 5.93 and 18.66 g and 5.95 and 41.15 g, respectively. This finding is similar to those reported by Comlekcioglu et al. [14] at 9–18 g and 10–29 g, Gökçe [15] at 5.95 g and 7.69 g, and Köybaşı [16] at 15.04 g for *C. orientalis*. Köybaşı [16] reported 72.25 g for *C. tataria* in the same study. For *C. orientalis* and *C. tataria*, the YPP (g) was between 37.54 and 266.19 g and 53.44 and 497.18 g, respectively. This finding was higher than that reported by Gökçe [15] (33.78 g and 33.00 g, respectively) and Köybaşı [16] (20.61 g and 31.07 g, respectively). For *C. orientalis* and *C. tataria*, the seeds per plant was between 2264.17 and 26,820.15 seeds and 2777.90 and 52,157.43 seeds, respectively. This finding is higher than that reported by Gökçe [15], which was 2486.05 seeds and 1823.16 seeds, respectively, and that reported by Köybaşı [16], which was 1885.8 seeds and 379.0 seeds, respectively. The variation was high between the mentioned characteristics of *C. maritima*, *C. orientalis* and *C. tataria* accessions. Davis [12], Keskiner [13], Comlekcioglu et al. [14], Gökçe [15] and Köybaşı [16] used fewer population genotypes in their wild *Crambe* studies, and their reported values are between the minimum and maximum values of this study, but may differ from the average values. Large variations can be seen within and between populations because of their not being stabilized genotypes. In addition, the difference in the values is the result of carrying out each study in different climatic conditions.

There are few records about the agro-morphological features of wild species. However, many studies exist on annually cultivated *Crambe* species. The morphological features of these annual species are quite different from the morphological features of perennial wild *Crambe* species. *C. abyssinica* species were reported with an H/H of 24–28.8% [17,18]. However, the H/H was determined as 30–79% in the wild *Crambe* species in the current study. Mastebroek et al. [19] reported the means for *C. abyssinica* Hochst. as 116 plants/m², and the average YPP as 2.5 g. Arslan et al. [20] reported TSW values between 2.6 and 8.5 g and YPP values of 0.8–5.1 g/plant for 82 *C. abyssinica* genotypes. Nevertheless, in the wild *Crambe* species in this study, there were approximately 4.5 plants/m², and the average YPP was 125.5 g. The PR, determined as 22.7% for *C. orientalis* and 22.3% for *C. tataria* in this study, had values similar to those reported by Sokolski et al. [21] as 20.8–23.8% in the culture form of *Crambe* (*Crambe abyssinica* Hochst. ex RE Fries). Annual *Crambe* species are morphologically quite different from wild perennial *Crambe* species. Therefore, there were great differences between all the features. Although the YPP is high in *C. tataria* and *C. orientalis*, it has been observed that these species are not suitable for conventional agriculture at the moment due to shell thickness, nonhomogeneous plant emergence and shooting.

5. Conclusions

Crambe species have good potential for use in industrial oil and animal feed (as a source of protein). *C. tataria* and *C. orientalis* are not suitable for conventional agriculture. The conventional cultivation of *Crambe* is only possible by eliminating negative features via breeding and agronomic studies.

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