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VARIABILITY STUDIES OF SOME BLACK CARAWAY (*Bunium persicum* BIOSS. FEDTS) ACCESSIONS ACROSS IMPORTANT GROWING SITES OF IRAN

SUMMARY

The present study was conducted at KANRRC to analyse the variability parameters of some *Bunium persicum* accessions during 2010-2015. The analysis of variance exhibited significant variation among the accessions for all the traits under study. Phenotypic coefficient of variation (PCV) was higher than the genotypic coefficient of variation (GCV) for all the traits indicating that all these characters had interacted with the environment. Moderate coefficient of variation (genotypic and phenotypic) was observed for number of seeds umbelt^{-1} and plant biomass plant^{-1} indicating fair amount of variability present for the traits under mention. High heritability estimates were recorded for all the traits except plant height where the heritability was moderate. High heritability accompanied by high genetic advance was observed for number of seed umblet^{-1}, umblet plant^{-1}, total plant weight, number of umbel^{-1} and bio yield. The genotype Khajeh forest was significantly superior with regard to number of seed umblet^{-1}, seed yield, bio yield and yield of essential oil. The accessions viz., Brown Ferdows, Khajeh forest, Chelmir and Chenaran-Frizi were found potential donors for seed yield and yield of essential oils.

Keywords: Characterization, black caraway, morphological traits, yield and yield attributes

INTRODUCTION

Black caraway (*Bunium persicum* Boiss.) is a perennial aromatic and medicinal herb, distributed in temperate areas of the world and mostly restricted to the sub- alpine mountain slopes (Dar *et al*., 2011). Its species grow wild in North Himalayan regions, Iran, Pakistan and generally it is native to central and Southern parts of Asia, with a wide geographical distribution in Iran. At present, seeds of this valuable medicinal spice plant are extensively collected from natural habitats (Khosravi, 2005), in forests and grasslands in India, at higher elevations including arid zones ranging from 1600 m to 3300 m above sea level. In Iran, it is distributed at higher elevations, such as mountains which are colder than

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surrounding lowlands mainly in the North-East as in Semnan Qazvin, Hormozgan, Esfahan, Razavi Khorasan, Yazd, Fars, Arak and Kerman. The crop mostly grow as wild under natural conditions in mountain, open hilly grassy slopes, low alpine and table lands, as sub – populations, mostly across the hilly areas. The sub-populations across the state represent a great diversity of this plant species which is naturally maintained as valuable germplasm repositories and are the sources of high genetic variability.

One of the primary objectives of breeders is to increase the seed yield. Generally, yield represents the final character resulting from many developmental and biochemical processes (Mishra and Tewari, 2014), which occur between germination and maturity. Before yield improvements can be realized, the breeder needs to identify the causes of variability in yield in any given environment. Since fluctuation in environment generally affects yield primarily through its components. Grafius (1960) suggested that individual yield components may contribute valuable information in breeding for yield. Yield when viewed from the mechanistic or geometric point of view is a product of its components. Knowledge of genetic variability in a given crop is essential for successful breeding improvement programme. To develop of high yielding cultivars it requires a thorough knowledge of the existing variability and association for yield contributing traits in the available germplasm. This will enable him to know how the selection pressure exerted by him on one trait will cause changes in other traits (Al-Aysh *et al*., 2014). The present study was conducted with an objective to estimate genetic variability with the aid of genetic parameters such as genotype coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability (h) and genetic advance.

The present investigation was taken up to elicit information for various morphological, yields and yield attributing traits of Black caraway. The study was carried out during 2010 and 2015. The seeds and bulbs of plant populations of Black Caraway were collected from the wild areas of provinces of Semnan (the mountain ZAR Damghan), Qazvin (Alamut mountain), Hormozgan (Geno mountain Bandar Abbas), North and South (Santa Aman mosque, Esfahan, Razavi Khorasan (a mountain of Akhlamad, Kashmar, Bajestan, Kalat, Chenaran, and altitude of Mashhad), Yazd (Lakheh Mehriz mountain) , Fars (Toodj Estahban Mountain), Markazi (Black Mountain) and the Kerman (Barez mountain). The seeds were planted in the separate plots. Experimental was laid in a randomized block design with three replications. Each line was grown in two rows of 3 m length, spaced at 50 cm, keeping plant to plant distance of 10 cm. The recommended packages of practices were followed to raise a healthy crop. During the third year of experiment, 5 plants were randomly selected from each accession in each plot and tagged for recording the observations on the following traits viz., plant height, plant seed weight, number of seed umblet^{-1}, umblet plant^{-1}, total plant weight, number of umbel^{-1}, umblet umbel $^{-1}$, number of main branch, 1000-seed weight (g), seed yield (g m^{-2}), bio yield (g m^{-2}), essential oil (%), yield of essential oil (g m^{-2}) and harvest index

Standard statistical procedure were used for the analysis of variance, genotypic and phenotypic coefficients of variation (Burton, 1952), heritability (Hanson *et al*., 1956) and genetic advance (Johnson *et al*., 1955). The computer software system of SAS (Institute, 2002) was used for analysis of data.

RESULTS AND DISCUSSION

The analysis of variance (Table 1) showed significant differences for all the characters studied except number of umbels and thereby provides an opportunity for selecting suitable genotypes with better performance for the traits. This further indicated that the genotypes selected in the present study were exhibiting considerable variation for almost all the traits. Similar results were also reported by Dar *et al*. (2011) and Devi (2004) who also reported high amount of variability between the collections. Improvement through breeding programme in any crop is dependent on the availability of information on genetic variability. The observed variability in crop plants is normally due to the variation in qualitative and quantitative heritability fractions influenced considerably by prevailing environmental condition. It is, therefore, desirable to study the nature of exhibited variability and to exploit same in the crop improvement programmes.

Variability in the population, especially in respect to the characters for which improvement is sought, is a prerequisite for successful selection. The estimates of phenotypic coefficient of variation (PCV) in general, were higher than the estimates of genotypic coefficient of variation (GCV) for all the characters (Table 2), indicating that all the characters had interacted with the environment. This suggested that apparent variation in all these characters is not only due to genotype but also due to the influence of environment and selection for such traits may not be reliable. These results are in close agreement with the earlier reports of Dar *et al*., (2011) and Azimzadeh *et al*., (2012). The estimates of genotypic coefficient of variation ranged from 0.07 - 1.98. The value was highest for yield of essential oil (g m^{-2}) (1.98) which was closely followed by harvest index (1.88), bio yield (g m^{-2}) (1.80) and seed yield (g m^{-2}) (1.54). This is indicative of less amenability of these traits to environmental fluctuations and hence, greater emphasis should be given to these characters, while breeding cultivars from the present material. The lowest genotypic coefficient of variance was recorded in number of main branch (0.07) followed by plant height (0.11), 1000-seed weight (g) (0.32), umblet $umbel^{-1}$ (0.51) and essential oil (%) (0.57). the low GCV suggests that the breeders should go for source of high variability for improvement in these traits. For rest of the characters the genotypic coefficient of variation (GCV) was found moderate.

Table 1. Analysis of variance for 14 characters in Black Caraway

Source of variation	df	Plant height	Plant seed weight	Number of seed umblet^{-1}	Umblet plant^{-1}	Total Plant weight	Number of umbel
Replications	2	5.635	2.542	48930.15	10.093	145.797	12.963
Treatments	12	166.789*	34.175**	556040.497**	28.936^{ns}	264.255**	187.564^{ns}
Error	24	68.81	2.170	77045.405	31.667	56.201	132.582
Total	38	97.059	12.269	226827.263	29.669	126.618	143.649

Umblet umbel $^{-1}$	No. main branch	1000-seed weight (g)	Seed yield (g m^{-2})	Bio yield (g m^{-2})	Essential oil (%)	Yield of essential oil (g m^{-2})	Harvest index
10.093	0.012	0.385	27.495	23.592	34.105	0.633	0.006
28.935 ^{ns}	0.0159*	0.538**	160.411**	133.344**	3.71*	0.261*	0.017**
31.667	0.006	0.005	10.832	14.12	1.501	0.104	0.002
29.669	0.0096	0.194	58.945	52.268	3.915	0.181	0.007

Dar *et al*. (2011) also noticed the moderate genotypic coefficient of variation for such traits and suggested that these traits can be improved by the vigorous selection. The estimates of phenotypic coefficient of variation (PCV) also followed the similar trend. The magnitude of PCV ranged from 0.08 for number of main branch to 2.09 for yield of essential oil. The characters with high phenotypic coefficient of variation indicated more influence of environmental factors. Therefore, caution has to be exercised during the selection program because the environmental variations are unpredictable in nature and may mislead the results. In the earlier studies also, Devi (2004), Majeed and Sharma (2006), Dar *et al*., (2011) and Azimzadeh *et al*., (2012) observed high genotypic and phenotypic coefficient of variation for the above studied traits.

The coefficient of variability does not give any idea regarding the heritable portion of the variability; it can be ascertained by working out the heritability estimates. Heritability in narrow sense is the ratio of additive genotypic variance to the total variance and in broad sense it is the ratio of genotypic variance to the phenotypic variance (Lush, 1949). In the present study heritability in broad sense is estimated. Encouraging results were obtained with respect to the heritability of the characters studied except for plant height. It could be observed from Table 2 that heritability estimates ranged from 0.61 to 0.98. The heritability estimates was highest for plant seed weight, seed yield (g m^{-2}), bio yield (g m^{-2}) (0.98 each) which was closely followed by number of seed $umblet^{-1}$ (0.96), harvest index (0.95), total plant weight (0.94) and number of main branch and 1000-seed weight (g) (0.91 each) which suggested that the characters are least influenced by the environmental factors and also indicates the dependency of phenotypic expression which reflects the genotypic ability of cultivars to transmit the genes to their off-springs. High heritability estimates for various characters have also been reported by Puschmann *et al*. (1992), Pank and Quilitzsch (1996) in caraway (*Carum carvi*), Kapila *et al*. (1997), Dar *et al*., (2011) and Azimzadeh *et al*., (2012) in Black Caraway (*Bunium persicum*). The lowest value of heritability was recorded for plant height (0.61) which indicates the character is highly influenced by environmental effects and genetic improvement through selection will be difficult. For rest of the characters, the estimates of heritability were found moderate. Characters with moderate heritability indicated that they are not dependable as their genotypic expression is superimposed by the environmental influences (Allard, 1960). Thus the degree of success through selection depends also upon magnitude of heritability values. Furthermore selection is also directly proportional to the amount of genetic advance.

Through the heritability estimates indicate the efficiency of selection system. Yet their scope is restricted as they are prone to change with environment, material used, etc. hence, more reliable information can be had from heritability estimates coupled with genetic advance rather than heritability alone in framing the selection procedure (Johnson *et al*., 1955). The genetic advance expressed as percentage of mean ranged from as low as 2.30 for number of main branches to as high as 4990.91 for number of seed $umblet^{-1}$.

Table 2. Estimate of mean, components of variance, heritability (bs) and expected genetic advance in respect of 14 characters in black caraway

Trait	Range	Mean	Coefficient of variation		Heritability (bs) %	Genetic advance	Genetic advance as %age of Mean
			GCV	PCV			
Plant height	45.33-68.35	53.85	0.11	0.14	0.61	69.98	129.95
Plant seed weight	1.14-13.92	4.67	1.29	1.30	0.98	74.91	1604.10
Number of seed umblet^{-1}	1.70-43.87	20.99	1.07	1.10	0.96	1047.69	4990.91
Umblet plant^{-1}	10.86-21.38	14.94	1.18	1.26	0.88	640.41	4286.56
Total Plant weight	5.14-34.33	16.54	1.09	1.13	0.94	674.60	4078.60
Number of umbels	10.94-37.08	22.05	0.81	0.87	0.88	659.73	2991.96
Umblet umbel^{-1}	10.86-21.38	14.94	0.51	0.56	0.86	121.43	812.59
No. main branch	2.00-2.20	2.04	0.07	0.08	0.91	0.05	2.30
1000-seed weight(g)	1.55-2.67	2.17	0.32	0.33	0.91	0.96	44.19
Seed yield (g m^{-2})	1.39-27.11	5.72	1.54	1.56	0.98	159.83	2793.68
Bio yield (g m^{-2})	3.10-32.97	7.31	1.80	1.82	0.98	355.35	4859.88
Essential oil (%)	3.50-6.67	4.90	0.57	0.61	0.85	15.89	324.51
Yield of essential oil (g m^{-2})	0.06-1.04	0.32	1.98	2.09	0.89	0.84	258.86
Harvest index	0.23-0.45	0.07	1.88	1.92	0.95	0.04	51.81

Table 3. Comparison of different traits measured in 13 selected genotypes *Bunium persicum* L. using Duncan's multiple range tests at 5% level.

S.No	Genotypes	Plant height	Plant seed weight	Number of seed umblet^{-1}	Umblet plant^{-1}	Total Plant weight	Number of umbel
1	Alamut-Qazvin	62.75^{b}	1.15^{h}	11.87^{d}	12.13^{de}	20.50^{d}	10.94^{h}
2	BroonFerdows	45.33^{e}	1.70^{gh}	12.56^{d}	15.66^{b}	5.14^{g}	13.07^{gh}
3	BiganShirvan	63.64^{b}	1.81^{g}	9.88^{fg}	15b^{c}	9.34^{f}	14.4^{gh}
4	Khajeh Forest	47.0d^{e}	2.55^{f}	32.97^{a}	10.86^{e}	34.33^{a}	16.58^{fg}
5	Chelmir	68.35^{a}	2.56^{f}	17.83^{b}	14.89^{bc}	15.60^{e}	18.75^{ef}
6	Ferezi	54.73^{c}	3.34^{e}	8.76^{gh}	12.98^{cde}	24.6^{c}	19.38^{ef}
7	KhairabadKhaf	48.59^{de}	3.70^{e}	10.48^{ef}	14.78 ^{bc}	14.49^{e}	20.59^{def}
8	Rafsanjan	55.0^{c}	5.50^{d}	13.96^{c}	21^{a}	8^{fg}	22.64^{de}
9	Black Mountain, Arak	47.67^{de}	5.62^{d}	11.43^{de}	13.64^{bcd}	30.80^{b}	23.71^{cd}
10	Shah Roud	54.3^{c}	5.65^{d}	3.1^{j}	13.31^{cd}	9.59^{f}	27.21^{bc}
11	Kerman	49.67^{d}	6.18^{c}	4.94^{i}	21.38^{a}	6^{g}	28.3^{b}
12	GNU mountain	45.8^{e}	6.93^{b}	7.87^{h}	13cd^{e}	22.26^{cd}	33.3^{a}
13	Mashhad	57.27^{c}	13.93^{a}	11.53^{de}	15.64^{b}	14.37^{e}	37.08^{a}

Umblet umbel $^{-1}$	No. main branch	1000-seed weight (g)	Seed yield (g m^{-2})	Bio yield (g m^{-2})	Essential oil (%)	Yield of essential oil (g m^{-2})	Harvest index
12.13de	2.0^{c}	1.74^{i}	5.17^{c}	11.87^{cde}	5.61^{b}	0.28^{d}	0.436^{a}
15.66b	2.0^{c}	2.23^{e}	5.55^{c}	12.55^{cd}	6.67^{a}	0.4^{c}	0.442^{a}
15bc	2.0^{c}	1.755^{i}	2.74^{def}	9.88^{def}	4.58^{d}	0.12^{f}	0.299^{d}
10.86e	2.0^{c}	2.23^{e}	27.11^{a}	32.97^{a}	3.54^{f}	1.04^{a}	0.431^{a}
14.89bc	2.0^{c}	1.91^{h}	7.69^{b}	17.83^{b}	4.58^{d}	0.83^{b}	0.431^{a}
12.98cde	2.2^{a}	2.51^{b}	3.82^{d}	8.76^{ef}	3.82^{ef}	0.42^{c}	0.436^{a}
14.78bc	2.0^{c}	2.31^{d}	3.02^{de}	10.48^{def}	6.25^{a}	0.18^{def}	0.300^{d}
21.0a	2.0^{c}	2.41^{c}	6.16^{c}	13.96^{c}	3.86^{ef}	0.25^{de}	0.441^{a}
13.64bcd	2.1^{b}	2.17^{f}	2.66^{def}	11.43^{cde}	6.42^{a}	0.17^{def}	0.232^{e}
13.31cd	2.2^{a}	2.06^{g}	1.38^{f}	3.1^{h}	4.25^{de}	0.063^{f}	0.446^{a}
21.38a	2.0^{c}	2.49^{b}	2.09^{ef}	4.94^{gh}	5.13^{c}	0.109^{f}	0.427^{a}
13cde	2.0^{c}	2.67^{a}	3.17^{de}	7.87^{fg}	5.40^{bc}	0.189^{def}	0.408^{b}
15.63b	2.0^{c}	1.55^{j}	3.80^{d}	11.53^{cde}	3.5^{f}	0.13^{ef}	0.327^{c}

In general, the expected genetic advance as per cent of mean for majority of traits was high, which indicates that traits are governed by additive genes and selection will be rewarding for improvement of each trait. High heritability coupled with high genetic advance was observed for number of seed umblet^{-1}, umblet plant^{-1}, and total plant weight, number of umbel^{-1} and bio yield (g m^{-2}) and thereby showing additive gene effect. Characters showing high heritability with high genetic advance may be due to additive gene action (Panse, 1957) and thus, could be improved upon by adapting selection without progeny testing. High heritability accompanied with low genetic advance were recorded for essential oil (%), yield of essential oil (g m^{-2}) and harvest index which indicates the presence of non-additive type of gene action. Panse (1957) reported that high heritability correlated with low genetic advance indicates non- additive gene effects. The high heritability is being exhibited due to favourable influence of environment rather than genotype and selection for such traits may not be rewarding. For rest of the characters the heritability accompanied with genetic advance were found moderate. The above results are in similarity with the findings of Majeed and Sharma (2006), Dar *et al*., (2011) and Azimzadeh *et al*., (2012).

The comparison of various morphological traits using Duncan's multiple range tests revealed significant variation among the 13 ecotypes *of Bunium persicum* (Table 3). The genotype Chelmir was the tallest plant (68.35 cm) and was significantly superior to other genotypes, while the genotypes Geno mountain was significantly inferior with regard to the plant height. Mashhad recorded significantly highest plant seed weight, while the lowest seed weight was recorded in Alamut Qazvin. The genotype Khajeh forest was significantly superior with regard to number of seed umblet^{-1} (32.97), seed yield (27.11 g m^{-2}), bio yield (32.97 g m^{-2}) and yield of essential oil (1.04 g m^{-2}), however, the same genotype recorded significantly lowest percentage of essential oil. Brown Ferdows being at par with Arak and Khairabad Khaf recorded significantly higher percentage of essential oil. Similarly, Ferezi and Shah Roud recorded significantly highest number of main branches per plant among the 13 genotypes. The genotypes Geno Mountain and Mashhad exhibited significantly highest and lowest 1000-seed weight, respectively. Based on the Duncan's multiple range test potential donors for growth, yield and yield attributes of *Bunium persicum* were calculated (Table 4). The data revealed that the genotypes viz., Brown Ferdows, Khajeh forest, Chelmir and Chenaran-Ferezi were found potential donors for seed yield and yield of essential oil, Brown Ferdows, Khari Abad Khaf and Arak for essential oil per cent, Brown Ferdows, Rafsanjan and Kerman for number of umbels and umblet umbel^{-1}. In general the genotypes Khajeh forest and Chelmir were found potential donors for almost all the traits.

Table 4. Potential donor accessions for yield and other recorded traits

S. No.	Characters	Accessions Potential Donors
1	Plant height	5, 3, 1
2	Plant seed weight	4, 5, 3, 1
3	Number of seed umblet^{-1}	4, 5, 8, 2
4	Umblet plant^{-1}	3, 1, 4
5	Total Plant weight	4, 5, 8
6	Number of umbels	11, 8, 2, 13
7	Umblet umbel $^{-1}$	11, 8, 2, 13
8	No.Main branch	6, 10, 9
9	1000-seed weight(g)	12, 6, 11, 8
10	Seed yield (g m^{-2})	4, 5, 8, 2, 1
11	Bio yield (g m^{-2})	4, 5, 8
12	Essential oil (%)	2, 9, 7
13	Yield of essential oil (g m^{-2})	4, 5, 6, 2
14	Harvest index	10, 2, 8, 6, 1, 5, 4, 11

where, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 and 13 are Alamut-Qazvin, Brown Ferdows, Biganshirvan, Khajeh forest, Chelmir, Chenaran-Ferezi, Khaf, Rafsanjan, Arak, Shahrud, Kerman, Geno mountain and Mashhad, respectively.

CONCLUSIONS

High heritability accompanied by high genetic advance was observed for number of seed umblet^{-1}, umblet plant^{-1}, total plant weight, number of umbel^{-1} and bio yield. Therefore, it is concluded that these traits had to be accounted for direct selection for the improvement of yield. From this point, the genotype Khajeh forest was significantly superior with regard to number of seed umblet^{-1}, seed yield, bio yield and as well for the yield of essential oil.

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