

Fenugreek (*Trigonella foenum-graecum* L.) Germplasm Collection in Oman

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Abstract – Fenugreek (*Trigonella foenum-graecum* L.) is a legume crop grown for medicinal and traditional consumption, not only in Oman but also in the neighboring gulf and other countries. This paper highlights the outputs of collecting missions of fenugreek germplasm and seed variation found in collected accessions. The mission led to the collection of 49 seed samples/accessions, from 43 sites, with the most from Batinah South governorate (14) represented mostly by Rustaq, followed by Interior/Al-Dakhliyah (13), Eastern/ Al-Sharqiyah (12) and Dhahira & Buraimi (10) governorates. The seed accessions were diverse with respect to all seed characters studied, i.e. seed length (cm) and width (cm) and 1000-seed weight (g) besides seed color. Critical analysis of seed colors of these samples indicated the presence of 16 groups of which the largest group of 10 seed accessions had green, yellowish green and light brown seeds. Collection Nos. 2, 24, 52, 155, 160, 175 and 212 formed groups of their own due to the unique combination of seed colors.

Keywords – Landraces, Accession, Seed Characters, Diversity, Fenugreek

I. INTRODUCTION

The Sultanate of Oman is the second largest country in the Arabian Peninsula with 85473.10 ha of agricultural land under cultivation [1]. Fruits occupy 36.11% followed by perennial and annual fodder crops (39.40%), vegetables (19.72%) and field crops (4.77%). Of the field crop area, fenugreek (*Trigonella foenum-graecum* L.) although grown in an insignificant area, forms an essential crop among only the few farmers who are aware of its medicinal importance [2]. Fenugreek is grown in plains and mountainous areas of North Oman as winter crop between November and April. Its exact area, productivity and yield figures are not documented. In Oman, Fenugreek is used in many ways; however, it is widely applied in local medicine. Fenugreek seeds are ground and roasted and used to flavor to curry. Ground seeds are often used to give a maple flavor to domestic preparations. Ground seeds are also used to flavor cattle food, including different vegetable meals and hays. Fenugreek's leaves, which are high in iron, are used in salads. In its medicinal use, taken internally, fenugreek is used to treat bronchitis, coughs, respiratory problems, sinus conditions and to increase milk supply in both humans and animals.

Due to varied ecological conditions, a range of fenugreek ecotypes are grown in Oman for their medicinal and food value, and affinity. However, due to changing land use patterns and the gradual introduction of high-yielding crops of commercial value, the local indigenous germplasm of various crop species, including fenugreek is slowly disappearing. In the past 30 years, several missions have been conducted to collect germplasm of crops grown in Oman. First collections were undertaken jointly with the International Bureau of Plant Genetic Resources in 1980, 1987 and 1988 [3]. Since 1996, several missions have been carried out by the Ministry of Agriculture & Fisheries in collaboration with regional and international organizations [4, 5, 6, 7] and by the Sultan Qaboos University and the Royal Gardens. During these missions, alfalfa, wheat, cucumber and grain legume landraces were collected and placed in local conservation facilities. A series of joint collection missions between the Sultan Qaboos University and the Ministry of Agriculture & Fisheries were undertaken from different sites within different governorates of Oman [8] from April 2008 to October 2009 to explore the genetic diversity of vast indigenous germplasm available in legume crops of Oman. This paper reports the results of fenugreek (*Trigonella foenum-graecum*) germplasm collection besides the diversity in respect of few seed traits.

II. MATERIALS AND METHODS

Materials and methods adopted for collecting the germplasm and conservation were described in 2014 by Al-Saady *et al.* [8]. Indigenous fenugreek accessions were collected from 43 sites (Table 1 and Fig. 1). Seed characters such as seed length and width (cm), test weight (1000 seed), seed color and nature of seed samples (pure or mixture) were determined in the laboratory according to Altuntas *et al.* [9] and McCormick *et al.* [10].

Table 1. Governorates, wilayats and villages along with latitude (N), longitude (E), Northing, Easting and altitude of each site from where indigenous fenugreek accessions were collected

No.	Site No	Governorate	Wilayat	Village/location	Latitude (N)	Longitude (E)	Easting	Northing:	Altitude (meters above msl)
1	1	Interior	Nizwa	Tanouf	23° 02.00'	57° 43.45'	574200	2547427	604
2	6	Interior	Manah	Hujrat albelad	22° 48.89'	57° 35.53'	560772	2523177	544
3	7	Interior	Manah	Manah Al Blaad	22° 47.88'	57° 35.98'	561549	2521316	430
4	9	Interior	Nizwa	Jabel Akhdar	23° 04.07'	57° 39.29'	567079	2551213	1829
5	11	Interior	Adam	Al Belad	22° 22.65'	57° 31.70'	554392	2474739	308
6	13	Interior	Bahla	AL-khtwah	22° 59.32'	57° 17.91'	530595	2542330	363
7	15	Interior	Bahla	Tawee A Nuseif	22° 57.66'	57° 12.63'	521579	2539251	583
8	18	Interior	Al Hamra	Al Qlaah	23° 05.28'	57° 17.40'	529702	2553324	647
*9	19	Interior	Al Hamra	Al A'Aradh	-	-	-	-	-
10	20	Interior	Al Hamra	Ghamour	23° 05.02'	57° 16.45'	528081	2552841	663
11	23	Batinah South	Rustaq	Haat	23° 11.34'	57° 24.52'	541824	2564535	1978
12	24	Batinah South	Rustaq	Balad Sait	23° 11.16'	57° 23.51'	540102	2564198	1983
13	26	Dhahira	Ibri	Bilad Al-Shahoom	23° 23.94'	56° 57.91'	496441	2587725	793
14	29	Dhahira	Ibri	Bat	23° 15.22'	56° 45.23'	474819	2571656	508
15	30	Dhahira	Ibri	Alablaah	23° 04.84'	56° 54.14'	489997	2552486	580
16	32	Interior	Bahla	Sint	23° 07.96'	57° 04.64'	507918	2558242	952
17	33	Dhahira	Dank	Aqaib-Kumairah	23° 56.15'	56° 16.87'	426846	2647344	860
18	37	Dhahira	Yanqul	Al-Bouwerdah	23° 38.06'	56° 29.76'	448591	2613868	586
19	38	Dhahira	Yanqul	Al-Bouwerdah	23° 41.89'	56° 30.33'	449585	2620932	623
*20	42	Batinah South	Rustaq	Amq	-	-	-	-	-
21	44	Batinah South	Rustaq	Al-Ayeer	23° 12.79'	57° 27.56'	547001	2567226	723
22	52	Batinah South	Rusaq	Almari	23° 27.89'	57° 02.19'	503728	2595013	678
23	53	Batinah South	Rustaq	Dhabaa	23° 26.99'	57° 06.82'	511610	2593356	632
24	55	Batinah South	Rusaq	AL Dahir					-
25	58	Batinah South	Rustaq	Almahdooth	23° 30.57'	57° 11.36'	519330	2599970	476
26	70	Batinah South	Rustaq	Alkhoof	23° 08.29'	57° 08.29'	514146	2558855	579
*27	72	Batinah South	Rustaq	Mori wadi bani Ghafer	-	-	-	-	-
28	73	Interior	Bid'bid	Al-Buwareed	23° 31.55'	57° 16.15'	527478	2601791	230
29	89	Buraimi	Buraimi	AL-Hail	24° 12.31'	56° 13.94'	422039	2677191	501
*30	90	Buraimi	Buraimi	AL-Raabi	-	-	-	-	-
*31	92	Buraimi	Madhah	Al Khabeen	-	-	-	-	-
32	96	Sharqiya	AL-Qabel	Bateen	22° 45.42'	58° 41.40'	673527	2517643	442
33	97	Sharqiya	AL-Qabel	Bateen	22° 39.25'	58° 41.13'	673194	2506251	625
34	99	Sharqiya	AL-Qabel	AL-Dubaha	22° 35.89'	58° 10.97'	621586	2499553	857
35	100	Sharqiya	Wadi Bani Khalid	AL-Raaki	22° 36.13'	59° 04.48'	713275	2500998	500
36	103	Sharqiya	Ibra	AL-Hiamah	22° 48.58'	58° 26.70'	648310	2523208	565
37	106	Sharqiya	Ibra	AL-Khoodood	22° 52.02'	58° 25.93'	646931	2529544	617
38	109	Sharqiya	Mudhaibi	AL-Rawadah	22° 53.05'	58° 13.25'	625231	2531249	576
39	110	Sharqiya	Mudhaibi	wadi endam	22° 52.71'	58° 00.31'	603111	2530455	434
40	115	Sharqiya	Wadi Atayeen	Asubal	23° 06.87'	58° 32.09'	657179	2557055	1089
41	118	Sharqiya	Wadi Atayeen	Maqtaa	22° 49.33'	58° 59.33'	704122	2525241	529
42	124	Sharqiya	Wadi bani Khalid	Halfah	22° 33.61'	59° 06.47'	717437	2496404	467
43	128	Batinah North	Sohar	Wadi Aheer	23° 59.35'	56° 28.93'	447324	2653159	604

* The team could not visit these sites as the seed samples were supplied at Agriculture Development Centers of respective Wilayats (districts).

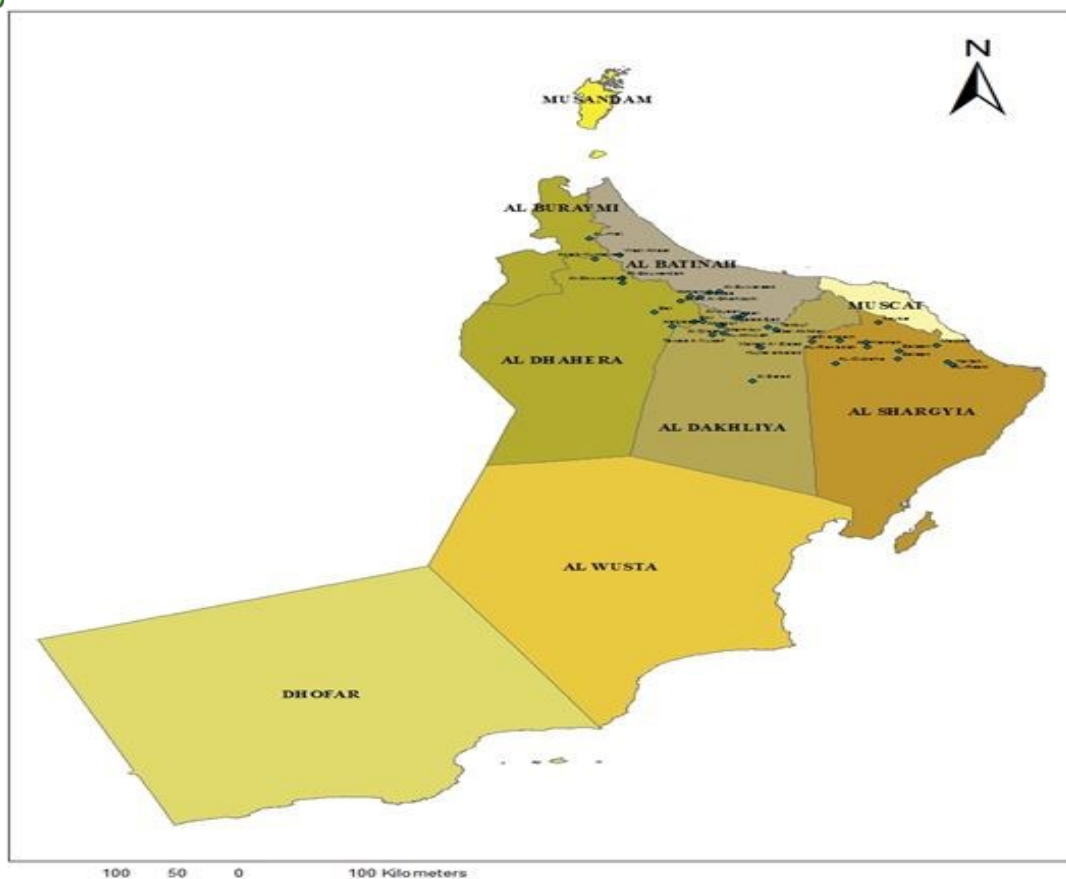


Fig. 1. Locations of collecting sites of indigenous fenugreek germplasm

III. RESULTS

49 seed samples/accessions were collected, with the most from Batinah South (14) represented mostly by Rustaq, followed by Interior (13), Sharqiya (12) and Dhahira & Buraimi (10) (Fig. 2).

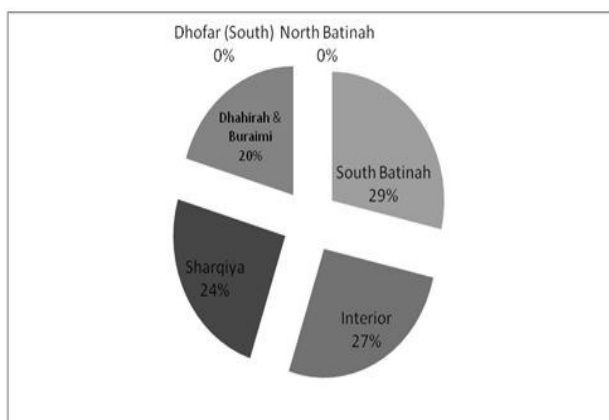


Fig. 2. Numbers of indigenous accessions of fenugreek collected from different governorates of Oman between April 2008 and October 2009

Seed accessions were diverse with respect to all the seed characters studied, i.e. seed length (cm) and width (cm), 1000-seed weight (g) and seed color (Table 2). Seed length varied from 0.305 cm (Collection No. 71 of Al-

Balad Sait, Rustaq, Interior) to 0.420 cm (Collection No. 209 of Al-Mori, Wadi Bani Gafer) with 0.364 as its mean; seed width ranged from 0.245 cm (Collection No. 260 of Al-Hiamah, Ibra, Sharqiya) to 0.385 cm (Collection No. 02 of Al-Ghubrah Tanuf, Nizwa, Interior) with 0.304 as its mean and 1000-seed weight ranged from 8.900 g (Collection No. 49 of Al-Qilah, Al-Hama, Interior) to 19.7 g (Collection No. 212 of Al-Rujh, Bidbid, Interior) with 13.5 as its mean value. In respect of seed color, only one accession—Collection No. 160 of Al-Dahir village of Rustaq, Batinah South—was homogenous (pure) with light green to light brown seeds; the remaining 48 accessions were heterogeneous (mixture) with seeds of various colors. Critical analysis of seed colors indicated the presence of 16 groups of which the largest group of 10 seed accessions had green, yellowish green and light brown seeds, a group of 8 seed accessions had light green, dark green, yellowish green, light brown and dark brown seeds, a group of 6 accessions had light and dark brown seeds and a group of 5 accessions had green, light brown and dark brown seeds. There were three groups of 3 accessions each which had (1) green, tan, yellowish brown and dark brown seeds, (2) green, tan, light brown and dark brown seeds and (3) light brown, dark brown and green seeds. There were two groups of 2 accessions each which had (1). Brown and dark brown seeds and (2) green, yellowish green, light brown and dark brown seeds. There were seven accessions—Collections Nos. 2, 24, 52, 155, 160, 175 and 212, 0 that formed groups of their own due to a unique combination of seed colors (Table 2).

Table 2. Variation among seed characteristics of 49 indigenous fenugreek accessions collected

Sl. No.	Collection No.	Length (cm)	Width (cm)	1000 seed weight (g)	Seed Nature	Color	Governorate
1	2	0.405	0.385	13.3	Heterogeneous	Tan, yellowish green, brown, dark brown	Interior
2	3	0.390	0.270	13.4	Heterogeneous	Green, tan, yellowish brown, dark brown	Interior
3	13	0.400	0.275	16.3	Heterogeneous	Light brown, dark brown	Interior
4	17	0.375	0.275	11.1	Heterogeneous	Brown, dark brown	Interior
5	24	0.365	0.34	19.7	Heterogeneous	Light green, green, yellowish brown	Interior
6	31	0.375	0.255	13.5	Heterogeneous	Light green, dark green, yellowish brown, light brown, dark brown	Interior
7	35	0.390	0.270	11.1	Heterogeneous	Light green, dark green, yellowish brown, light brown, dark brown	Interior
8	43	0.415	0.385	17.9	Heterogeneous	Light green, dark green, yellowish brown, light brown, dark brown	Interior
9	49	0.380	0.275	8.9	Heterogeneous	Green, light brown, dark brown	Interior
10	52	0.345	0.29	10.5	Heterogeneous	Green, yellowish green, light brown	Interior
11	54	0.350	0.330	13.9	Heterogeneous	Light green, dark green, yellowish brown, light brown, dark brown	Interior
12	63	0.395	0.305	10.8	Heterogeneous	Green, light brown, dark brown	Batinah South
13	71	0.305	0.285	12.1	Heterogeneous	Green, yellowish green, light brown	Batinah South
14	77	0.345	0.315	17	Heterogeneous	Green, yellowish green, light brown	Dhahira
15	89	0.375	0.335	10.1	Heterogeneous	Green, yellowish green, light brown	Dhahira
16	94	0.350	0.330	12.6	Heterogeneous	Green, yellowish green, light brown	Dhahira
17	97	0.375	0.350	14.5	Heterogeneous	Green, tan, light brown, dark brown	Dhahira
18	101	0.355	0.330	10.3	Heterogeneous	Light green, dark green, yellowish brown, light brown, dark brown	Interior
19	104	0.350	0.325	10.2	Heterogeneous	Green, tan, yellowish brown, dark brown	Dhahira
20	119	0.365	0.340	14.1	Heterogeneous	Green, yellowish green, light brown	Dhahira
21	122	0.375	0.285	14.1	Heterogeneous	Green, yellowish green, light brown, dark brown	Dhahira
22	132	0.355	0.335	10.6	Heterogeneous	Light brown, dark brown	Batinah South
23	135	0.350	0.290	14.4	Heterogeneous	Green, yellowish green, light brown	Batinah South
24	153	0.345	0.270	14.2	Heterogeneous	Green, yellowish green, light brown	Batinah South
25	155	0.350	0.325	17.1	Heterogeneous	Yellowish green, light brown	Batinah South
26	160	0.325	0.270	14.3	Homogeneous	Light green to light brown	Batinah South
27	166	0.360	0.335	13.5	Heterogeneous	Green, yellowish green, light brown	Batinah South
28	175	0.365	0.340	14.6	Heterogeneous	Yellowish brown, dark brown	Batinah South
29	182	0.355	0.335	15.4	Heterogeneous	Green, yellowish green, light brown	Batinah South
30	203	0.345	0.310	19.1	Heterogeneous	Green, tan, light brown, dark brown	Batinah South
31	204	0.360	0.335	13.8	Heterogeneous	Green, tan, yellowish brown, dark brown	Batinah South
32	209	0.420	0.345	14.2	Heterogeneous	Light brown, dark brown	Batinah South
33	212	0.380	0.250	19.7	Heterogeneous	Light brown, green	Interior
34	235	0.370	0.295	12.8	Heterogeneous	Light brown, dark brown, green	Dhahira (Buraimi)
35	237	0.345	0.315	14.1	Heterogeneous	Light green, dark green, yellowish brown, light brown, dark brown	Dhahira (Buraimi)
36	240	0.345	0.310	14.4	Heterogeneous	Light green, dark green, yellowish brown, light brown, dark brown	Dhahira (Buraimi)
37	246	0.360	0.290	11.3	Heterogeneous	Green, light brown, dark brown	Sharqiya
38	250	0.350	0.250	12.1	Heterogeneous	Brown, dark brown	Sharqiya
39	254	0.350	0.255	13.4	Heterogeneous	Light brown, dark brown	Sharqiya

Sl. No.	Collection No.	Length (cm)	Width (cm)	1000 seed weight (g)	Seed Nature	Color	Governorate
40	256	0.36	0.295	14.3	Heterogeneous	Green, light brown, dark brown	Sharqiya
41	260	0.360	0.245	10.3	Heterogeneous	Light brown, dark brown	Sharqiya
42	265	0.380	0.280	10.6	Heterogeneous	Light green, dark green, yellowish brown, light brown, dark brown	Sharqiya
43	272	0.355	0.330	18	Heterogeneous	Green, tan, light brown, dark brown	Sharqiya
44	274	0.345	0.250	10.8	Heterogeneous	Green, light brown, dark brown	Sharqiya
45	286	0.370	0.345	13.4	Heterogeneous	Green, yellowish green, light brown, dark brown	Sharqiya
46	294	0.365	0.285	13.6	Heterogeneous	Light brown, dark brown	Sharqiya
47	296	0.355	0.275	10.6	Heterogeneous	Light brown, dark brown, green	Sharqiya
48	304	0.355	0.340	13.4	Heterogeneous	Green, yellowish green, light brown	Sharqiya
49	312	0.385	0.270	12.9	Heterogeneous	Light brown, dark brown, green	Batinah South
Statistical Parameters							
Minimum	0.305	0.245	8.9				
Maximum	0.420	0.385	19.7				
Mean	0.364	0.304	13.5				
S.E.(±)	0.305	0.245	8.9				

Variation in Collection Sites

Collection sites varied in their characteristics and altitude. Altitude ranged from 12 m at site No.133 of Al-Muntafa, Wilayat Saham of Batinah North to 1983 m at site No. 24 of Balad Sait, wilayat Rustaq of Batinah South. Soil characteristics also varied. Sites ranged in soil texture viz. sands, sandy loam, sandy clay, sandy clay loam, clay and loam. Soils were hard, firm or loose, variable-loose to crust and friable. With respect to drainage, soils were imperfect, free or variable. Soil pH ranged from 2.1 (Site No.58, Al-Mahdooth Hajer Bani Omer, Rustaq, Batinah South) and Site No.65, Al-Qoora, Nakhal, Batinah South) to 9.9 (Site No. 87, Al-Hafeet, Buraimi). Soil EC varied from 0.02 (Site No.42, Al-Amq, Rustaq, Batinah South) to 22.7 dSm⁻¹ (Site No. 51, Al-Ghasab, Rustaq, Batinah South). Soil color ranged from light brown to dark brown).

IV. DISCUSSION

A range of fenugreek germplasm was collected during the current mission through the seven governorates of the Sultanate. South Batinah represented the most collections (28.57%), followed by Interior (26.53%), Sharqiya (24.49%) and Dhahirah & Buraimi (20.41%). Interestingly, North Batinah and Dhofar (South) had no contribution to collections during this collection mission (Figs.1 and 2). This is attributed to edaphic factors and climate change.

Critical examination of fenugreek seed samples at the laboratory revealed wide variation in seed coat patterns (color) and seed weights. Villages located in the vicinity of collecting sites had different seed samples. With seed accessions changing from village to village it is possible that uncollected landraces still exist in areas not visited. Seed accessions with heterogeneous seeds with respect to seed color need intensive purification into sub-groups.

The widespread shift of landraces of fenugreek between wilayats and neighboring governorates indicates that these landraces/accessions are the outcome of centuries of

selection for adaptation to local climatic, edaphic and cultural selection forces and hold unique gene complexes which reflect local agro-climatic variation and evolution [11, 12]. Such landraces might have been more prevalent for more than 40 years; according to one farmer/herder, who practices local medicine, his fenugreek sample was the product of continued harvesting of seed from his forefathers for more than 35 years. Constant availability of local cultivars with farmers may be an important local conservation strategy for sustainable production. This collecting mission has clearly shown the pattern of adaptation of Omani landraces based on relatively small samples available from farmers and has illustrated the importance of socio-economic context in relation to germplasm collection [13].

Genetic erosion of landraces of fenugreek was observed in both North Batinah and Dhofar Governorates as there were no collections (Figs. 1 and 2). This is attributed to factors associated with displacement of landraces by modern high-yielding crops, changes in land use pattern, erratic drought, and population movement and resettlements, as well as the lack of interest among current farmers to grow non-commercial crops like fenugreek as it has only medicinal value.

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REFERENCES

- [1] MAF. (2017). Annual Agriculture Statistics-2017. Director General of planning and Investment Promotions. Department of Statistics and Information. Ministry of Agriculture & Fisheries. Oman.
- [2] MAF. (2005). Agriculture Census-2004-2005. Ministry of Agriculture & Fisheries. Sultanate of Oman.
- [3] Guarino, L. (1990). Crop collecting in the Sultanate of Oman in the context of Arabian Peninsula. *FAO/ IBPGR. PGR Newsl.* 77: 27-33.
- [4] Ferguson, M. (1999). Report on collection of rangeland plant germplasm in the Sultanate of Oman in March-April, 1998. Presented in the ICARDA-APRP Meeting held at Muscat. June 1999.
- [5] Osman, A., Nadaf, S.K., Al-Farsi, S.M., and Al-Hinai, S.A. (2002). Forage and range germplasm collection in Dhofar, Oman. Arabian Peninsula Research Program (APRP). Presented in ICARDA-APRP Annual Meeting held in Yemen. 28 September -2 October 2002. Annual Report 2001/2002. pp. 103-106.
- [6] Jaradat, A.A., Shahid, M., and Al-Maskri, A. (2004 a). Genetic diversity in Batini barley land race from Oman I. Spike and seed quantitative and qualitative traits. *Crop Sci* 44: 304-315.
- [7] Jaradat, A.A., Shahid, M., and Al-Maskri, A. (2004 b). Genetic diversity in Batini barley land race from Oman I. Response to salinity stress. *Crop Sci.* 44: 997-1007.
- [8] Al-Saady, N.A., Nadaf, S.K., Al-Hinai, S.A., Al-Subhi, A.S., Al-Farsi, S.M., Al-Habsi, K.M., Esechie, H.A., and Siddique, K.H.M. (2014). Multicrop Legume Germplasm Collection in Oman. *International Journal of Agriculture & Biology.* 16: 231-241.
- [9] Altuntas, E., Ozgoz, E., and Taser, O.F. (2005). Some physical properties of fenugreek (*Trigonella foenum-graecum* L.) seeds. *J Food Eng.* 71: 37-43.
- [10] McCormick, K.M., Norton, R.M., and Eagles, H.A. (2009). Phenotypic variation within a fenugreek (*Trigonella foenum-graecum* L.) germplasm collection I. Description of the collection. *Genet Resour Crop Evol.* 56:639-649.
- [11] Frankel, O.H., and Bennett, E. (1970). Genetic resources. In: Frankel OH, Bennett E, editors. Genetic Resources in Plants – their Exploration and Conservation. IBP Handbook No. 11, Blackwell Scientific Publications, Oxford and Edinburgh, UK. pp. 7–17.
- [12] Mathur, V.L. (2010). Genetic divergence in fenugreek (*Trigonella foenum-graecum* L.). *Indian J. Genetics & Plant Breeding.* 52: 428-432.
- [13] Vavilov, N.I. (1951). The Origin, Variation, Immunity and Breeding of Cultivated Plants. Roland Press, New York, USA.