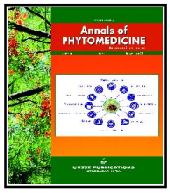
Annals of Phytomedicine 10(1): 289-297, 2021

DOI: http://dx.doi.org/10.21276/ap.2021.10.1.31

Annals of Phytomedicine: An International Journal
http://www.ukaazpublications.com/publications/index.php

Print ISSN : 2278-9839 Online ISSN : 2393-9885



Original article: Open access

Analysis of seed quality and vigour in fifty fennel genotypes (*Foeniculum vulgare* mill.)

Ravi Kumar Telugu◆, S.K. Tehlan, V.S. Mor, P. Syam Sundar Reddy and N. Kowsalya

Department of Horticulture, Chaudhary Charan Singh Haryana Agricultural University, Hisar-124004, Haryana, India

**Department of Seed Science and Technology, Chaudhary Charan Singh Haryana Agricultural University, Hisar-124004, Haryana, India*

Article Info

Article history
Received 5 May 2021
Revised 23 June 2021
Accepted 24 June 2021
Published online 30 June 2021

Keywords
Fennel
Seed quality
Standard germination
Seedling length
Vigour

Abstract

During the years 2015-16 and 2016-17, a study was undertaken at the Lab of the Department of Seed Science and Technology at CCS Haryana Agricultural University, Hisar, with fifty genotypes of fennel to examine seed quality and vigour. Fennel seeds from fifty distinct genotypes were obtained from various areas across India (Haryana, Rajasthan, Gujarat, Uttar Pradesh and Bihar). The genotype HF-171 had the greatest standard germination (%) (93.00%), seedling length (cm) (23.59 cm), dry weights of 10 seedlings (10.96 mg), vigour index-I (2194), and vigour index-II (1018). The results revealed significant variation across the fifty fennel genotypes, with HF-171, HF-173, HF-169, and HF-168 showing improved seed quality and vigour indices. As a result, these genotypes can be employed as breeding material in the future.

1. Introduction

Fennel (*Foeniculum vulgare* Mill.) is a herbaceous plant that grows as an annual, biennial or perennial and is widely used as a spice and medicinal. As one of the most significant winter season spices, fennel is grown in Gujarat, Rajasthan and Haryana, as well as to some extent in other regions. Fennel is an open pollinated spice crop belonging to the Umbelliferae (Apiaceae) family that originated in the Mediterranean region, where it retains a high level of genetic variety (Miranldi, 1999). It is a well-known aromatic plant species that grows on good soils in sunny warm climates. Bitter fennel, *Foeniculum vulgare* Mill. Subsp. *vulgare* var. *vulgare*, and Sweet fennel, *Foeniculum vulgare* Mill. Subsp. *vulgare* var. *dulce*, are the two economically important fennel kinds in the *Foeniculum vulgare* genus. Fennel is grown on about 0.91 lakh hectares in India, with a yearly production of 1.53 lakh MT and a productivity of 1.7 MT per hectare (Anon, 2017). The seed is a schizocarp consisting of two mericarps linked to a splitting carpophore. Fennel seed contains 6.3 per cent moisture, 9.5 per cent protein, 10% fat, 13.4% minerals, 18.5 per cent fibre, and 42.3 per cent carbohydrates, as well as vitamins such as vitamin C, thiamin, riboflavin, and niacin, as well as minerals such as calcium, phosphorus, iron, salt, and potassium (Bhunia *et al*., 2005). Fennel fruits are used to treat cholera, bile disorders, mental disorders, constipation, dysentery, and diarrhoea, as well as ailments of the chest, lungs, spleen, and kidney, as well as colic discomfort. Mastication and chewing are done with fennel seeds alone or with betel leaves (Girija, 1952).

Corresponding author: Dr. Ravi Kumar Telugu
Department of Horticulture, Chaudhary Charan Singh Haryana Agricultural University, Hisar-124004, Haryana, India
E-mail: ravikumar.horti@gmail.com
Tel.: +91-8919593384

Fennel volatile oil is made up of at least a dozen distinct compounds, the most important of which being a anethole (40-70%), fenchone (1-20%), and estragole (2-9 per cent). Antioxidant, antibacterial, anticancer, and antifungal properties are all present in fennel essential oil (Lucinewton *et al*., 2005).

Quality seed is a basic input for realizing higher yield potential and this quality is determined by its purity, germination and health. A good quality seed should be clean, genetically pure, viable, vigours and free from diseases and insect pests. Nowadays, besides seed germination, the seed vigour as a quality attribute that comprises the potential for rapid, uniform field emergence and development of normal seedlings has attained significance to reflect field performance of a variety under varied environmental conditions (McDonald, 1980). To increase production and productivity, high-quality seed is required (Sidhawani, 1991). It has been established that using high-quality seeds increases agricultural productivity by 15-20%. The International Seed Testing Association (ISTA, 1999) has recommended a number of tests for evaluating seed vigour, however proper techniques for selecting the best single (or multiple) predictors of seed performance are required. Since there is not much data on seed vigour in fennel, other crops have been mentioned (Pramila *et al*., 2013; Mor *et al*., 2009).

2. Materials and Methods

The experiment “Assessment of seed quality and vigour in fifty genotypes of fennel (*Foeniculum vulgare* Mill.)” was conducted at CCS Haryana Agricultural University, Hisar, in 2015-16 and 2016-17 (Haryana). The seeds were obtained from several areas across India (Haryana, Rajasthan, Gujarat, Uttar Pradesh, and Bihar) and seeded on November 14th, 2015 for the first year and November 12th, 2016 for the second year. The plot was 3.0 m × 1.0 m in size, with 50 cm x 20 cm spacing. Seed harvesting took place after full maturity (on May 23rd, 2016 for the first year and May 26th, 2017 for the

second year) and seeds were sun dried for 4 to 5 days in the field. For a successful crop raising, all of the essential agronomic techniques were followed on time. The treatments were replicated three times in this trial, which used a randomized block design.

Seeds were collected and transported to the laboratory after proper drying, cleaning, and achieving the ideal moisture content to analyze seed quality characteristics such as seed germination %, seedling length, seedling dry weight, and seed vigour Index I and II.

2.1 Standard germination (%)

It was determined using the Between Paper method, which involved choosing 100 seeds from each genotype (BP). The seeds were placed separately between two layers of moist germination paper in this way, and then incubated at 25°C in a seed germinator. On the 14th day, the final count of normal seedlings was recorded and reported as a percentage of germination.

2.2 Seedling length (cm)

The seedling length was measured and expressed in centimetres using 10 randomly selected normal seedlings from the standard germination test.

2.3 Seedling dry weight (mg)

Weighing 10 randomly selected normal seedlings that were utilised in seedling length measurement yielded the seedling dry weight. The selected seedlings were dried for 48 h at 80°C and their dry weight was measured in milligrammes.

2.4 Seed vigour indices

The formulas proposed by Abdul Baki and Anderson (1973) were used to calculate seed vigour.

Seed vigour index-I: Standard germination (%) x Average seedling length (cm).

Seed vigour index- II: Standard germination (%) x Average seedling dry weight (mg).

3. Results

Table 1 shows that the mean sum of squares due to fennel genotypes was very significant for all of the metrics, indicating that there was a great level of variability among the genotypes for all of the vigour measures. Seed viability and vigour differ as a result of a complex combination of genetic constitution, environment, nutrition, or mother plant, harvest maturity, seed weight and size, mechanical integrity, and ageing variables. Because of the high heritability of character combined with genetic advance, the variability results in wheat crop demonstrated that seed vigour parameters are significantly under genetic control (Wani *et al*., 2013). Variation in seed lifespan and vigour among genotypes can also be influenced genetically, according to James (1967).

Table 1: Analysis of variance for different seed quality and vigour assessment parameters in 50 genotypes of fennel

Sr. No.	Source/parameters	Variety (MSS)	Error	CV (%)
1	Standard germination	22.27**	1.24	1.29
2	Seedling length	4.73**	0.54	3.48
3	Seedling dry weight	2.62**	0.06	3.09
4	Vigour index-I	76292.35**	4875.90	3.85
5	Vigour index-II	30368.30**	447.18	3.14

** Significant at 1%

Table 2: Mean values of standard germination (%) in 50 genotypes of fennel during 2015-16 and 2016-17

Sl. No.	Genotypes	Mean		Pooled mean	Sl. No.	Genotypes	Mean		Pooled mean	S1. No.	Genotypes	Mean		Pooled mean
		2015-16	2016-17				2015-16	2016-17				2015-16	2016-17	
1	HF-162	83.67	8433	84.00	19	HF-180	89.00	90.00	89.50	37	JK-/RM/AK-13	85.00	86.00	85.50
2	HF-163	83.33	85.67	84.50	20	HF-182	89.00	87.67	88.33	38	JK-/RM/AK-19	83.67	84.33	84.00
3	HF-164	86.67	86.67	86.67	21	NDF-28	86.67	87.33	87.00	39	JK-/RM/AK-24	87.33	84.00	85.67
4	HF-165	83.67	85.00	84.33	22	NDF-38	89.33	89.00	89.17	40	RF-21	83.67	84.33	84.00
5	HF-166	83.67	85.67	84.67	23	NDF-39	86.00	86.33	86.17	41	RF-38	80.67	81.33	81.00
6	HF-167	90.67	89.00	89.83	24	NDF-41	85.00	88.67	86.83	42	RF-54	82.00	85.00	83.50
7	HF-168	90.33	89.67	90.00	25	NDF-42	87.67	88.00	87.83	43	RF-57	83.67	85.00	84.33
8	HF-169	89.67	91.00	90.33	26	NDF-43	88.00	85.33	86.67	44	GF-11	84.33	85.33	84.83
9	HF-170	86.33	86.00	86.17	27	NDF-44	87.33	86.00	86.67	45	GF-12	84.67	86.00	85.33
10	HF-171	93.33	92.67	93.00	28	JF-12	79.67	77.33	78.50	46	HF-33	84.33	88.00	86.17
11	HF-172	87.00	86.33	86.67	29	JF-382-2	83.67	84.00	83.83	47	HF-39	85.00	85.33	85.17
12	HF-173	90.00	91.67	90.83	30	JF-406	84.33	81.67	83.00	48	PF-35	87.67	85.33	86.50
13	HF-174	86.67	87.00	86.83	31	JF-421	83.00	83.33	83.17	49	GF-2	84.00	84.33	84.17
14	HF-175	89.67	90.67	90.17	32	JF-494	81.00	78.67	79.83	50	R.sourbh	86.00	86.33	86.17
15	HF-176	86.67	86.33	86.50	33	JF-533-2	84.33	83.33	83.83		**Overall mean**	**85.83**	**85.98**	**85.90**
16	HF-177	86.67	85.67	86.17	34	JF-582	84.00	83.00	83.50		**Range**	**93.33 - 79.67**	**92.67-77.33**	**93.00-78.50**
17	HF-178	85.33	86.67	86.00	35	JK-/RM/AK-7	86.33	87.33	86.83		**CD**	**2.77**	**1.68**	**1.80**
18	HF-179	85.00	84.33	84.67	36	JK-/RM/AK-9	86.67	87.00	86.83		**CV**	**1.99**	**1.21**	**1.29**

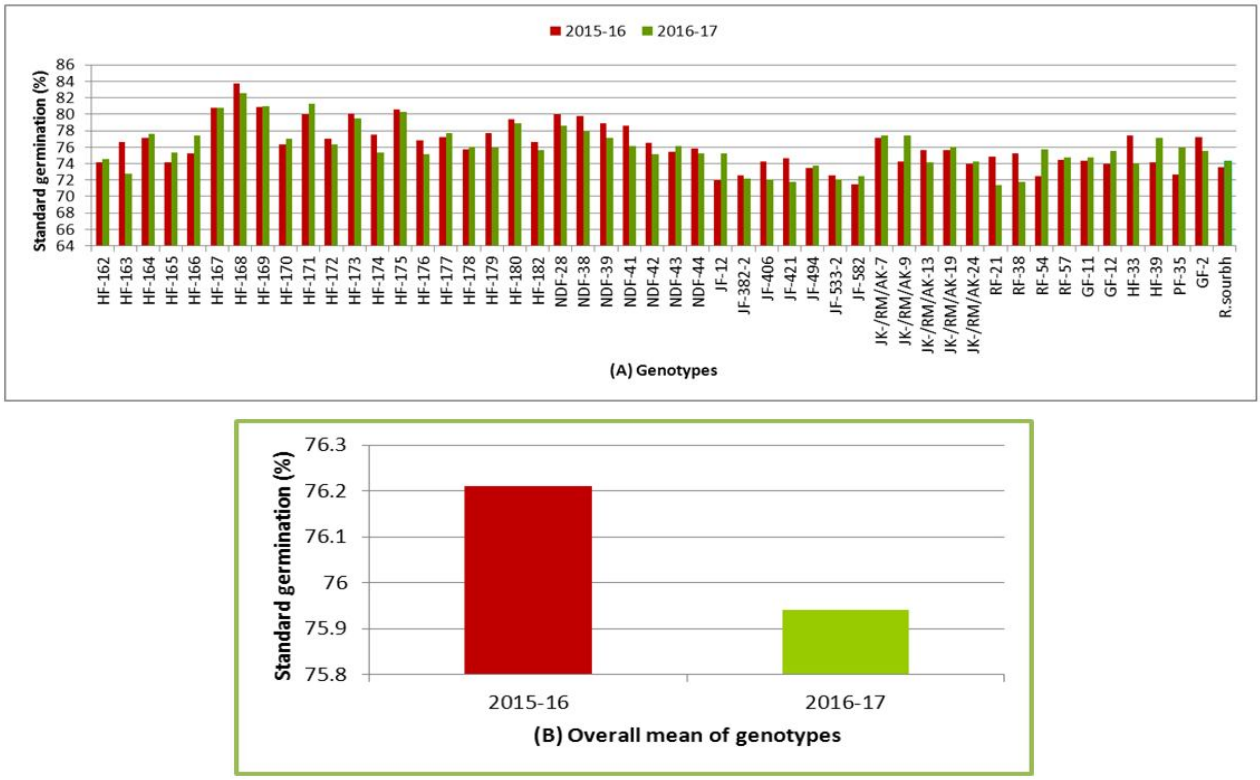


Figure 1: Standard germination percentage of genotypes (A) and overall mean of genotypes (B).

Table 3: Mean values of seedling length (cm) of 10 seedlings in 50 genotypes of fennel during 2015-16 and 2016-17

Sl. No.	Genotypes	Mean		Pooled mean	Sl. No.	Genotypes	Mean		Pooled mean	S1. No.	Genotypes	Mean		Pooled mean
		2015-16	2016-17				2015-16	2016-17				2015-16	2016-17	
1	HF-162	20.30	19.01	19.65	19	HF-180	22.25	22.24	22.25	37	JK-/RM/AK-13	20.48	21.24	20.86
2	HF-163	20.86	20.58	20.72	20	HF-182	22.27	21.96	22.12	38	JK-/RM/AK-19	20.78	21.94	21.36
3	HF-164	21.33	21.91	21.63	21	NDF-28	21.51	22.18	21.84	39	JK-/RM/AK-24	22.34	21.60	21.98
4	HF-165	20.53	20.59	20.56	22	NDF-38	22.50	22.03	22.27	40	RF-21	21.03	20.49	20.77
5	HF-166	21.27	20.95	21.11	23	NDF-39	21.10	21.03	21.07	41	RF-38	20.65	20.75	20.70
6	HF-167	22.95	22.31	22.63	24	NDF-41	21.08	20.68	20.88	42	RF-54	20.68	19.69	20.19
7	HF-168	23.40	22.45	22.93	25	NDF-42	21.53	20.58	21.06	43	RF-57	20.56	20.63	20.59
8	HF-169	23.76	22.13	22.95	26	NDF-43	22.90	21.59	22.25	44	GF-11	20.27	21.44	20.85
9	HF-170	21.50	20.56	21.03	27	NDF-44	21.99	20.68	21.34	45	GF-12	20.80	21.40	21.11
10	HF-171	24.33	22.84	23.59	28	JF-12	17.10	16.44	16.77	46	HF-33	21.37	21.78	21.58
11	HF-172	21.21	21.41	21.31	29	JF-382-2	19.46	19.76	19.61	47	HF-39	21.07	21.77	21.42
12	HF-173	23.82	21.74	22.78	30	JF-406	18.65	17.96	18.31	48	PF-35	21.04	20.18	20.61
13	HF-174	20.60	21.83	21.22	31	JF-421	20.05	19.86	19.96	49	GF-2	20.99	21.01	21.01
14	HF-175	22.45	22.64	22.55	32	JF-494	17.84	18.76	18.30	50	R.sourbh	21.89	21.16	21.53
15	HF-176	20.66	20.47	20.57	33	JF-533-2	20.12	19.21	19.67		**Overall mean**	**21.16**	**20.94**	**21.05**
16	HF-177	20.44	20.82	20.64	34	JF-582	18.28	19.80	19.04		**Range**	**24.33 - 17.10**	**22.84 - 16.44**	**23.59-16.77**
17	HF-178	20.93	21.21	21.07	35	JK-/RM/AK-7	22.12	21.33	21.72		**CD**	**1.90**	**1.56**	**1.19**
18	HF-179	21.25	20.65	20.95	36	JK-/RM/AK-9	21.77	21.76	21.77		**CV**	**5.55**	**4.58**	**3.48**

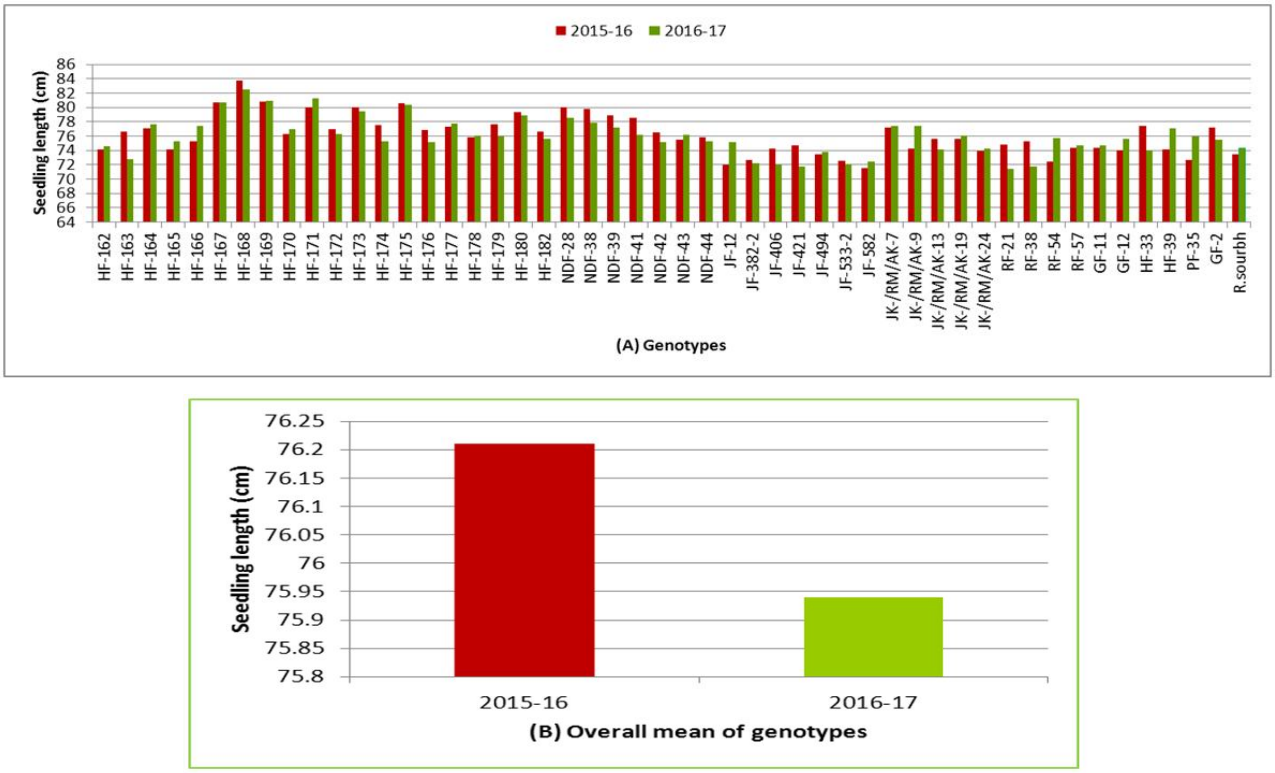


Figure 2: Seedling length (cm) of genotypes (A) and overall mean of genotypes (B).

Table 4: Mean values of seedling dry weight (mg) of 10 seedlings in 50 genotypes of fennel during 2015-16 and 2016-17

Sl. No.	Genotypes	Mean		Pooled mean	Sl. No.	Genotypes	Mean		Pooled mean	S1. No.	Genotypes	Mean		Pooled mean
		2015-16	2016-17				2015-16	2016-17				2015-16	2016-17	
1	HF-162	7.21	6.93	7.07	19	HF-180	7.37	7.84	7.61	37	JK-/RM/AK-13	7.97	7.25	7.61
2	HF-163	6.85	7.50	7.18	20	HF-182	8.19	8.79	8.49	38	JK-/RM/AK-19	7.75	8.25	8.00
3	HF-164	7.26	7.52	7.39	21	NDF-28	8.58	8.97	8.78	39	JK-/RM/AK-24	8.34	8.48	8.41
4	HF-165	7.47	7.70	7.59	22	NDF-38	9.00	9.04	9.02	40	RF-21	7.41	7.08	7.25
5	HF-166	7.09	7.16	7.13	23	NDF-39	7.52	7.73	7.63	41	RF-38	7.30	7.19	7.25
6	HF-167	9.15	9.11	9.13	24	NDF-41	8.08	8.34	8.21	42	RF-54	7.09	7.13	7.11
7	HF-168	10.02	10.15	10.09	25	NDF-42	7.13	7.34	7.24	43	RF-57	7.15	7.12	7.14
8	HF-169	9.86	9.64	9.75	26	NDF-43	8.13	8.03	8.08	44	GF-11	7.32	7.82	7.57
9	HF-170	8.23	8.34	8.29	27	NDF-44	7.07	7.57	7.33	45	GF-12	7.33	8.07	7.70
10	HF-171	10.82	11.10	10.96	28	JF-12	6.83	6.16	6.50	46	HF-33	7.86	7.97	7.92
11	HF-172	8.22	8.33	8.28	29	JF-382-2	6.59	7.00	6.80	47	HF-39	7.26	7.10	7.18
12	HF-173	9.51	9.55	9.53	30	JF-406	6.95	6.96	6.95	48	PF-35	7.27	7.34	7.31
13	HF-174	6.77	7.06	6.92	31	JF-421	6.86	6.73	6.80	49	GF-2	7.32	7.65	7.48
14	HF-175	8.91	9.16	9.04	32	JF-494	6.27	6.93	6.61	50	R.sourbh	7.76	7.99	7.87
15	HF-176	7.77	7.48	7.62	33	JF-533-2	7.12	6.87	7.00		Overall mean	7.76	7.87	7.81
16	HF-177	7.50	7.75	7.63	34	JF-582	7.11	6.59	6.85		Range	10.82-6.27	11.10-6.16	10.96-6.50
17	HF-178	7.37	7.53	7.45	35	JK-/RM/AK-7	8.45	8.34	8.40		CD	0.54	0.52	0.39
18	HF-179	7.95	8.05	8.00	36	JK-/RM/AK-9	7.57	7.53	7.56		CV	4.31	4.03	3.09

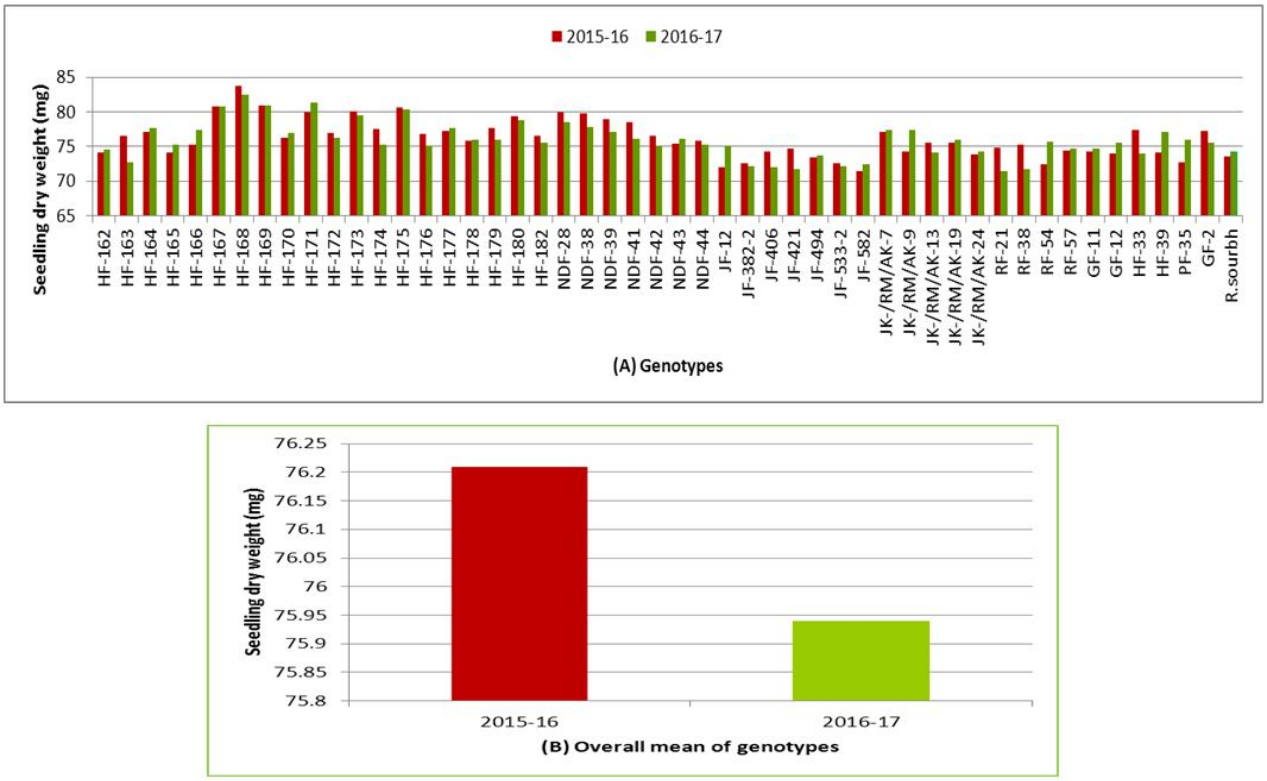


Figure 3: Seeding dry weight (mg) of genotypes (A) and overall mean of genotypes (B).

Table 5: Mean values of vigour index-I in 50 genotypes of fennel during 2015-16 and 2016-17

Sl. No.	Genotypes	Mean		Pooled mean	Sl. No.	Genotypes	Mean		Pooled mean	S1. No.	Genotypes	Mean		Pooled mean
		2015-16	2016-17				2015-16	2016-17				2015-16	2016-17	
1	HF-162	1,698	1,603	1,650	19	HF-180	1,983	2,001	1,992	37	JK-/RM/AK-13	1,741	1,826	1,783
2	HF-163	1,737	1,764	1,750	20	HF-182	1,983	1,925	1,954	38	JK-/RM/AK-19	1,739	1,849	1,794
3	HF-164	1,850	1,900	1,875	21	NDF-28	1,865	1,937	1,901	39	JK-/RM/AK-24	1,951	1,815	1,883
4	HF-165	1,718	1,750	1,734	22	NDF-38	2,010	1,960	1,985	40	RF-21	1,760	1,728	1,744
5	HF-166	1,779	1,795	1,787	23	NDF-39	1,815	1,816	1,815	41	RF-38	1,666	1,687	1,677
6	HF-167	2,081	1,985	2,033	24	NDF-41	1,792	1,833	1,812	42	RF-54	1,695	1,674	1,685
7	HF-168	2,114	2,012	2,064	25	NDF-42	1,886	1,814	1,850	43	RF-57	1,719	1,754	1,736
8	HF-169	2,135	2,014	2,074	26	NDF-43	2,016	1,842	1,929	44	GF-11	1,709	1,829	1,769
9	HF-170	1,857	1,768	1,812	27	NDF-44	1,920	1,778	1,850	45	GF-12	1,761	1,841	1,801
10	HF-171	2,271	2,117	2,194	28	JF-12	1,362	1,271	1,317	46	HF-33	1,803	1,917	1,860
11	HF-172	1,846	1,849	1,847	29	JF-382-2	1,629	1,659	1,644	47	HF-39	1,792	1,858	1,825
12	HF-173	2,142	1,993	2,067	30	JF-406	1,572	1,467	1,520	48	PF-35	1,842	1,723	1,783
13	HF-174	1,785	1,899	1,842	31	JF-421	1,665	1,655	1,660	49	GF-2	1,760	1,772	1,767
14	HF-175	2,010	2,053	2,032	32	JF-494	1,445	1,476	1,460	50	R.sourbh	1,882	1,827	1,854
15	HF-176	1,790	1,767	1,779	33	JF-533-2	1,697	1,602	1,650		Overall mean	1819	1803	1811
16	HF-177	1,771	1,784	1,778	34	JF-582	1,536	1,643	1,590		Range	2271-2136	2117-1271	2194-1317
17	HF-178	1,786	1,838	1,812	35	JK-/RM/AK-7	1,909	1,862	1,886		CD	171.401	141.781	113.287
18	HF-179	1,806	1,741	1,774	36	JK-/RM/AK-9	1,886	1,893	1,889		CV	5.807	4.846	3.855

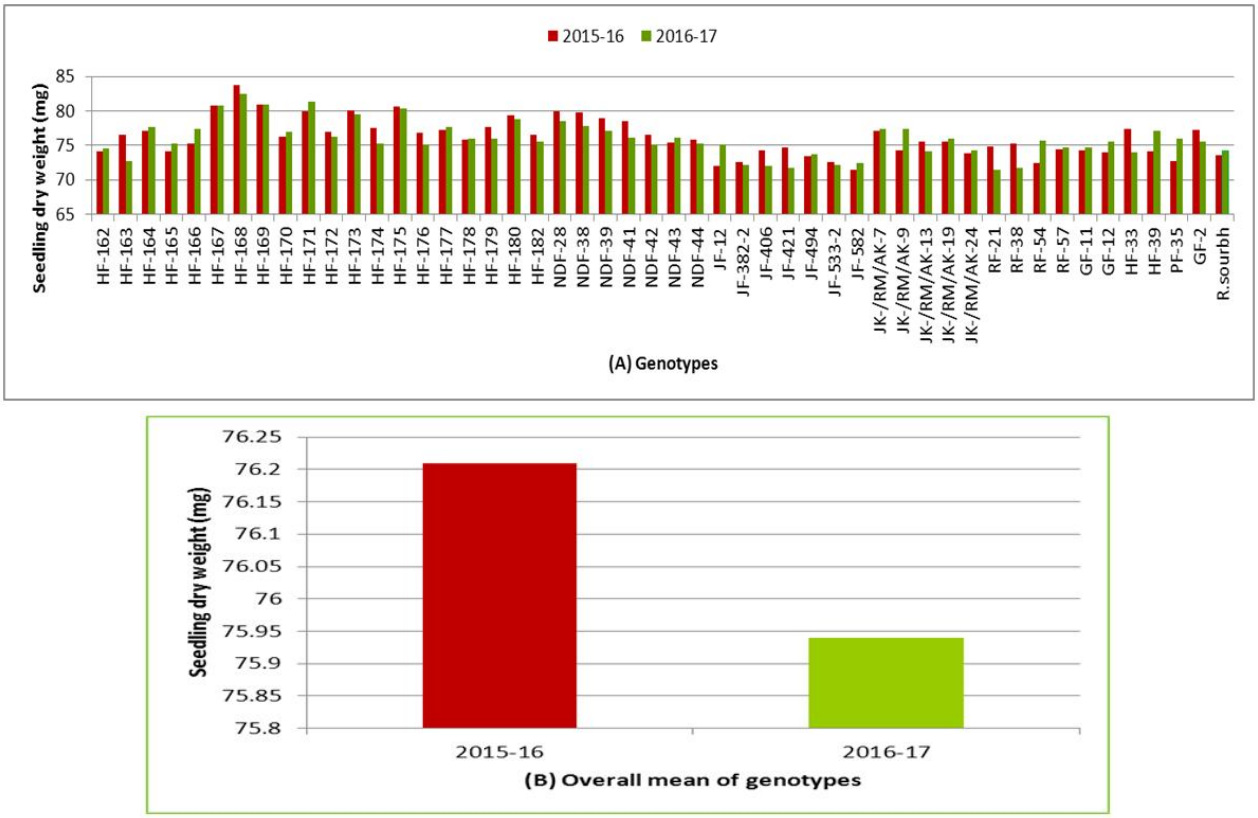


Figure 4: Vigour index-I of genotypes (A) and overall mean of genotypes (B).

Table 6: Mean values of vigour index-II in 50 genotypes of fennel during 2015-16 and 2016-17

Sl. No.	Genotypes	Mean		Pooled mean	Sl. No.	Genotypes	Mean		Pooled mean	S1. No.	Genotypes	Mean		Pooled mean
		2015-16	2016-17				2015-16	2016-17				2015-16	2016-17	
1	HF-162	603	584	594	19	HF-180	656	705	681	37	JK-/RM/AK-13	678	623	651
2	HF-163	571	643	607	20	HF-182	729	770	749	38	JK-/RM/AK-19	649	696	672
3	HF-164	629	651	640	21	NDF-28	744	783	764	39	JK-/RM/AK-24	729	712	720
4	HF-165	625	655	640	22	NDF-38	805	804	804	40	RF-21	620	597	609
5	HF-166	593	613	603	23	NDF-39	646	667	657	41	RF-38	589	585	587
6	HF-167	830	811	820	24	NDF-41	687	739	713	42	RF-54	581	607	594
7	HF-168	906	910	908	25	NDF-42	625	646	636	43	RF-57	598	605	602
8	HF-169	883	877	880	26	NDF-43	716	685	701	44	GF-11	617	667	642
9	HF-170	711	717	714	27	NDF-44	617	651	634	45	GF-12	621	694	658
10	HF-171	1009	1028	1018	28	JF-12	544	476	510	46	HF-33	662	701	682
11	HF-172	716	719	717	29	JF-382-2	551	588	570	47	HF-39	617	606	611
12	HF-173	856	876	866	30	JF-406	586	568	577	48	PF-35	637	626	632
13	HF-174	586	615	601	31	JF-421	570	560	565	49	GF-2	614	644	629
14	HF-175	798	831	814	32	JF-494	508	545	527	50	R.sourbh	668	690	679
15	HF-176	673	645	659	33	JF-533-2	601	573	587		**Overall mean**	**668**	**678**	**673**
16	HF-177	651	664	657	34	JF-582	598	547	572		**Range**	**1009-508**	**1028-476**	**1019-510**
17	HF-178	629	653	641	35	JK-/RM/AK-7	729	729	729		**CD**	**49.763**	**45.667**	**34.308**
18	HF-179	676	679	677	36	JK-/RM/AK-9	656	656	656		**CV**	**4.593**	**4.149**	**3.141**

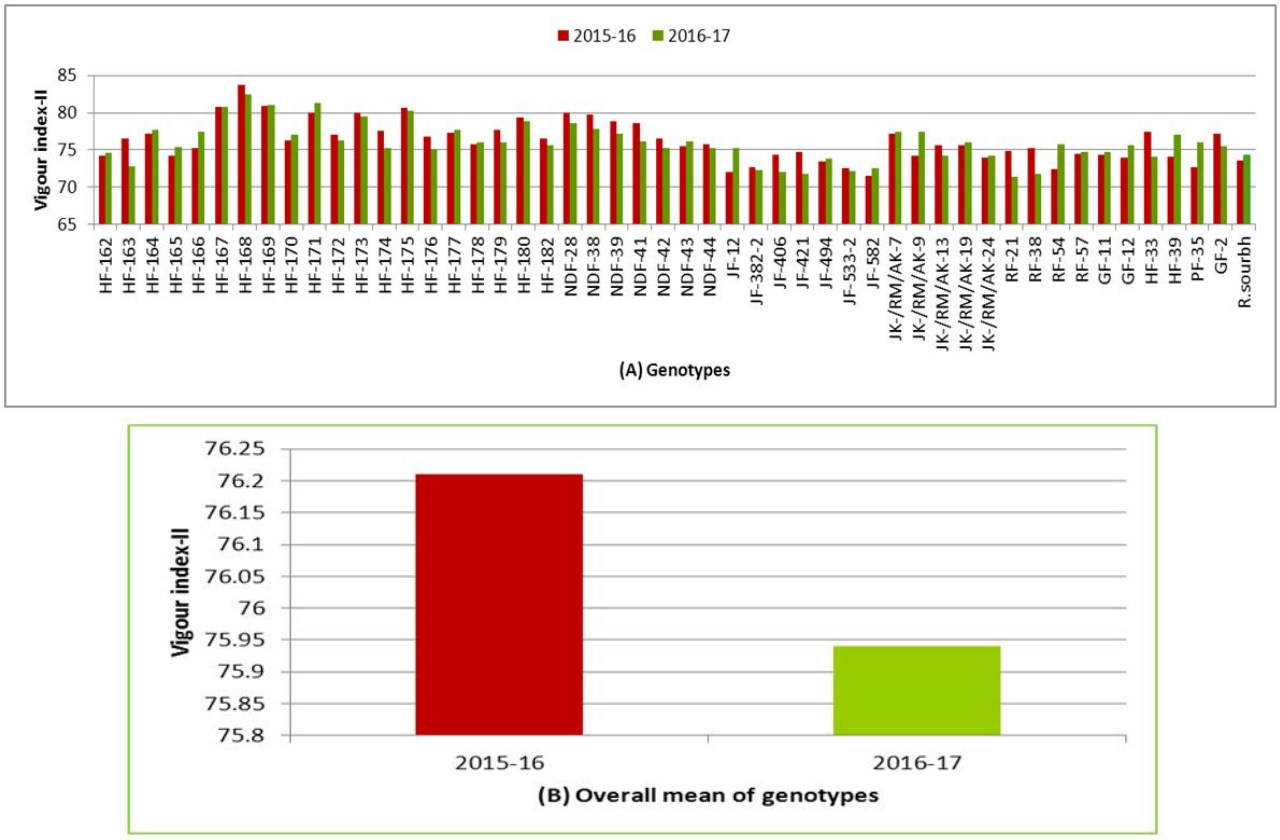


Figure 5: Vigour index-II of genotypes (A) and overall mean of genotypes (B).

The results on standard germination (percentage) revealed that there were substantial differences in all genotypes (Table 2 and Figure 1). The maximum standard germination percentage (93.00%) was observed in seeds harvested from the genotype HF-171, followed by HF-173 (90.83 %), HF-169 (90.33 %), HF-175 (90.17 %), HF-168 (90.00 %), HF-167 (89.83 %) and HF-180 (89.50), while the minimum standard germination percentage (78.50%) was observed in seeds harvested from the genotypes JF-12. The overall mean of standard germination recorded for all genotypes was 85.90 per cent.

The perusal of data presented in Table 3 and Figure 2 revealed a significant variation among all the genotypes with respect to seedling length. The maximum value for seedling length (23.59 cm) was registered in genotype HF-171, which was found at par with five other genotypes (HF-169, HF-168, HF-173, HF-167 and HF-175), whereas, the minimum value for seedling length (16.77 cm) was registered with the genotypes JF-12. The overall mean of seedling length recorded for all genotypes was 21.05 cm.

The data recorded for the seedling dry weight demonstrate the significant variations (Table 4 and Figure 3) in all the genotypes. Among different fennel genotypes, the highest mean value for seedling dry weight (10.96 mg) was recorded in genotype HF-171, followed by HF-168 (10.09), which was found at par with HF-168 (9.75), whereas, the lowest mean value for seedling dry weight (6.50 mg) was recorded in JF-12. The overall mean of seedling dry weight recorded for all genotypes was 7.81 mg.

The data recorded for the seed vigour index-I have been presented in Table 5 and Figure 4. Significant variation was recorded in all the genotypes with respect to seed vigour index-I. Vigour index-I was calculated by multiplying the standard germination per cent with seedling length. The maximum value for vigour index-I (2194) was registered in seeds extracted from the HF-171, followed by HF-169 (2074), which was found at par with HF-173 (2067), HF-168 (2064) and HF-167 (2033), while the minimum value for vigour index-I (1317) was recorded in seeds extracted from the genotypes JF-12. The overall mean of vigour index-I recorded for all genotypes was 1811.

Vigour index-II was calculated by multiplying standard germination per cent with seedling dry weight. The data recorded for all fennel genotypes revealed that the maximum seed vigour index-II, HF-171 (1018), followed by HF-168 (908), HF-169 (880), HF-173 (866) and HF-167 (820), while the minimum seed vigour index-II (510) was recorded in JF-12. The overall mean of vigour index-II recorded for all genotypes was 673 (Table 6 and Figure 5).

4. Discussion

All the genotypes differed significantly with respect to standard germination percentage. The maximum standard germination percentage (93.00%) was observed in genotype HF-171, followed by HF-173 (90.83 %), HF-169 (90.33 %), HF-175 (90.17 %), HF-168 (90.00 %) and HF-167 (89.83 %), while the minimum standard germination percentage (78.50%) was observed in seeds harvested from the genotypes JF-12. The results indicating that most of genotypes with more size and test weight of seed bear better germination percentage, however, this is not true in respect of each genotype. Similarly, Pereira *et al.* (2008) reported that increase in seed germination and development is owing to the higher seed size,

weight and density. Seeds with fully mature embryos and high amounts of food reserves are potentially the most germinative and vigorous ones (Carvalho and Nakagawa, 1983; Ioana *et al.*, 2015). Deswal *et al.* (2017) results revealed that significant variability among the sixty genotypes of fennel. Similar differences in genotypes in respect of standard germination percentage were also showed by Singh *et al.* (2014) in carrot; Usha and Dadlani (2015) in soyben; Singh *et al.* (2015) in fenugreek.

A significant difference was observed in all the genotypes with respect to seedling length (cm) and seedling dry weight (mg). The maximum value for seedling length (23.59 cm) was registered in genotype HF-171, which was found at par with five other genotypes (HF-169, HF-168, HF-173, HF-167 and HF-175), whereas, the minimum value for seedling length (16.77cm) was registered with the genotypes JF-12. The highest mean value for seedling dry weight (10.96 mg) was recorded in genotype HF-171, followed by HF-168 (10.09), which was found at par with HF-168 (9.75), whereas, the lowest mean value for seedling dry weight (6.50 mg) was recorded in JF-12. These findings are consistent with those of Soltani *et al.* (2002), who found that genotypes with greater test weight and seed size have longer seedlings and higher dry weight in chickpea. Yadav *et al.* (2015) recorded that significant differences were observed in shoot and root length of different varieties. Seedling length and vigour index were revealed lower in artificially aged seed than fresh seeds in pearl millet (Gupta *et al.*, 2005). Singhal *et al.* (2017) recorded that the dry weight of seedling is decreased as the ageing period increased in fennel.

Significant variations were recorded in all the genotypes with respect to seed vigour index-I and II. The maximum value for vigour index-I (2194) was registered in seeds extracted from the HF-171, followed by HF-169 (2074), which was found at par with HF-173 (2067), HF-168(2064), and HF-167 (2033), while the minimum value for vigour index-I (1317) was recorded in seeds extracted from the genotypes JF-12. Similarly, seed vigour index-II was maximum in HF-171 (1018) followed by HF-168 (908), HF-169 (880), HF-173 (866) and HF-167 (820), while the minimum seed vigour index-II (510) was recorded in JF-12.

These findings are consistent with those of Sonmez (2000), who found that the dry weight of barley seedlings responded positively to water and nutrient uptake. According to Pramila *et al.* (2013), fenugreek seed lots had the highest physical purity, seed germination, and seedling vigour index, followed by fennel and coriander. Similar findings were also noticed in this experiment and by Yadav and Dhankhar (2001) in okra; Ajala (2003) in winged bean and pigeonpea.

5. Conclusion

The results of mean sum of squares due to genotypes was highly significant for all the vigour parameters, which indicated presence of considerable and significant amount of variability among the genotypes for all vigour parameters of seeds.

The maximum standard germination percentage (93.00%) was observed in seeds harvested from the genotype HF-171, followed by HF-173 (90.83 %), HF-169 (90.33 %), HF-175 (90.17 %), HF-168 (90.00 %), HF- 167 (89.83 %) and HF-180 (89.50), while the minimum standard germination percentage (78.50%) was observed in seeds harvested from the genotypes JF-12.

The maximum value for seedling length (23.59 cm) was registered in genotype HF-171, which was found at par with five other genotypes (HF-169, HF-168, HF-173, HF-167 and HF-175), whereas, the minimum value for seedling length (16.77cm) was registered with the genotypes JF-12. The highest mean value for seedling dry weight (10.96 mg) was recorded in genotype HF-171, followed by HF-168 (10.09), which was found at par with HF-168 (9.75), whereas, the lowest mean value for seedling dry weight (6.50 mg) was recorded in JF-12.

The maximum value for vigour index-I (2194) was registered in seeds extracted from the HF-171, followed by HF-169 (2074), which was found at par with HF-173 (2067), HF-168 (2064), and HF-167 (2033), while the minimum value for vigour index-I (1317) was recorded in seeds extracted from the genotypes JF-12. Vigour index-II was maximum in HF-171 (1018) followed by HF-168 (908), HF-169 (880), HF-173 (866) and HF-167 (820), while the minimum seed vigour index-II (510) was recorded in JF-12.

The results revealed significant variation across the fifty fennel genotypes, with HF-171, HF-173, HF-169, and HF-168 showing improved seed quality and vigour indices. As a result, these genotypes can be employed as breeding material in the future.

Conflict of interest

The authors declare that there are no conflicts of interest relevant to this article.

References

Abdul-Baki, A. A. and Anderson, J. D. (1973). Vigour determination in soybean seed by multiple criteria. Crop Science, **13**:630-633.

Ajala, M.O. (2003). Influence of seed quality attributes on field emergence of pigeonpea (*Cajanus cajan* L.) and winged bean (*Psophocarpus tetragonolobus* L.). Tropical Agriculture, **80**(2):118-122.

Anonymous (2017). Department of Agriculture, Cooperation and Farmers Welfare (Horticulture Statistic Division) Third Advanced Estimates.

Bhunia, S. R.; Chauhan, R. P. S. and Yadav, B S. (2005). Effect of nitrogen and irrigation on water use, moisture extraction pattern, nutrient uptake and yield of fennel (*Foeniculum vulgare*). Indian Journal of Agronomy, **50**:73-76.

Carvalho, N. M. and Nakagawa, J. (1983). Sementes: Ciencia, tecnologia e producao. 2.ed. Campinas: Fundacao Cargill. 429.

Deswal, S.; Mor, V. S.; Malik, T. P.; Tehlan, S. K. and Srikanth, M. (2017). Seed quality and vigour assessment of fennel (*Foeniculum vulgare* L.) genotypes. International Journal of Current Microbiology and Applied Science, **6**(10):4970-4980.

Girija, L. (1952). Taxonomical studies of a few economic genera in umbelliferae. M.Sc. Thesis, Madras University, Madras (INDIA).

Gupta, V.; Arya, L.; Pandey, C. and Kak, A. (2005). Effect of accelerated ageing on seed vigour in pearl millet (*Pennisetum glaucum*) hybrids and their parents. International Journal of Agriculture Sciences, **75**(6): 346-347.

Ioana, N.V.; Apahidean, A.S.; Anca, M.H. and Raluca, C. (2015). Study of fennel seed germination (*Foeniculum vulgare* var. *azoricum*). Agriculture - Science and Practice, **1**(2):93-94.

ISTA (1999). International rules for seed testing. Seed Science and Technology, **27**:50-52.

James, E. (1967). Preservation and seed stocks. Advance Agronomy, **19**: 87-106.

Lucinewton, S.; Rahul, N.; Carvaalho, J.; Mirian, B.; Lin, C. and Angela, A. (2005). Supercritical fluid extraction from fennel (*Foeniculum vulgare*), global yield, composition and kinetic data. Journal of Supercritical Fluid, **35**:212-219.

McDonald, M.B. (1980). Assessment of seed quality. Horticultural Science, **15**(6):784-788.

Miranldi, E. (1999). Comparison of the essential oil from ten *Foeniculum vulgare* Mill. samples of fruits of different origin. Flavour and Fragrance Journal, **14**:379-382.

Mor, V. S.; Verma, S. S. and Verma, U. (2009). Studies on seed viability and vigour in various order umbels of fennel (*Foeniculum vulgare* Miller). Seed Science and Technology, **37**(3):747-757.

Pereira, R. S.; Nascimento, W. M. and Vierira, J.V. (2008). Carrot seed germination and vigor in response to temperature and umbel orders. Scientific Agriculture, **65**:145-150.

Pramila, C. K.; Prasanna, K. P. K.; Balakrishna, P. V.; Devaraju and Siddaraju. (2013). Assessment of seed quality in seed spices. Journal of Spices and Aromatic Crops, **22**(2):233-237.

Sidhawani, S.K. (1991). Use of certified seeds and its contribution towards productivity. In seminar seed industry in Haryana, present at September pp:12-13, CCS HAU, Hisar.

Singh, P. K.; Pandita, V. K.; Tomar, B. S. and Seth, R. (2014). Use of seed vigour tests to predict seedling emergence of carrot. Indian Journal of Horticulture. **71**(4):516-521.

Singh, B.; Bhuker, A.; Mor, V. S.; Dahiya, O. S. and Punia, R. C. (2015). Effect of natural ageing on seed quality of fenugreek (*Trigonella foenum-graecum* L.). International Journal of Scientific Research in Science and Technology, **1**(4):243-248.

Singhal, D. K.; Vinod, K.; S. K. Tehlan and V. S. Mor. (2017). Evalution of biochemical changes associated with seed quality under naturally stored conditions in fennel. International Journal of Chemical Studies, **5**(5):1800-1803.

Soltani, A.; Galeshi, S.; Zeinali, E. and Latifi, N. (2002). Germination, seed reserve utilization and seedling growth of chickpea as affected by salinity and seed size. Seed Science and Technology, **30**(1):51-60.

Sonmez, F. (2000). Effect of seed size and nitrogen fertilizer on root and shoot growth in the early development stage of barley. Turkish Journal of Agriculture and Forestry, **24**(6):669-675.

Usha, T.N. and Dadlani, M. (2015). Evaluation of seed vigour in soybean (*Glycine max*). Legume Research, **38**(3):308-312.

Wani, B. A.; Ram, M.; Yasin, A.; Ali, M.; Pandith, A. and Mir, R. A. (2013). Seedling vigour in wheat (*Triticum aestivum* L.) as a source of genetic variation and study of its correlation with yield and yield components. African Journal of Agricultural Research, **8**(4):370-372.

Yadav, S. K. and Dhankar, B. S. (2001). Correlation studies between various fields parameters and seed quality traits in okra *cv.* Varsha Uphar. Seed Research, **29**(1):84-88.

Yadav, C.; Tomar, P. and Malik, C. P. (2015). Assessment of fennel (*Foeniculum vulgare*) seed germination characteristics and comparison of different seedling growth parameters at initial stages. Journal of Plant Science Research, **31**(2):241-247.

Citation **Ravi Kumar Telugu, S.K. Tehlan, V.S. Mor, P. Syam Sundar Reddy, and N. Kowsalya (2021). Analysis of seed quality and vigour in fifty fennel genotypes (*Foeniculum vulgare* mill.). Ann. Phytomed., 10(1):289-297. http://dx.doi.org/10.21276/ap.2021.10.1.31**