



Influence of integrated nutrient combinations on relative storability of fennel (*Foeniculum vulgare*) seed

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ABSTRACT

A field experiment was conducted during *rabi* 2016–17 and 2017–18 at Research Farm of CCS Haryana Agricultural University, Hisar. It comprised of sixteen treatment levels of fertilizer in randomized block design with three replications. After proper drying, cleaning and attaining the optimum moisture content the seeds were collected and the completely randomized design (CRD) was followed to conduct laboratory testing for the seed relative storability parameters in the seed testing laboratory, CCS Haryana Agricultural University, Hisar. After accelerated ageing for 24, 48, 72, 96 and 120 h the seed received from the treatment T₉: 100% RDN through vermicompost + *Azotobacter* + PSB showed highest standard germination (87.83, 77.34, 69.39, 52.34 and 27.17%), seedling length (20.95, 18.93, 16.15, 14.95 and 12.50 cm), seedling dry weight (3.77, 3.44, 2.84, 2.21 and 1.87 g) and seed vigour index-I (1837, 1474, 1119, 780 and 339) and seed vigour index-II (330.7, 265.7, 196.9, 115.2 and 50.6) in treatment T₉: 100% RDN through vermicompost + *Azotobacter* + PSB. The least value observed in treatment T₁₆: control. The lowest value of electrical conductivity at 24, 48, 72, 96 and 120 hours (144.8, 233.0, 353.1, 497.7, 697.78 μ S/cm/g) was observed in treatment T₉: 100% RDN through vermicompost + *Azotobacter* + PSB the same treatments while the highest value was observed in (T₁₆) control (190.1, 302.9, 434.1, 602.2, 841.8 μ S/cm/g) on pooled mean basis.

Key words: Accelerated ageing, Germination, EC, Vermicompost, Vigour Index

Fennel (*Foeniculum vulgare* Mill.) is an open pollinated spice crop of subtropical and temperate regions belonging to *Apiaceae* family. It is originated from the Mediterranean region, where its high degree of genetic variability persists (Miranldi 1999). It is one of the most important winter season seed spices grown in Northern India for its edible seeds. However, its inflated leaf bases both raw and cooked are also eaten as a vegetable. In India, Gujarat, Rajasthan, West Bengal, Uttar Pradesh and Haryana are the major fennel growing states. It occupies an area of 91 thousand ha with production of 153 thousand metric tonnes. In Haryana, mainly grown in the district of Rewadi, Mahendragarh, Palwal, Hisar, which occupies an area of about 0.27 thousand hectares with the production of 0.17 thousand metric tonnes (Anonymous 2018). The seed quality is prerequisite to enhance the production and productivity. Use of high quality seeds increased productivity of crop by 15–20% (Sidhawani 1991). The quality of seed is mainly

measured by its genetic purity and capacity to develop into a healthy plant. Further, due to high value of seed spices, the quality of seeds becomes more important. The advantages of high seed vigor are most often associated with high rate of emergence and stand establishment. The laboratory germination test provides information about the seedling emergence potential of seed lots under favorable conditions (Singhal *et al.* 2017).

Quality seed is a basic input for realizing higher yield potential and determined by its purity, germination and health. Nowadays, besides seed germination, the seed vigor 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). Seed deterioration is a serious problem especially in tropical countries, where seed attains higher moisture at higher temperature and respiration becomes also high, which leads to seed deterioration and loss of viability (Singhal *et al.* 2017). Keeping in view, the present study has been conducted to study the effect of INM on relative storability of fennel seed.

MATERIALS AND METHODS

The present experiment was carried out during 2016-17 and 2017-18 at Chaudhary Charan Singh Haryana

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Agricultural University, Hisar. The seed material comprised a single variety Hisar Sawrup. The field experiment consisted of sixteen treatments, viz. T₁ {100% RDN through FYM + *Azotobacter*}, T₂ {75% RDN through FYM + *Azotobacter*}, T₃ {100% RDN through Vermicompost + *Azotobacter*}, T₄ {75% RDN through Vermicompost + *Azotobacter*}, T₅ {RDF (100%) + *Azotobacter*}, T₆ {RDF (75%) + *Azotobacter*}, T₇ {100% RDN through FYM + *Azotobacter* + PSB}, T₈ {75% RDN through FYM + *Azotobacter* + PSB}, T₉ {100% RDN through vermicompost + *Azotobacter* + PSB}, T₁₀ {75% RDN through vermicompost + *Azotobacter* + PSB}, T₁₁ {RDF (100%) + *Azotobacter* + PSB}, T₁₂ {RDF (75%) + *Azotobacter* + PSB}, T₁₃ {100% RDN through FYM}, T₁₄ {100% RDN through vermicompost}, T₁₅ {Recommended dose of fertilizer (N 50: P 25 kg/ha)} and T₁₆ {Control} combinations on the basis of recommended dose of fertilizer (N 50: P 25 kg/ha), vermicompost, farmyard manure, *Azotobacter* and PSB of fennel. The experiment was conducted in randomized complete block design with three replications. After proper drying, cleaning and attaining the optimum moisture content the seeds were collected and the completely randomized design (CRD) was followed to conduct laboratory testing for the seed relative storability parameters in the seed testing laboratory, Department of Seed Science and Technology, Chaudhary Charan Singh Haryana Agricultural University, Hisar. Freshly harvested seed from each treatment will be subjected to accelerated ageing for 24, 48, 72, 96 and 120 h at 40±1°C at 100% relative humidity and following seed quality parameters will be recorded. The observations recorded on seed relative storability parameters were standard germination, seedling length (cm), seedling dry weight (mg), seed vigour index-I, seed vigour index-II and electrical conductivity.

The observations recorded for seed germination were later converted into percent seed germination. Fifty seeds of each treatment in each replication were placed between the germination papers at a temperature of 25±1°C with 90-95% relative humidity in germinator. Final count was taken on 14th day. Seedling length (cm): It was measured for randomly selected 10 normal seedlings were collected from three replications by standard germination test and expressed in centimeter. At last, for final calculation average of 10 seedlings were considered. Seedling dry weight (mg): 10 normal seedlings selected for measuring seedling length were further kept in hot air oven for taking dry weight. These are dried at 80°C for 48 h and then seedling dry weight was expressed in milligram. The average weight of 10 seedlings was taken for further calculations. The vigour indices were calculated according to the following formulae suggested by Abdul Baki and Anderson (1973). Seed vigour Index I: Standard germination (%) × Average seedling length (cm). Seed vigour Index II: Standard germination (%) × Average seedling dry weight (mg). Electrical conductivity meter was used to measure the electrical conductivity, 50 normal and uninjured seeds in three replications were soaked in 75 ml deionized water in 100 ml beakers. Seeds were immersed completely in water and beakers were covered with foil.

Thereafter, these samples were kept for 24 h at 25°C. The electrical conductivity of the seed leakages was measured using a direct reading conductivity meter. The conductivity was measured in µS/cm/g. The recorded data were averaged and statistically analyzed as per Sheoran *et al.* (1998) using the statistical programme OPSTAT.

RESULTS AND DISCUSSION

Seed aging chamber was used to check the standard germination percentage of the fennel seeds (Table 1). The standard germination percentage at 24 h 87.83%, at 48 h 77.34%, at 72 h 69.39%, at 96 h 52.34 and at 120 h 27.17% under the treatment combination 100% RDN through vermicompost + *Azotobacter* + PSB (T₉), which were significantly higher over control (T₁₆). It was observed that standard germination of seed fennel reduced at different hours of interval during storability. Prolonged storage of seeds leads to deterioration and loss of germinability. Among the various reasons, the main are external and internal factors. Among the external factors the important one are irradiation, or fungal attack. Among the internal factors, the main are accumulation of noxious compounds, loss of vitamins or hormones, degradation of nucleic acids and proteins or membranes (Hussein *et al.* 2011). In the present study, under the control treatment (T₁₆), the standard germination was found lowest while in the combination of 100% RDN through vermicompost + *Azotobacter* + PSB (T₉) provided better opportunity to the fennel crop to accumulate more photosynthates, better partitioning, translocation and capability to less cellular deterioration and increased capacity to synthesis new m-RNAs and proteins as compared under the controlled conditions (Gidrol *et al.* 1988).

Seedling length and seedling dry weight were also observed higher under 100% RDN through vermicompost + *Azotobacter* + PSB (T₉) treatment as compared to control (T₁₆). The main reason is the higher photosynthetic ability of the fennel plants under vermicompost + *Azotobacter* + PSB (T₉) condition. Also *Azotobacter* might provide the fixed nitrogen to fennel plants resulting into higher growth. Higher dry matter syntheses resulted into higher photosynthetic ability and ultimately higher seedling length and seedling weight. The seedling length was 20.95 cm at 24 h, 18.93 cm at 48 h, 16.15 cm at 72 h, 14.95 cm at 96 h and 12.50 cm at 120 h in T₉: 100% RDN through vermicompost + *Azotobacter* + PSB as compared to lowest in T₁₆: Control i.e., 15.07 cm at 24 h, 14.27 cm at 48 h, 12.42 at 72 h, 11.61 cm at 96 h and 9.55 cm at h, respectively. Similar trend was observed in seedling dry weight (Table 1).

The electrical conductivity of the stored seed under seed chamber were recorded lowest, i.e. 133.7 µS/cm/g at 24 h, 215.9 µS/cm/g at 48 h, 332.5 S/cm/g at 72 h, 472.3 µS/cm/g at 96 h and 661.8 µS/cm/g at 120 h in the T₉ treatment where 100% RDN through vermicompost + *Azotobacter* + PSB as compared to higher electrical conductivity under controlled conditions (T₁₆), where no chemical source or organic source of fertilizer was used in fennel (Table 1). This suggested that under nutrient deficient conditions the leakage

Table 1 Effect of INM on standard germination, electrical conductivity and seedling length of fennel under accelerated ageing for different time period

Treatment	Standard germination (%)					Electrical conductivity ($\mu\text{S}/\text{cm}/\text{g}$)					Seedling length (cm)				
	24 h	48 h	72 h	96 h	120 h	24 h	48 h	72 h	96 h	120 h	24 h	48 h	72 h	96 h	120 h
T1	81.33	73.17	64.67	46.00	21.17	167.3	268.5	392.8	549.8	769.4	16.85	15.73	13.45	12.53	10.40
T2	79.33	71.67	63.17	44.17	19.00	177.8	285.0	412.4	575.0	805.2	15.40	14.65	12.53	11.73	9.68
T3	85.83	76.17	68.11	50.50	25.33	144.8	233.0	353.1	497.7	697.8	19.72	18.00	15.28	14.18	11.86
T4	84.00	74.67	66.67	48.50	23.33	155.1	249.6	374.6	523.2	733.2	18.35	16.72	14.40	13.37	11.13
T5	83.83	74.67	66.34	48.17	23.17	155.6	250.9	373.1	523.9	733.3	18.28	16.85	14.37	13.35	11.12
T6	81.50	73.17	64.84	46.00	21.00	166.7	268.1	392.6	549.3	769.0	16.85	15.73	13.44	12.56	10.41
T7	83.50	74.33	66.17	47.84	23.17	155.6	251.6	372.5	524.0	733.5	18.13	16.55	14.33	13.26	11.07
T8	81.50	73.17	64.84	45.83	21.34	166.5	268.8	392.2	549.4	768.4	16.85	15.73	13.44	12.52	10.42
T9	87.83	77.34	69.39	52.34	27.17	133.7	215.9	332.5	472.3	661.8	20.95	18.93	16.15	14.95	12.50
T10	86.17	75.95	67.72	50.33	25.33	144.4	232.8	352.5	497.7	696.6	19.58	17.85	15.23	14.12	11.77
T11	85.67	75.83	67.84	49.83	25.17	144.7	234.0	352.6	498.2	697.1	19.57	17.68	15.23	14.05	11.76
T12	83.50	74.67	66.33	48.00	23.17	155.8	251.3	372.3	523.4	732.0	18.28	16.68	14.38	13.33	11.12
T13	79.50	72.00	63.33	44.17	19.34	176.9	284.3	411.6	574.1	803.9	15.55	14.58	12.61	11.85	9.76
T14	84.17	74.83	66.72	48.67	23.50	154.3	248.8	372.0	522.2	732.2	18.29	17.00	14.46	13.48	11.21
T15	81.83	73.50	65.00	46.17	21.33	165.8	267.2	391.9	548.4	767.9	16.98	15.65	13.52	12.66	10.47
T16	78.17	70.67	62.50	43.33	18.33	190.1	302.9	434.1	602.2	841.8	15.07	14.27	12.42	11.61	9.55
SEm±	0.42	0.32	0.30	0.43	0.48	1.9	3.7	4.3	6.0	9.4	0.32	0.27	0.22	12.53	0.16
CD (P=0.05)	1.23	0.92	0.85	1.23	1.39	5.9	11.6	12.3	17.2	27.3	0.94	0.77	0.65	11.73	0.48

Table 2 Effect of INM on seedling dry weight, seed vigour index-I and seed vigour index-II of fennel under accelerated ageing for different time period

Treatment	Seedling dry weight (mg)						Seed vigour index-I						Seed vigour index-II								
	24 h	48 h	72 h	96 h	120 h	24 h	48 h	72 h	96 h	120 h	24 h	48 h	72 h	96 h	120 h	24 h	48 h	72 h	96 h	120 h	
T1	2.92	2.67	2.31	1.78	1.52	1370	1151	870	581	220	237.6	195.0	149.4	81.8	32.0						
T2	2.65	2.41	2.13	1.64	1.40	1222	1046	789	518	184	210.0	172.7	134.2	72.4	26.5						
T3	3.55	3.22	2.68	2.08	1.76	1692	1368	1042	716	300	304.1	244.9	182.7	104.9	44.5						
T4	3.25	2.95	2.50	1.94	1.65	1542	1248	960	648	259	272.7	220.5	166.7	94.1	38.3						
T5	3.23	2.94	2.49	1.93	1.64	1533	1258	953	643	257	269.9	219.2	165.1	92.9	37.8						
T6	2.93	2.68	2.30	1.79	1.52	1373	1151	871	578	218	238.6	196.2	149.2	82.3	31.7						
T7	3.19	2.89	2.47	1.91	1.62	1514	1257	949	638	256	265.8	215.0	163.2	91.0	37.4						
T8	2.93	2.66	2.31	1.78	1.52	1373	1150	870	574	222	238.4	194.8	149.6	81.5	32.2						
T9	3.77	3.44	2.84	2.21	1.87	1837	1474	1119	780	339	330.7	265.7	196.9	115.2	50.6						
T10	3.48	3.18	2.66	2.06	1.74	1687	1355	1032	711	298	299.4	241.7	180.3	103.6	43.9						
T11	3.46	3.16	2.64	2.06	1.73	1676	1345	1033	700	295	296.3	239.6	179.3	102.5	43.6						
T12	3.21	2.94	2.49	1.92	1.64	1527	1242	954	639	257	267.8	219.4	165.0	92.1	37.8						
T13	2.71	2.46	2.16	1.67	1.42	1236	1049	793	521	188	215.1	177.2	136.9	73.5	27.4						
T14	3.32	3.01	2.53	1.82	1.67	1551	1267	965	655	263	279.3	224.9	169.0	95.5	39.0						
T15	3.00	2.73	2.34	1.97	1.54	1390	1154	841	583	223	245.3	200.4	152.1	83.7	32.7						
T16	2.57	2.33	2.03	1.60	1.35	1178	1008	773	503	175	200.7	164.9	127.1	69.2	24.6						
SEM±	0.06	0.06	0.04	0.03	0.02	39.8	31.1	22.7	17.1	7.90	7.70	5.30	3.60	2.00	1.1						
CD (P=0.05)	0.19	0.17	0.12	0.09	0.06	115	90.0	65.8	49.6	22.8	22.4	15.40	10.30	5.90	3.1						

of the membrane is more due to which metabolites and biomolecules leached out and the seed quality deteriorates over the storage interval. Vermicompost along with both the biofertilizers created the nutrient efficient environment to fennel crop where the nutrient like nitrogen (*Azotobacter*) and phosphorus (PSB) might sufficiently provide to plants resulting in better growth and development. Also the better sink size (seed) resulting into storage of more reserve food material, helping the seed to face the extreme temperature and humid environments during their storage. The results are in confirmation with Kaewnaree *et al.* (2011) in sweet pepper, Singh (2012) in fenugreek and Sadik (2012) in of ajwain.

Seed vigour index-I and vigour index-II at 24 (1837, 330.7), 48 (1474, 265.7), 72 (1119, 196.9), 96 (780, 115.2) and 120 (339, 50.6) hours were found highest under T₉, where 100% recommended dose of nitrogen was applied through vermicompost along with *Azotobacter* and phosphorus solubilizing bacteria as compared to control T₁₆ (control), i.e. 1178, 200.7 at 24 h, 1008, 164.9 at 48 h, 773, 127.1 at 72 h, 503, 69.2 at 96 h, 175, 24.6 at 120 h, respectively (Table 2). The increase in vigour index is the better seed reserve food material due to better source-sink relationship and better nutrient availability due to vermicompost containing complex microorganisms supporting the better plant growth. It finally favored the better seed vigour index-I and II (ISTA 1993). The similar results were reported by Kumar (2015) in coriander and Shariq *et al.* (2015) in *Nigella sativa*.

The studied on the integrated nutrient management of fennel revealed that after accelerated ageing for 24, 48, 72, 96 and 120 h the seed received highest value of relative storability parameters in the treatment T₉: 100% RDN through vermicompost + *Azotobacter* + PSB, while T₁₆: control showed the minimum values for irrespective of all the parameters during both the years.

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