Indian Journal of Agricultural Sciences **91** (9): 1401–7, September 2021/Article
https://doi.org/10.56093/ijas.v91i9.116099

Storability as affected by seed pelleting and priming in fennel (*Foeniculum vulgare*)

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Received: 02 February 2021; Accepted: 26 February 2021

ABSTRACT

The present study was carried out at Laboratory of Department of Seed Science and Technology, CCS Haryana Agricultural University, Hisar to ascertain the effect of pelleting and priming material on storability of fennel (*Foeniculum vulgare* Mill.) seeds during 2017–19. The treatments comprising of 7 pelleting treatments, 14 priming treatments and a control were laid out in Completely Randomized Design with three replications. The seed quality relating to physiological traits decreased with advancement in storability except for electrical conductivity. Better retention of seed quality characters, viz. standard germination, speed of emergence, seedling dry weight, vigour indices was observed in the seeds pelleted with Captan (3 g/kg) + Imidacloprid (2 g/kg) followed by KNO_3 (1%) and neem leaf powder (100 g/kg seeds) after 18 months of storage (except seedling length and seed vigour index-I). The minimum EC was recorded in seeds primed with *Trichoderma viride* (8 g/kg seed), followed by KNO_3 (1%) and seeds pelleted with Captan @3 g/kg + Imidacloprid @2 g/kg. Therefore, it can be concluded that in order to maintain better seed quality of fennel during storage, seed pelleting proved superior over seed priming that ought to be given as pre-sowing treatment not as pre-storage treatment.

Keywords: Fennel, Pelleting, Priming, Storability

Fennel (*Foeniculum vulgare* Mill.), also known as *Saunf* is an aromatic biennial plant. India is the largest producer with 53.3% of global production and covering 89.58 thousand ha area producing 148.64 thousand metric tonnes (Anonymous 2017). The whole plant of fennel is valuable. Its leaves and seeds are used in many culinary traditions (Ehsanipour *et al*. 2012), Its aromatic fruits Used in various food preparations. The average productivity is only 1.66 MT/ha ascribed to poor seed germination rate. Seed deterioration is a serious problem Indian climatic condition. In view of the fact that the loss of viability impairs the biological and planting value of seed, it is of special concern to breeders, farmers and businessmen. Higher relative humidity and temperature cause high moisture content in seeds ensuing in low germination at the end of storage (McCormack 2004). Hence, storage of seeds after harvest till next planting time is of prime importance in any successful seed production programme. Complete and appropriate knowledge regarding storage of fennel seeds under ambient environmental conditions with minimum loss in seed quality for a period of atleast one or more seasons will be of enormous use for seed industry and farming community. As there is meager information available regarding storage life of primed and pelleted fennel seeds, therefore, keeping in view the above background and considering the importance of fennel in national economy, the investigation was undertaken to ascertain the effect of seed pelleting and priming on storability of fennel seeds.

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MATERIALS AND METHODS

The investigation was conducted to ascertain the combined effect of both pelleting and priming on the storability of fennel seeds for a period of 18 months under ambient conditions on cultivar Hisar Swarup (HF 33) during 2017–19 at CCS Haryana Agricultural University, Hisar. Fennel seeds of cultivar Hisar Swarup (HF 33) were collected from Department of Vegetable Science with standard germination above Indian Minimum Seed Certification Standard (IMSCS). The experiment was laid in completely randomized block design with three replications and 22 number of treatments (7 for pelleted seeds + 14 for primed seeds + control). The statistical method described by Panse and Sukhatme (1961) was followed for the analysis and interpretation of experimental results. The pelleting of fennel seed was done with three botanicals and four chemicals. Gum arabica was used as binder/adhesive and wood ash was used as filler material for pelleting of treatments P_5 to P_8. Before pelleting, moisture content of seeds was brought to about 8.0%. Afterwards the treated seeds were dried for three days under shade. Seed priming

was carried out using three botanicals, four chemicals, one hydration-dehydration, three bio-agents each with two different concentrations. The pelleted and primed seeds were stored under ambient conditions and observations were taken at three months interval for 18 months or till the germination falls below IMSCS (Indian Minimum Seed Certification Standards). Seeds were stored in polythene bags of 700 gauge. Immediately, polythene bags were heat sealed. The treatment details are here as-

P_1- Control; P_2 - *Pongamia* leaf powder (100 g/kg seed); P_3 - Turmeric leaf powder (100 g/kg seed); P_4 - Neem leaf powder (100 g/kg seeds); P_5 - KH_2PO_4 (2.0%); P_6 - KNO_3 (1.0%); P_7 - K_2SO_4 (1.0%); P_8 - Captan (3 g/kg) + Imidacloprid (2 g/kg).

T_2 - Hydration- dehydration; T_3 - $CaCl_2$ (1%); T_4 - NaCl (1%); T_5 - KH_2PO_4 (1%); T_6 - KNO_3 (1%); T_7 - Turmeric leaf extract (10%); T_8 - *Pongamia* leaf extract (10%); T_9 - Neem leaf extract (10%); T_{10} - *Trichoderma viride* (4 g/kg seed); T_{11} - *Trichoderma viride* (8 g/kg seed); T_{12} - *Pseudomonas fluorecens* (4 g/kg seed); T_{13} - *Pseudomonas fluorecens* (8 g/kg seed); T_{14} - *Trichoderma harzianum* (4 g/kg seed); T_{15} - *Trichoderma harzianum* (8 g/kg seed).

For measuring the moisture content (%), five grams of seeds was taken. The powdered seed material was placed in a weighed moisture aluminium cup and placed in hot air oven maintained at 105 ± 2°C for 24 h (Selvi *et al*. 2006) after removing the lid. After that the dried content was weighed in an electronic balance along with bottle and lid. The moisture content was worked out by using the following formula and expressed as percentage.

$$\text{Moisture content (\%)} = \frac{M_2 - M_3}{M_2 - M_1} \times 100$$

where, M_1 = weight of the aluminium cup alone; M_2 = weight of the aluminium cup + sample before drying; M_3 = weight of the aluminium cup + sample after drying.

Germination percentage was worked out according to standard germination procedure of ISTA (2011).

$$\text{Germination (\%)} = \frac{\text{Number of normal seedlings}}{\text{Total number of seeds used}} \times 100$$

Speed of emergence was calculated as per formula of Maguire (1962).Twenty five seeds were selected at random from all the treatments and were used for the radical emergence studies. This was carried out by using top paper methods in the seed germinator at 25°C. The radicle emergence was recorded up to 14th day. Germination counts were taken every day till last count.

$$\text{Speed of emergence} = \sum [n1/d1 + n2\text{-}n1/d2 + \ldots\ldots nn\text{-} nn\text{-} 1/dn]$$

where, n= number of seeds germinated on day (d); d= serial number of days.

The height of seedlings was measured on 14th day of germination test. Ten normal seedlings selected at random and the seedling height was worked out by taking the total of seedlings from the tip of the primary leaf to the tip of primary root with the help of scale and expressing the mean value in centimeter (cm). Seedlings selected for measuring seedling height were used to work out seedling dry weight and were kept in oven at 80°C for 48 h. Weights were measured and mean values were expressed in milligrams (mg). Seedling vigour index-I (SVI-I) and Seedling vigour index -II (SVI-II) were calculated as per the formula given by Abdul-Baki and Anderson (1973).

SVI-I = Average length of seedling × Seed germination percentage

SVI-II = Average dry weight of seedling × Seed germination percentage

Electrical conductivity was measured using 50 normal and undamaged seeds of each treatment. Seeds were imbibed in 75 ml deionized water in 100 ml beakers. The beakers were covered with aluminum foil and were kept at 25°C for 24 h. The electrical conductivity of the seed leachates was measured using a direct reading conductivity meter and was expressed in µS/cm/seed. The seed quality parameters at initial levels, fennel cv. HF 33 before storage (Initial level) were moisture content (7.96%), standard germination (80%), speed of emergence (21.66), seedling length (12.42 cm), seedling dry weight (3.41 mg), seedling vigour Index-I (992), seedling vigour Index-II (266) and electrical conductivity (4.83 µS/cm/g).

RESULTS AND DISCUSSION

Marked differences in moisture content among the pelleted and primed seeds can be seen during storage and it also indicates the gradual decrease of moisture content with the course of storage period (Table 1). From the third month of storage period to the end of the experiment, significantly higher moisture content (%) was noticed in primed seeds as compared to control and pelleted seeds. At the end of experiment, maximum moisture content (7.34%) was recorded when seeds were primed with KH_2PO_4 (1.0%) and KNO_3 (1%), which was statistically at par with all other priming treatments, whereas, the minimum (7.03%) was recorded when seeds are pelleted with *Pongamia* leaf powder (100 g/kg seed), which was statistically at par with all other pelleting treatments and control. Higher moisture content in primed seeds could be due to the maintenance of higher water balance in the seed tissues throughout the storage period. The comparison of pelleting and priming on standard germination of fennel cv. HF-33 at different ageing periods (3, 6, 9, 12, 15 and 18 months old) indicates that, with the advancement of storability standard germination (%) declined irrespective of seed treatment (Table 1). Rate of decrease was higher in priming treatments as compared to pelleting treatments. After 3 months of storage, maximum germination (89.33%) was found in seeds pelleted with Captan (3 g/kg) + Imidacloprid (2 g/kg), which was statistically at par with neem leaf powder (100 g/kg seeds), i.e. 87.00% and KNO_3 (1.0%), i.e. 86.00%. Whereas, in primed seeds after three months of storage, the standard germination was found higher with *Trichoderma viride* (8 g/kg seed), i.e. 88.67%, with KNO_3 (1%), i.e. 88.00%, with neem leaf extract (10%), i.e. 87.33% and with *Trichoderma harzianum* (8g/kg seed),

Table 1 Effect of seed pelleting and priming on moisture content (%), standard germination (%), speed of emergence and seedling length (cm) during storability of fennel cv. HF 33

Treatment	Moisture content (%); Standard germination (%)						Speed of emergence; Seedling length (cm)					
	Storage period (in months)											
	3	6	9	12	15	18	3	6	9	12	15	18
P_1	7.86; 78.33 (62.27)*	7.67; 7.33 (61.56)	7.44;75.67 (60.45)	7.29; 75.33 (60.22)	7.13; 4.67 (59.76)	7.06; 73.33 (58.90)	21.33; 11.87	19.02; 10.51	18.40; 10.19	17.33; 10.07	15.34; 9.77	13.77; 9.13
P_2	7.84; 84.33 (66.71)	7.52; 83.33 (65.93)	7.37; 83.00 (65.64)	7.17; 82.33 (65.13)	7.09; 82.00 (64.88)	7.03; 80.33 (63.66)	22.78; 12.87	21.78; 12.79	20.81; 12.05	19.80; 11.59	18.23; 10.88	16.85; 10.24
P_3	7.81; 84.33 (66.67)	7.57; 82.67 (65.38)	7.42; 81.33 (64.39)	7.29; 80.67 (63.94)	7.15; 80.33 (63.66)	7.04; 79.33 (62.97)	22.84; 12.87	21.69; 12.71	20.85; 11.79	19.68; 11.51	18.01; 10.88	17.09; 10.23
P_4	7.85; 87.00 (68.84)	7.62; 85.67 (67.76)	7.40; 85.33 (67.47)	7.30; 84.33 (66.70)	7.15; 83.67 (66.15)	7.05; 81.67 (64.63)	24.03; 12.85	23.64; 12.66	21.94; 11.39	21.53; 11.08	19.79; 9.91	18.71; 9.32
P_5	7.89; 82.00 (64.90)	7.64; 81.33 (64.38)	7.46; 80.67 (63.93)	7.28; 78.67 (62.49)	7.12; 77.00 (61.33)	7.05; 75.33 (60.21)	22.45; 12.65	20.01; 11.82	19.75; 11.63	19.00; 11.12	16.25; 9.87	14.99; 9.43
P_6	7.85; 86.00 (68.05)	7.66; 85.66 (67.74)	7.40; 84.67 (66.96)	7.22; 83.33 (65.95)	7.16; 83.00 (65.70)	7.09; 81.67 (64.63)	23.15; 13.12	23.04; 12.98	21.95; 12.37	21.48; 11.61	19.69; 11.08	18.88; 10.69
P_7	7.86; 84.00 (66.42)	7.55; 82.33 (65.13)	7.38; 82.00 (64.87)	7.22; 80.33 (63.69)	7.09; 79.67 (63.18)	7.05; 79.00 (62.70)	22.80; 12.72	20.78; 12.14	20.22; 11.72	19.25; 11.34	17.86; 10.81	16.81; 10.18
P_8	7.84; 89.33 (70.99)	7.57; 89.00 (70.65)	7.43; 87.33 (69.14)	7.25; 86.67 (68.57)	7.12; 86.00 (68.06)	7.05; 83.67 (66.15)	24.88; 13.72	24.00; 13.27	22.83; 13.11	22.15; 12.71	20.40; 12.04	19.23; 11.72
T_2	8.29; 82.00 (64.90)	8.13; 80.00 (63.42)	7.93; 79.67 (63.19)	7.78; 79.00 (62.73)	7.42; 78.33 (62.26)	7.27; 78.33 (62.24)	22.03; 12.40	19.44; 11.47	18.88; 11.08	18.30; 10.79	17.11; 10.27	15.88; 9.82
T_3	8.31; 85.00 (67.28)	8.19; 85.00 (67.21)	8.00; 84.33 (66.69)	7.69; 82.67 (65.40)	7.40; 80.67 (63.91)	7.25; 78.33 (62.28)	23.40; 13.14	20.68; 12.05	19.57; 11.64	18.49; 10.83	17.50; 10.39	15.86; 9.75
T_4	8.33; 85.00 (67.26)	8.05; 84.00 (66.40)	8.02; 83.67 (66.16)	7.63; 82.33 (65.16)	7.47; 80.33 (63.66)	7.32; 77.67 (61.79)	23.03; 13.03	20.41; 11.84	19.39; 11.27	18.02; 10.68	16.80; 10.22	15.82; 9.72
T_5	8.22; 82.67 (65.42)	8.12; 79.67 (63.18)	8.00; 79.33 (62.95)	7.65; 78.67 (62.48)	7.52; 78.00 (62.03)	7.34; 76.00 (60.65)	21.56; 12.13	19.29; 11.27	18.89; 11.06	17.68; 10.67	16.70; 10.12	15.01; 9.48
T_6	8.36; 88.00 (69.71)	8.13; 87.67 (69.42)	8.03;86.00 (68.01)	7.83; 84.67 (66.95)	7.42; 82.33 (65.16)	7.34; 78.33 (62.26)	24.09; 13.42	23.13; 12.64	21.89; 11.66	21.69; 11.25	19.58; 10.44	18.39; 10.00

(*Contd.*)

Table 1 (*Concluded*)

Treatment	Moisture content (%); Standard germination (%)						Speed of emergence; Seedling length (cm)					
	Storage period (in months)											
	3	6	9	12	15	18	3	6	9	12	15	18
T_7	8.27; 81.33 (64.42)	8.06; 81.00 (64.16)	7.98; 80.33 (63.69)	7.86; 78.33 (62.24)	7.40; 77.33 (61.56)	7.25; 75.67 (60.43)	21.70; 12.20	19.50; 11.43	19.01; 11.12	17.60; 10.46	16.45; 10.12	15.01; 9.46
T_8	8.37; 80.67 (63.93)	8.22; 79.00 (62.71)	7.96; 78.33 (62.24)	7.70; 77.67 (61.80)	7.42; 77.00 (61.33)	7.32; 76.00 (60.65)	21.49; 12.05	19.10; 11.21	18.46; 10.61	17.54; 10.32	16.28; 9.89	15.03; 9.64
T_9	8.28; 87.33 (69.14)	8.13; 85.67 (67.80)	7.99; 83.67 (66.15)	7.76; 84.00 (66.44)	7.52; 82.00 (64.89)	7.29; 79.33 (62.95)	24.00; 13.26	20.88; 12.11	19.58; 11.54	18.23; 10.73	17.00; 10.24	15.89; 9.91
T_{10}	8.31; 80.67 (63.90)	8.17; 79.67 (63.19)	8.05; 78.67 (62.48)	7.68; 77.67 (61.81)	7.50; 76.67 (61.11)	7.26; 75.33 (60.22)	21.56; 12.14	19.30; 11.37	18.63; 10.87	17.44; 10.19	16.00; 9.87	15.00; 9.32
T_{11}	8.24; 88.67 (70.41)	8.18; 86.67 (68.64)	7.95; 85.67 (67.82)	7.65; 84.67 (66.93)	7.54; 83.33 (65.91)	7.24; 80.00 (63.44)	24.39; 13.51	23.03; 12.57	21.85; 11.75	21.65; 11.33	19.82; 10.67	18.69; 10.13
T_{12})	8.25; 80.33 (63.66)	8.23; 79.67 (63.18)	8.06; 77.33 (61.59)	7.67; 77.00 (61.33)	7.51; 75.00 (59.98)	7.28; 74.33 (59.57)	21.46; 12.04	19.29; 11.25	18.56; 10.59	17.41; 10.17	15.89; 9.79	14.62; 9.21
T_{13}	8.24; 82.67 (65.38)	8.08; 80.67 (63.92)	7.98; 78.67 (62.47)	7.69; 78.00 (62.02)	7.47; 77.33 (61.56)	7.27; 76.67 (61.10)	22.09; 12.32	19.99; 11.79	18.67; 10.98	17.59; 10.34	16.32; 10.10	15.35; 9.72
T_{14}	8.36; 82.00 (64.89)	8.17; 81.33 (64.39)	7.98; 80.00 (63.43)	7.81; 79.00 (62.73)	7.53; 78.67 (62.49)	7.25; 77.33 (61.58)	22.19; 12.42	19.67; 11.73	19.25; 11.17	18.45; 10.81	17.06; 10.27	16.00; 9.87
T_{15}	8.21; 87.33 (69.13)	8.17; 86.67 (68.61)	8.06; 84.67 (66.99)	7.68; 83.67 (66.16)	7.49; 82.00 (64.89)	7.29; 79.67 (63.18)	23.34; 13.20	20.95; 12.15	20.25; 11.69	19.55; 10.96	18.51; 10.53	17.72; 10.05
SEm±	0.063; 1.12	0.091; 0.94	0.105; 0.98	0.093; 0.99	0.065; 0.87	0.059; 0.85	0.40; 0.22	0.38; 0.21	0.36; 0.22	0.34; 0.20	0.29; 0.16	0.32; 0.15
CD at 5%	0.18; 3.20	0.26; 2.71	0.30; 2.81	0.26; 2.85	0.18; 2.49	0.16; 2.43	1.14; 0.65	1.08; 0.60	1.02; 0.63	0.96; 0.57	0.84; 0.47	0.92; 0.44

* The figures in parentheses are angular transformed values

Table 2 Effect of seed pelleting and priming on seedling dry weight (mg), seedling vigor index I, seedling vigor index- II and electrical conductivity (µS/cm/seed) during storability of fennel cv. HF 33

Treatment	Seedling dry weight (mg) ; Seedling vigor index- I						Seedling vigor index- II; Electrical conductivity (µS/cm/seed)					
	Storage period (in months)											
	3	6	9	12	15	18	3	6	9	12	15	18
P_1	3.23; 930	3.18; 812	3.11; 772	3.04; 758	2.99; 730	2.90; 669	253; 6.83	245; 7.03;	236; 7.28	229; 7.62	224; 8.08	213; 8.62
P_2	3.59; 1084	3.60; 1071	3.52; 1001	3.46; 954	3.41; 895	3.35; 822	302; 5.15	301; 5.50	292; 5.87	285; 6.27	280; 6.82	269; 7.20
P_3	3.62; 1089	3.60; 1050	3.52; 957	3.45; 929	3.40; 872	3.33; 812	306; 5.13	297; 5.47	285; 5.80	279; 6.19	273; 6.66	264; 7.12
P_4	3.67; 1115	3.65; 1087	3.61; 973	3.56; 933	3.51; 819	3.40; 758	322; 4.33	313; 4.84	308; 5.22	300; 5.66	290; 6.12	283; 6.74
P_5	3.42; 1041	3.43; 968	3.39; 939	3.38; 874	3.08; 761	3.01; 710	281; 5.34	280; 5.69	273; 5.99	266; 6.44	238; 6.99	227; 7.39
P_6	3.64; 1179	3.63; 1138	3.56; 1096	3.54; 1044	3.51; 991	3.43; 924	320; 4.93	310; 5.41	306; 5.71	294; 6.04	291; 6.40	285; 6.87
P_7	3.54; 1066	3.48; 1000	3.47; 959	3.43; 909	3.38; 863	3.30; 805	296; 5.11	286; 5.47	284; 5.79	275; 6.10	270; 6.60	261; 7.00
P_8	3.76; 1220	3.72; 1180	3.66; 1143	3.58; 1098	3.55; 1031	3.46; 980	336; 3.99	330; 4.48	319; 4.87	309; 5.27	304; 5.95	293; 6.39
T_2	3.45; 1016	3.31; 918	3.22; 883	3.28; 854	3.28; 805	3.16; 769	282; 5.29	265; 5.69	256; 5.98	260; 6.32	257; 6.88	247; 7.28
T_3	3.63; 1143	3.47; 1038	3.41; 979	3.35; 905	3.32; 848	3.15; 791	316; 4.24	299; 4.60	287; 4.92	280; 5.38	271; 5.98	256; 6.45
T_4	3.62; 1115	3.45; 995	3.35; 942	3.25; 886	3.20; 831	3.14; 787	309; 4.28	290; 4.61	280; 4.97	270; 5.47	260; 6.04	254; 6.56
T_5	3.31; 978	3.25; 900	3.22; 880	3.19; 839	3.17; 789	3.03; 723	266; 5.97	259; 6.44	256; 6.81	251; 7.37	247; 7.72	231; 7.99
T_6	3.74; 1185	3.59; 1146	3.55; 1106	3.48; 954	3.44; 874	3.41; 813	330; 3.94	314; 4.37	304; 4.70	288; 5.17	278; 5.82	266; 6.32
T_7	3.35; 994	3.30; 926	3.30; 891	3.16; 820	3.12; 784	3.02; 716	272; 5.36	267; 5.76	264; 6.05	248; 6.51	242; 7.03	228; 7.43
T_8	3.29; 971	3.21; 887	3.17; 831	3.14; 801	3.09; 763	3.05; 737	265; 6.44	254; 6.79	248; 6.98	244; 7.38	239; 7.76	233; 8.23
T_9	3.66; 1007	3.52; 1038	3.36; 971	3.26; 901	3.26; 854	3.21; 818	319; 3.96	302; 4.39	283; 4.84	274; 5.21	272; 5.87	265; 6.34
T_{10}	3.33; 987	3.28; 908	3.18; 854	3.10; 792	3.06; 758	3.00; 701	270; 5.30	261; 5.70	250; 5.99	241; 6.40	235; 6.89	226; 7.33
T_{11}	3.75; 1196	3.55; 1190	3.54; 1118	3.47; 1076	3.46; 988	3.42; 914	332; 3.89	315; 4.35	306; 4.67	292; 5.07	287; 5.80	275; 6.23
T_{12}	3.28; 968	3.25; 897	3.16; 818	3.09; 781	3.00; 736	2.96; 686	263; 5.72	258; 6.13	244; 6.44	237; 6.88	226; 7.36	221; 7.93
T_{13}	3.39; 1008	3.37; 950	3.22; 864	3.16; 808	3.11; 783	3.13; 747	277; 6.47	271; 6.81	253; 7.02	247; 7.47	241; 7.83	241; 8.27
T_{14}	3.47; 1020	3.39; 954	3.34; 894	3.30; 855	3.23; 807	3.22; 765	285; 5.19	275; 5.58	267; 5.93	261; 6.32	254; 6.85	250; 7.23
T_{15}	3.65; 1153	3.54; 1051	3.46; 987	3.37; 917	3.32; 876	3.27; 818	318; 4.04	306; 4.59	292; 4.87	282; 5.31	276; 5.98	267; 6.44
SEm±	0.06; 20.9	0.06; 24.1	0.06; 17.8	0.05; 22.2	0.05; 18.7	0.06; 19.8	6.63; 0.09	7.16; 0.09	5.74; 0.10	7.02; 0.11	6.10;0.12	6.84; 0.14
CD at 5%	0.17; 60	0.18; 69	0.16; 51	0.15; 63	0.15; 53	0.17; 56	19; 0.26	20; 0.28	16; 0.29	20; 0.32	17; 0.36	20; 0.40

i.e. 87.33%, which was statistically at par with seeds pelleted with Captan (3 g/kg) + Imidacloprid (2 g/kg). At the end of experiment, maximum germination (83.67 %) was retained by the seeds pelleted with Captan @ 3 g/kg + Imidacloprid @ 2 g/kg, followed by neem leaf powder (100 g/kg seeds), i.e. 81.67 %, KNO_3 (1.0%), i.e. 81.67% and *Pongamia* leaf powder (100 g/kg seed), i.e. 80.33%, while minimum (73.33%) was recorded in control. Speed of emergence was found maximum in the beginning in all the treatments, but a decreasing trend was observed afterwards (Table 1). The seeds pelleted using Captan (3 g/kg) + Imidachloprid (2 g/kg) maintained higher speed of emergence (19.23) till the end of experiment followed by KNO_3 (1%), i.e. 18.88, neem leaf powder (100 g/kg seeds), i.e. 18.71, seed primed with *Trichoderma viride* (8 g/kg seed), i.e. 18.69 and with KNO_3 (1.0%), i.e. 18.39, while the lower speed of emergence (13.77) was recorded in control. The pelleting and priming treatments showed significant variation in seedling length throughout the storage period (at 3, 6, 9, 12, 15, 18 months of storage). In general, there was linear decrease in the seedling length with increased storage period (Table 2). At the end of the experiment, maximum seedling length (11.72 cm) was recorded in seeds pelleted with Captan (3 g/kg) + Imidacloprid (2 g/kg) followed by KNO_3 (1.0%), i.e. 10.69 cm, whereas minimum seedling length (9.13 cm) was recorded in control. A gradual decrease in the seedling dry weight can be observed with the passage of storage period among all the treatments (Table 2). At the end of storage period, the maximum value for seedling dry weight was recorded in the seeds pelleted with Captan (3 g/kg) + Imidacloprid (2 g/kg), i.e. 3.46 mg, which was statistically at par with KNO_3 (1.0%), i.e. 3.43 mg, *Trichoderma viride* (8 g/kg seed), i.e. 3.42 mg, KNO_3 (1%), i.e. 3.41 mg and neem leaf powder (100 g/kg seeds), i.e. 3.40 mg and the lowest (2.90 mg) was observed under the control. The perusal of data on seedling vigour index-I (Table 2) indicates a decrease in seedling vigour index-I as the storage period increases among all the treatments. At the end of storage period, maximum value was recorded when the seeds were pelleted with Captan (3 g/kg) + Imidacloprid (2 g/kg), i.e. 980, which was statistically at par with seeds pelleted with KNO_3 (1.0%), i.e. 924 and the lowest (669) was found in control. Data (Table 2) shows a decline in the seedling vigour index-II as the storage period progresses among all the treatments. At the end of storage period, the highest value (293) was recorded when the seeds were pelleted with Captan (3 g/kg) + Imidacloprid (2 g/kg), which was statistically at par with KNO_3 (1.0%), i.e. 285, neem leaf powder (100 g/kg seeds), i.e. 283 and the lowest was indicated in the control (213). Retaining the different physiological parameters even after storage for 18 months in pelleting treatments might be due to the control of physiological deterioration of seeds owing to fungal invasion, insect attack and physiological ageing by their antifungal and antioxidant effects as a result of which seed viability could be maintained for longer period of time in fennel. The results of present study confirms the results of Hridya *et al*. (2017) in soyabean, which was in favour of botanicals treatments in order to enhance the seed quality performance and contradicts with Sharanamma (2002) who noticed that seed pelleting with different chemicals recorded decline in seed quality parameters with the increase in storage period in chilli. Contrarily, an opposite trend was found in case of electrical conductivity as compared to above parameters studied, which were increasing. At the end of storage period, the lowest value (6.23 µS/cm/seed) was observed when seeds were primed with *Trichoderma viride* (8 g/kg seed), which was statistically at par with seeds primed with KNO_3 (1%), i.e. 6.32 µS/cm/seed, seeds pelleted with Captan (3 g/kg) + Imidacloprid (2 g/kg), i.e. 6.39 µS/cm/seed, seeds primed with $CaCl_2$ (1%), i.e. 6.45 µS/cm/seed, *Trichoderma harzianum* (8g/kg seed), i.e. 6.44 µS/cm/seed and NaCl (1%), i.e. 6.56 µS/cm/seed, while the highest value was recorded in control (8.62 µS/cm/seed) (Table 2). The difference in electrical conductivity of seed leachate might be due to the fact that there is enhanced rate of lipid peroxidation with ageing, which resulted in the high leakage of metabolites from aged seed along with increased membrane permeability and decrease in cellular membrane integrity. The experimental results are in line with the findings of Beedi *et al*. (2018) who reported that, seeds treated with mancozeb 50% + carbendazim 25% @ 3 g/kg of seed recorded significantly lowest electrical conductivity (0.742 dS/m) at the end of ninth month of storage in kabuli chickpea cv. MNK-1 and also with Baig (2005) who noted that seed coating with vitavax or bavistin @ 2 g/kg seed and polymer @ 5 g/kg seed exhibited lower electrical conductivity throughout the storage period in soybean.

Based on results, it is concluded that seed should be pelleted with Captan @ 3 g/kg + Imidacloprid @ 2 g/kg so as to maintain better seed quality of fennel during storage and in case of botanicals/organic treatments, one could use neem leaf powder (100 g/kg seeds) as pelleting material. Also, priming treatment must be given as pre-sowing treatment not as pre-storage treatment.

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