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EFFECT OF DIFFERENT SEED ENCRUSTATION TREATMENTS ON SEED QUALITY PARAMETERS OF RADISH CROP UNDER AMBIENT STORAGE CONDITION

Pranaya Padhi*, Abhinav Dayal and Prashant Kumar Rai
Department of Genetics and Plant Breeding. Sam Higginbottom University of Agriculture, Technology and Sciences, Naini, Prayagraj-211007, U.P., India
* Email- padhipranay@gmail.com
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ABSTRACT

Seed encrustation is one of the important seed quality enhancement techniques adopted in small seeded crops to overcome the problem of slow, asynchronous and poor seedling establishment. Considering the effect of various seed encrustation treatment on the physiological properties of a seed during germination, an experiment was conducted during March 2022 to June 2022 at the Seed Testing Laboratory (Notified by Government of Uttar Pradesh) Department of Genetics and Plant Breeding, SHUATS, Prayagraj (U.P) India. In this research, seeds of radish variety Pusa Chetki were taken to study and to evaluate the influence of different organic botanicals and storage containers on the seedling character under ambient conditions of storage. Radish seeds were encrusted with five different organic botanicals *viz.* neem leaf powder, aloevera leaf powder, turmeric powder, moringa leaf powder, and black pepper powder and are stored in three types of containers viz. polyurethane containers (C1), aluminium zip pouches (C2) and cloth bag (C3). All the quality parameters were evaluated during every month of storage. The experiment was conducted in factorial CRD with 4 replications. The experimental result showed that the organic botanicals influenced the radish seedling as well as physiological parameters. Seed treated with moringa leaf powder @15g/kg of seed (T11) performed better in terms of seed quality parameters; viz. germination per cent (81.25%), germination rate (0.30), root length (6.63 cm), shoot length (6.52 cm), seedling length (13.16 cm), fresh weight (1.79 gm/10 seedlings), dry weight (0.55 gm /10 seedlings), vigour indices (VI-I=1068.49, VI-II= 45.48), seed density (1.13 gm/cm^3), electrical conductivity (0.924 dSm^{-1}), seed metabolic efficiency (0.24), and seed mobilization efficiency (60.39%) as compared to control (T0) at the end of 3 months of storage. The study concluded that the combination of aluminium zip pouch with moringa leaf powder @15g/kg of seed can be used to expand the storability of radish seeds under ambient storage condition.

Keywords: Seed encrustation, Radish, Organic botanicals, Seedling parameters, Physiological properties.

Introduction

Radish (*Raphanus sativus L.*) belongs to Brassicaceae family; it is a cool season crop which grows best in autumn and spring all over the world. It is originated probably in indo-Pakistan subcontinent and western and central China (Khan *et al.,* 2021). It can be cultivated under cover for early production but large scale production in field is more common in India. Radish is grown for its young tender tuberous root which is consumed either cooked or raw. It is a good source of Vitamin C (ascorbic acid) and minerals like calcium, potassium and phosphorus. (Randy & Politud, 2016) The variability existing among the cultivated forms is in morphology and ecology signifies the multicentre origin of the crop. Is has been in cultivation for ages, having been grown and used by the ancient Egyptians and Greeks. Radish is a favourite crop of farmers because of its quick growth. It is grown as an important winter vegetable for its edible young.

Seed encrustation is one of the important seed quality enhancement techniques adopted in small seeded crops to overcome the problem of slow, asynchronous and poor seedling establishment. Radish seeds are small in size, irregular in shape hence pose problems in sowing due to singling and ultimately crop establishment. Seed enhancement techniques like film coating and encrusting help in giving uniform size, singling seed and facilitate better sowing. Thus helps to reduce emergence time, accomplish uniform emergence and give better crop stand Seed encrustation is one of the important seed quality enhancement techniques adopted in small seeded crops to overcome the problem of slow, asynchronous and poor seedling establishment (Malik & Hilli, 2020)

Encrusting is an important seed quality enhancement technique which involves gradual accumulation of layers of adhesive and inert material on the seed together with the application of insecticides, fungicides, nutrients and growth regulators. There is difference between pelleted and encrusted seeds, while both differ by change in their size and weight; encrusted seeds have the same shape as that of original seeds, but pelleted seeds become completely spherical (Malik & Hilli, 2020).

Encrusted seed is coated with a smaller amount of material than that of pelleted seed. The buildup of coating material is stopped before the treated seed attains roundness. Encrusted seeds can be used in protected culture or direct field applications. Encrusting adds more weight to the finished product than film coating and significantly less weight than pelleting. Generally, encrusting increases the weight of the seed from 150% to 350%.

Materials and Method

The current study was conducted in a factorial CRD with four replications. To standardize the seedling parameters, the present study was conducted at Seed testing laboratory (Notified by Govt. of Uttar Pradesh), Department of Genetics and Plant Breeding. Sam Higginbottom University of Agriculture, Technology and Sciences, Naini, Prayagraj (U.P.) India during march 2022 to June 2022.

Sources of seeds and organic botanicals

The seeds of radish variety Pusa Chetki were purchased from the local seed market in Prayagraj, U.P., India. The botanicals viz., Neem leaf powder, and moringa leaf powder were prepared handmade at home by collecting the leaves of neem and moringa, sundrying it for 2 days then crushing it into fine powder form, black pepper powder and turmeric powder were purchased from the local grocery shop in prayagraj and the aloevera leaf powder was purchased from the online shopping website.

Treatment details

The experiment consists of 45 treatment combinations involving 3 storage containers and 15 seed treatments.

Treatments (T)

S. No	Treatments	Concentration
T_O	Control	-
T_1	Neem leaf powder	10g/kg of seed
T_2	Neem leaf powder	15g/kg of seed
T_3	Neem leaf powder	25g/kg of seed
T_4	Aloevera leaf powder	15g/kg of seed
T_5	Aloevera leaf powder	20g/kg of seed
T_6	Aloevera leaf powder	25g/kg of seed
T_7	Turmeric powder	15g/kg of seed
T_8	Turmeric powder	25g/gm of seed
T_9	Turmeric powder	20g/kg of seed
T_{10}	Moringa leaf powder	10g/kg of seed
T_{11}	Moringa leaf powder	15g/kg of seed
T_{12}	Moringa leaf powder	20g/kg of seed
T_{13}	Black pepper powder	15g/kg of seed
T_{14}	Black pepper powder	20g/kg of seed

Seed treatment and preparation of seeds for storage

After recording the initial seed quality parameters, seeds of radish variety Pusa Chetki were encrusted with 5 different botanicals viz. neem leaf powder, aloevera leaf powder, turmeric powder, moringa leaf powder and black pepper powder by using corn starch as a binding agent in a ratio of 1:2. After treating the seeds with botanicals the seeds were dried for 6 hours at room temperature. Then the seeds were packed into 3 different containers viz. polyurethane containers, aluminium zip pouches , and cloth bag and are stored under ambient condition with 20 ± 5ºC temperature 95% relative humidity and at 8% moisture content in Seed Testing Laboratory (Notified under Uttar Pradesh), Department of Genetics and Plant Breeding, SHUATS. Seed samples was taken every month (4 weeks) during storage period of three months to evaluate the physiological and seedling parameters of Radish.

The Observations taken during the storage period are:-

1. Germination percent

Germination test was conducted using four replicates of 100 seeds each in the paper (between paper) medium in the walking germination room. The germination room was maintained at 25 ± 2ºC temperature and 90 ± 2% Relative Humidity. The number of normal seedling in each replication was counted at the final count days of 6th day for radish the germination percentage was calculated and expressed in percentage (ISTA, 2011).

$$(\%) = \frac{\text{Number of seeds ger min ated ger min ation}}{\text{Number of seeds put for ger min ation}} \times 100$$

2. Germination rate

It was calculated by the formula:-

$$\text{Rate of germination} = \frac{\text{Number of seeds germinated in 48 hrs}}{\text{Number of seeds germinated in 120 hrs}}$$

3. Root length (cm)

Ten seedlings were selected randomly from each treatment on 6th day from germination test. The root length was measured from the tip of the primary root to base of hypocotyls with the help of a scale and mean root length was expressed in centimeters (ISTA, 2011).

4. Shoot length (cm)

Ten normal seedlings used for root length measurement, were also used for the measurement of shoot length. The shoot length was measured from the tip of the primary leaf to the base of the hypocotyls and mean shoot length was expressed in centimeter (ISTA, 2011).

5. Seedling length (cm)

Seedling length was calculated by adding root and shoot length. It was expressed in cm.

6. Seedling fresh weight (gm)

10 healthy seedlings were picked randomly from each replication and the fresh weight of the seedlings was measured with the help of electronic balance and expressed in gm.

7. Seedling dry weight (gm)

10 healthy seedlings were picked randomly from each replication and wrapped in butter paper and kept in oven at 100°C for 24 hours. Dry weight was calculated after cooling in a desiccator containing silica gel. Weight was measured with the help of electronic balance and expressed in gm (Gupta, 1993).

8. (a) Vigour indices I

Seedling vigour index (length) was calculated by adopting the method suggested by Abdul Baki and Anderson,(1973)

Vigour indices I = germination percent (%) x total seedling length (cm).

(b) Vigour indices II

Seedling vigour index (mass) was calculated by adopting the method suggested by Abdul Baki andAnderson, (1973)

Vgour indices-II = germination percent (%) **x** seedling dry weight (gm).

9. Electrical conductivity

The electrical conductivity of seed leachates was measured for seeds of different age. Fifty seeds were soaked in 75 ml deionised water and incubated at 25ºC for 24 h. Seed leachates were collected, and conductivity was recorded by using digital conductivity meter along with deionised water as a control. Finally, the mean value was expressed in dSm^{-1}.

10. Seed density (gm cm^3)

$$\text{It is measured by Seed density} = \frac{\text{weight of seed (gm)}}{\text{Volume of seed (cm}^3\text{)}}$$

11. Seed metabolic efficiency (gm)

Seed metabolic efficiency is calculated as:-

SME = DWS + DWR / RFM

Where,

DWS = Dry weight of shoot

DWR = Dry weight of root

RFM = Respired food material

Quantity of respired food material is calculated as:-

FRM= DWSBG- (DWS+DWR+DWFRAG)

Where,

DWSBG= Dry weight of seed before germination

DWFRAG= Dry weight of food reserve after germination

12. Seed mobilization efficiency (%)

Seed mobilization efficiency is calculated by:-

$$\text{ME}(\%) = \frac{\text{Dry weight of seedling}}{\text{Decrease in weight of food reserve}}$$

Statistical Analysis

All the data were analyzed by factorial CRD and the mean was subjected to the critical difference at 5% level of significance and the data was analyzed using OPSTAT software.

Result and Discussion

Effect of seed encrustation treatment on seed quality parameters

The seed treatment significantly affected the seed quality parameters during every month of storage. Mean germination per-cent (88.25%, 81.58% and 81.25%) was recorded at Moringa leaf powder @15gm/kg (T11) respectively after first, second and third month of storage. Yadav (2018) found that encrusted seed depicted significantly higher germination percentage in comparison to the control under laboratory condition. Germination rate was significantly affected by treatments during the storage period. The seeds treated with moringa leaf power @ 15g/kg seed (T11) recorded maximum germination rate (0.30) as compared to the (T0) control (0.24) and lowest germination rate (0.22) was recorded by black pepper powder @20g/kg seed (T14) at the end of storage period. *Akinbode and Ikotun* (2008) stated that the maximum physiological growth and development in cowpea was observed due to the application of moringa leaves extract. Moringa leaf powder@ 15g/kg seed recorded the highest root length (7.52 cm, 7.26 cm & 6.63 cm), shoot length (6.35cm, 6.83cm & 6.52 cm) and seedling length (13.88 cm, 14.10 cm, & 13.16 cm) respectively during 1^{st}, 2^{nd} and 3^{rd} month of storage. *Phiri and Mbewe* (2010) reported that *Moringa oleifera* leaf extracts priming in the ratio of 1:10 (w/v) on seeds of maize, rice, sorghum and wheat in a growth room at 25 °C for 14 days and found that it not only increased the length of radical but also increased hypocotyls length of maize and wheat. Maximum fresh weight (2.66 gm, 1.85 gm, & 1.79 gm) and dry weight (0.72 gm, 0.62 gm, & 0.55 gm) was recorded with moringa leaf powder@ 15gm/kg of seed treatment after 1^{st}, 2^{nd}, & 3^{rd}, month of storage. Higher vigour indices I (1068.49) and vigour indices II (45.48) was recorded with moringa leaf powder@ 15gm/kg of seed treatment after the end of storage period. Lowest electrical conductivity (0.924 dSm^{-1}) was found at moringa leaf powder@ 15gm/kg of seed due to the less electrolyte leachate of integrated membranous structure at the particular concentration which shows less damage and more vigour but at the control (T0) due to more damage of integrated membranous structure highest electrical conductivity (1.009 dSm^{-1}) was found after the end of storage period. Highest seed density (1.23 gm cm^{-3}, 1.14gm cm^{-3} and 1.13 gm cm^{-3}) was found at moringa leaf powder@ 15gm/kg of seed respectively after first, second and third month of storage (Table 2.1, 3.1 and 4.1). Moringa leaf powder@ 15g/kg seed recorded the highest seed metabolic efficiency (0.240 gm) and seed mobilization efficiency (60.39 %) at the end of three months of storage period.

Table 1 : Initial seed quality parameters of radish variety Pusa Chetki before storage

S.No	Seed quality parameters	Initial observation recorded
1.	Germination per-cent (%)	76
2.	Germination rate	0.37
3.	Seedling fresh weight (gm/10 seedlings)	2.03
4.	Seedling dry weight (gm/10 seedlings)	0.95
5.	Root length (cm)	6.82
6.	Shoot length (cm)	5.95
7.	Seedling length (cm)	12.77
8.(a)	Vigour indices I (Abdul baki and Anderson,1973)	970.52
(b)	Vigour indices II (Abdul baki and Anderson,1973	72.2
9.	Electrical conductivity test (dSm^{-1})	0.951
10.	Seed density (gm/cm)	1.12
11.	Seed metabolic efficiency	0.325
12.	Seed Mobilization efficiency (%)	58.26

Table 4.2.1 : Impact of various container and treatments on seed quality parameters of radish variety Pusa Chetki after one month of storage

Container	Germination per-cent	Germination rate	Root length	Shoot length	Seedling length	Fresh weight	Dry weight	Vigour indices I	Vigour indices II	Electric conductivity	Seed density	Seed metabolic efficiency	Seed mobilization efficiency
C1	82.28	0.27	6.43	5.424	12.147	2.181	0.580	1007.338	48.644	0.980	0.955	0.256	60.10
C2	**82.81**	**0.28**	**6.72**	**5.795**	**12.495**	**2.449**	**0.641**	**1034.308**	**53.149**	**0.958**	**1.037**	**0.311**	**70.83**
C3	82.55	0.28	6.7	5.605	12.029	2.088	0.631	993.495	52.435	0.964	0.980	0.293	68.98
Mean	82.54	0.27	6.61	5.623	12.222	2.239	0.617	1011.713	51.409	0.967	0.990	0.286	66.63
S.Em	1.179	0.013	0.256	0.241	12.685	0.226	0.044	7.173	5.253	0.018	0.138	0.022	0.021
S.Ed	1.668	0.018	0.362	0.34	17.939	0.32	0.063	10.067	7.429	0.025	0.195	0.031	0.051
CD @ 5%	3.423	NS	0.742	0.698	NS	NS	0.128	20.251	15.012	0.051	NS	0.062	0.042
F test	**S**	NS	S	S	NS	NS	S	S	S	S	NS	S	S
Treatment													
T0	78.75	0.243	6.12	4.85	11.05	1.79	0.547	872.38	43.19	1.025	0.84	0.340	65.76
T1	82.58	0.262	6.18	5.42	11.62	1.94	0.543	959.34	44.89	0.962	0.78	0.336	62.94
T2	80.58	0.283	5.96	5.33	11.3	2.10	0.620	912.53	50.20	1.031	1.04	0.283	68.59
T3	82.41	0.281	6.39	5.32	11.72	2.05	0.583	966.03	48.05	0.916	0.95	0.259	58.46
T4	82.75	0.29	6.51	5.24	11.82	2.16	0.578	978.08	47.91	0.984	0.96	0.376	71.55
T5	85.16	0.259	6.91	5.63	12.55	2.28	0.56	1068.92	47.70	0.963	0.97	0.305	64.39
T6	**85.66**	**0.282**	6.43	5.71	12.14	2.30	0.585	1028.68	49.60	0.937	0.97	0.328	62.17
T7	85.41	0.273	6.75	5.86	12.61	2.49	0.646	1077.23	55.28	1.030	1.11	0.277	66.05
T8	84.08	0.276	7.07	5.84	12.80	2.47	0.69	1076.97	57.97	0.973	0.88	0.237	66.30
T9	82.58	0.269	7.02	5.71	12.69	2.62	0.754	1048.77	62.24	0.969	1.05	0.312	80.01
T10	84.66	0.28	6.44	5.89	12.33	2.51	0.73	1056.96	62.58	0.926	0.85	0.335	84.7
T11	**88.25**	**0.294**	**7.52**	**6.35**	**13.88**	**2.66**	**0.729**	**1225.72**	**64.39**	**0.929**	**1.23**	**0.242**	**80.50**
T12	82.41	0.257	7.06	5.70	12.77	2.10	0.669	1052.88	55.19	1.002	1.12	0.247	67.14
T13	85	0.267	7.11	5.92	13.01	2.30	0.663	1105.97	56.27	0.933	1.00	0.226	63.4
T14	**67.91**	**0.234**	**5.75**	**5.28**	**10.93**	**1.77**	**0.366**	**740.52**	**25.63**	**1.124**	**1.05**	**0.198**	**37.62**
Mean	77.39	0.253	6.62	5.60	12.21	2.09	0.579	1011.40	51.40	0.980	0.99	0.198	66.64
S.Em	1.336	0.013	0.256	0.241	1.412	0.226	0.053	13.542	3.725	0.021	0.068	0.027	5.264
S.Ed	1.890	0.018	0.362	0.340	1.996	0.320	0.075	18.028	5.268	0.029	0.096	0.038	7.444
CD @ 5%	3.878	0.54	0.742	0.698	1.256	0.625	1.25	16.244	10.811	0.624	0.196	0.079	5.277
F test	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**

Table 4.2.2 : Impact of various container and treatments on seed quality parameters of radish variety Pusa Chetki after two month of storage

Container	Germination per-cent	Germination rate	Root length	Shoot length	Seedling length	Fresh weight	Dry weight	Vigour indices I	Vigour indices II	Electric conductivity	Seed density	Seed metabolic efficiency	Seed mobilization efficiency
C1	79.9	0.245	5.59	7.29	11.23	1.63	0.53	845.08	43.236	1.007	1.008	0.245	58.584
C2	**75.2**	**0.294**	**8.07**	**5.64**	**15.36**	**1.99**	**0.58**	**1228.97**	**44.036**	**0.983**	**1.067**	**0.300**	**65.861**
C3	75	0.283	5.57	5.74	11.32	1.61	0.57	853.97	43.238	0.995	0.97	0.298	64.410
Mean	**76.8**	0.440	6.41	6.22	37.92	1.74	0.56	976.006	43.503	0.995	1.015	0.281	62.951
S.Em	1.403	0.054	0.746	0.509	1.36	0.142	0.054	6.290	1.419	0.040	0.103	0.027	3.168
S.Ed	1.985	0.035	1.248	0.654	1.952	0.186	0.064	7.836	2.007	0.056	0.145	0.038	4.480
CD @ 5%	4.010	0.18	1.54	1.24	NS	0.63	0.16	10.23	3.19	0.01	0.34	0.26	5.60
F test	S	S	S	S	NS	S	S	S	S	S	S	S	S
Treatment													
T0	73.58	0.235	5.54	5.35	10.89	1.554	0.438	809.66	32.109	1.007	0.838	0.284	53.246
T1	76.08	0.255	6.12	5.54	11.67	1.74	0.51	895.55	38.824	1.002	0.937	0.308	59.195
T2	75.25	0.272	5.78	5.82	11.60	1.69	0.561	881.07	42.42	1.020	0.97	0.317	64.407
T3	74.91	0.29	6.14	5.96	12.11	1.712	0.514	913.85	38.345	0.981	0.753	0.254	54.01
T4	77.16	0.290	6.42	6.23	12.65	1.684	0.524	986.97	40.41	0.985	0.981	0.254	56.426
T5	76.41	0.262	6.22	5.92	12.14	1.655	0.56	933.29	42.786	0.991	0.999	0.290	70.057
T6	**79.08**	**0.298**	6.03	6.37	12.41	1.79	0.581	972.45	45.117	0.996	1.075	0.287	65.318
T7	76.33	0.267	6.70	6.63	13.34	1.865	0.640	1024.7	49.260	1.021	1.255	0.292	71.85
T8	78.25	0.285	6.64	6.65	13.29	1.85	0.598	1045.36	46.622	1.017	1.045	0.319	71.35
T9	77.33	0.271	6.78	6.50	13.29	1.941	0.711	1030.11	55.166	0.965	1.051	0.315	81.483
T10	77.83	0.270	6.64	6.79	13.43	1.883	0.675	1066.43	53.511	0.988	1.013	0.258	72.444
T11	**81.58**	**0.299**	**7.26**	**6.83**	**14.10**	**1.855**	**0.628**	**1152.03**	**51.087**	**0.947**	**1.14**	**0.270**	**66.454**
T12	79	0.289	6.94	6.81	13.76	1.751	0.541	1088.87	42.599	1.001	1.039	0.297	56.932
T13	78.08	0.282	6.68	6.45	13.14	1.676	0.530	1028.94	41.191	0.989	1.079	0.251	52.425
T14	**69.58**	**0.246**	**6.27**	**5.47**	**11.75**	**1.546**	**0.469**	**810.82**	**33.091**	**1.012**	**1.05**	**0.218**	**48.663**
Mean	76.7	0.274	6.41	6.22	12.64	1.747	0.565	976.00	43.503	0.995	1.015	0.281	62.951
S.Em	2.131	0.021	0.864	0.569	1.412	0.143	0.053	3.644	1.344	0.020	0.068	0.027	2.040
S.Ed	3.014	0.030	1.223	0.805	1.996	0.203	0.075	6.409	3.143	0.028	0.096	0.038	3.485
CD @ 5%	3.56	0.086	0.652	0.24	2.054	0.245	0.12	10.447	4.606	0.024	0.196	0.056	3.68
F test	S	S	S	S	S	S	S	S	S	S	S	S	S

Table 4.2.3 : Impact of various container and treatments on seed quality parameters of radish variety Pusa Chetki after three month of storage.

Container	Germination per-cent	Germination rate	Root length	Shoot length	Seedling length	Fresh weight	Dry weight	Vigour indices I	Vigour indices II	Electric conductivity	Seed density	Seed metabolic efficiency	Seed mobilization efficiency
C1	76.4	0.22	5.76	5.67	11.44	1.60	0.27	890.606	21.27	1.005	1.01	0.26	33.21
C2	**77.7**	**0.29**	**6.11**	**6.20**	**12.31**	**1.73**	**0.57**	**939.584**	**44.87**	**0.96**	**1.28**	**0.29**	**70.37**
C3	76.7	0.28	5.80	5.81	11.62	1.59	0.56	905.911	43.92	0.97	1.03	0.28	64.44
Mean	77.2	0.26	5.89	5.89	11.79	1.64	0.46	912.033	36.68	0.978	1.10	0.27	56.00
S.Em	1.139	0.014	0.713	0.577	1.161	0.096	0.041	6.54	2.16	0.025	0.288	0.037	1.56
S.Ed	1.968	0.020	1.008	0.816	1.642	0.136	0.059	7.56	3.24	0.036	0.407	0.053	1.94
CD @ 5%	3.643	0.041	1.054	0.564	2.52	NS	0.096	9.52	4.21	0.072	0.956	0.106	2.863
F test	S	S	S	S	S	NS	S	S	S	S	S	S	S
Treatment													
T0	73.41	0.24	4.66	4.72	9.38	1.46	0.38	688.682	28.478	1.009	0.976	0.332	52.47
T1	75.75	0.24	5.39	5.24	10.64	1.56	0.41	809.507	31.384	0.967	0.940	0.319	54.74
T2	76.75	0.25	5.43	5.68	11.11	1.57	0.42	853.945	32.701	0.992	1.088	0.268	54.28
T3	75.91	0.26	5.45	5.78	11.24	1.53	0.46	854.641	35.310	1.0006	0.929	0.232	55.71
T4	76.58	0.28	6.15	5.64	11.79	1.65	0.45	904.410	34.659	0.972	1.047	0.3	54.26
T5	77.75	0.27	6.01	5.68	11.70	1.58	0.47	908.980	36.523	0.947	1.275	0.340	60.79
T6	**80.08**	**0.30**	5.68	5.91	11.59	1.62	0.46	904.741	35.795	0.993	1.221	0.273	55.02
T7	78	0.27	5.90	6.15	12.06	1.65	0.46	942.478	36.153	0.997	1.065	0.296	51.54
T8	78	0.29	6.17	6.05	12.23	1.70	0.47	979.663	38.691	1.007	1.211	0.355	64.54
T9	78.75	0.29	6.21	6.18	12.40	1.7	0.52	975.932	41.601	0.977	1.213	0.292	60.59
T10	78.25	0.29	6.21	6.38	12.59	1.76	0.54	986.53	42.63	0.988	1.068	0.254	58.56
T11	**81.25**	**0.30**	**6.63**	**6.52**	**13.16**	**1.79**	**0.55**	**1068.49**	**45.485**	**0.924**	**1.136**	**0.240**	**60.39**
T12	79.16	0.27	6.28	6.06	12.35	1.75	0.49	978.367	39.189	0.969	1.166	0.250	52.42
T13	78.08	0.25	6.29	6.42	12.72	1.72	0.51	992.374	40.675	0.965	1.191	0.249	55.66
T14	**70.41**	**0.22**	**5.92**	**5.96**	**11.88**	**1.57**	**0.43**	**831.760**	**31.101**	**0.983**	**1.148**	**0.209**	**49.14**
Mean	77.21	0.26	5.89	5.89	11.79	1.64	0.47	912.034	36.692	0.979	1.111	0.280	56.01
S.Em	1.336	0.023	0.281	0.273	0.522	0.052	0.101	4.698	2.698	0.023	0.142	0.021	2.011
S.Ed	1.890	0.032	0.397	0.387	0.739	0.073	0.143	6.213	3.213	0.032	0.201	0.030	3.986
CD @ 5%	3.878	0.046	0.815	0.794	1.516	0.150	0.12	10.72	6.422	0.054	0.641	0.062	2.564
F test	S	S	S	S	S	S	S	S	S	S	S	S	S

Conclusion

According to the results of the current study, it is concluded that Seed treated with moringa leaf powder @15gm/kg of seed (T11) performed better in terms of seed quality parameters; viz; germination percent, germination rate, root length, shoot length, seedling length, fresh weight, dry weight, vigour indices I & II, electrical conductivity, seed density, seed metabolic efficiancy and mobilization efficiency as compared to control at the end of three months of storage. Moringa leaf powder @ 15gm/kg of seed performed best during storage whereas the least performance was recorded in black pepper powder @20gm/kg of seed as compared to control at the end of three months of storage. So, this can be recommended for radish to improve seed quality parameters and to extend the storage life. These recommendations are based on three months experimentation and therefore further investigation is needed to arrive at valid recommendation.

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