

Effect of Plant Products and Containers on Seed Quality during Ambient Storage Conditions in Okra

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ABSTRACT: A laboratory experiment was conducted to study the effect of plant products and containers on seed quality during ambient storage conditions in okra, wherein the seeds of okra cv. GJO 6 were treated with seven plant products (S₁ - Control (Untreated); S₂ - *Trichoderma* @5 g/kg of seed; S₃ - Sweet flag (*Achorusculmus*) @10g/kg of seed; S₄ - Castor oil @ 10 ml/kg of seed; S₅ - Neem oil (10 ml/kg of seed); S₆ - Neem powder (5g/kg of seed); S₇ - Neem seed kernel extract). Seeds from all treatments were packed in P₁ - Cloth bag and P₂ - Aluminium foil bag, and stored under ambient storage conditions of Junagadh. Observations were recorded on seed germination (%), root length (cm), shoot length (cm), seedling length (cm), seedling fresh weight (g), seedling dry weight (mg), seedling vigour index-I, seedling vigour index-II, seed moisture content (%) and electrical conductivity of seed leachates (dS/m) every two months interval until the germination percentage fell below the Indian Minimum Seed Certification Standards (65%). Seeds treated with sweet flag @ 10g/kg seed and stored in aluminium foil bag recorded the maximum germination percentage (95.33%), root length (8.10 cm), shoot length (13.83 cm), seedling fresh weight (288.67 mg), seedling dry weight (28.35 mg) and seedling vigour index II (2702.50) after twelve months of storage.

Keywords: Containers, Okra, Plant products, Seed quality, Storage

INTRODUCTION

Good seed is a basic input in vegetable production. Successful olericulture programme depends on the quality of seeds used for sowing. Thus, the seed producers hold greater responsibility in maintaining genetically pure seeds and to preserve the quality of seeds from harvest to next sowing. Since, seed is a living entity and is subjected to various environmental stresses which affect the quality of seed. In storage, the viability and vigour of the seeds not only vary from genera to genera and variety to variety, but these are also regulated by many physico-chemical factors like moisture content, atmospheric relative humidity, temperature, initial seed quality, physical and chemical composition of seed, gaseous exchange, storage structure, packaging materials, etc.

In order to suppress, prevent, or repel diseases, insects, and other pests that attack seeds and impair the vigour and viability of seeds during storage, seeds are treated with physical, chemical, and biological agents. Protein, carbs, and other food reserves are mostly broken down by seed microflora, which reduces vigour and germination. Many techniques, such as treating seeds

with the appropriate chemicals or plant products, are being used to prevent the quantitative and qualitative losses caused by various biotic agents during storage. In comparison to untreated seed, post-harvest seed treatment would improve the quality of the seed, including seed germinability, storage capacity, and field performance.

Therefore, in order to prevent the quantitative and qualitative losses due to several biotic (bacteria, fungi, mites, insects and rodents) and abiotic factors during storage, several methods are being adopted. Seed treatment with suitable chemicals or plant products and storing the seeds in vapour proof containers like polythene bag, aluminium foils, tins or any sealed containers are found to be more useful in maintaining the desired quality of seeds for longer period. Keeping this in mind, the present experiment was conducted to study the effect of plant products and containers on seed quality during ambient storage conditions in okra.

MATERIALS AND METHODS

A laboratory experiment was conducted at Seed Testing Laboratory, Department of Seed Science and Technology,

College of Agriculture, Junagadh Agricultural University, Junagadh from *Kharif*, 2020 and onwards to study the “effect of plant products and containers on seed quality during ambient storage conditions in okra”, wherein the seeds of okra cv. GJO 6 were treated with seven plant products (S₁ - Control (Untreated), S₂ - *Trichoderma* (5 g/kg of seed), S₃ - Sweet flag (*Achorusculmus*) 10 g/kg of seed, S₄ - Castor oil (10 ml/kg of seed), S₅ - Neem oil (10 ml/kg of seed), S₆ - Neem powder (5g/kg of seed), S₇ - Neem seed kernel extract) and after treatment, they were packed in P₁- Cloth bag and P₂-Aluminium foil bag, and were stored under ambient storage condition. Observations viz., hundred seed weight (g), seed germination (%), root length (cm), shoot length (cm), seedling length (cm), seedling fresh weight (g), seedling

dry weight (mg), seedling vigour index-I, seedling vigour index-II, seed moisture content (%) and electrical conductivity of seed leachates (dS/m) were recorded every two months interval until the germination percentage fell below the Indian Minimum Seed Certification Standards (65%). The data were analyzed using Completely Randomized Design (Factorial) as per the method given by Cochran and Cox [1].

RESULTS AND DISCUSSION

Effect of Seed Treatments on Seed Storability

The different seed treatments of okra exhibited non-significant influence on hundred seed weight (Table 1). The effect of seed treatments on seed germination and

Table 1. Effect of seed treatments and containers on hundred seed weight (g) in okra seeds during storage

Treatments	2 month after storage	4 month after storage	6 month after storage	8 month after storage	10 month after storage	12 month after storage
Seed treatments (S)						
S ₁	6.55	6.53	6.50	6.34	6.19	6.11
S ₂	6.68	6.67	6.64	6.48	6.38	6.24
S ₃	6.92	6.91	6.88	6.69	6.55	6.43
S ₄	6.73	6.72	6.69	6.56	6.44	6.29
S ₅	6.83	6.81	6.78	6.65	6.52	6.38
S ₆	6.63	6.62	6.58	6.40	6.31	6.18
S ₇	6.78	6.77	6.74	6.62	6.48	6.34
S.Em+	0.08	0.08	0.08	0.08	0.08	0.07
C.D. at 5%	NS	NS	NS	NS	NS	NS
Containers (P)						
P ₁	6.69	6.66	6.63	6.47	6.35	6.22
P ₂	6.78	6.78	6.76	6.59	6.47	6.34
S.Em+	0.04	0.04	0.04	0.04	0.04	0.04
C.D. at 5%	NS	NS	NS	NS	NS	NS
Seed treatments (S) x Containers (P)						
P ₁ S ₁	6.51	6.48	6.44	6.28	6.17	6.09
P ₁ S ₂	6.65	6.62	6.58	6.41	6.32	6.18
P ₁ S ₃	6.82	6.80	6.77	6.61	6.47	6.35
P ₁ S ₄	6.69	6.67	6.64	6.51	6.38	6.22
P ₁ S ₅	6.79	6.76	6.73	6.59	6.44	6.31
P ₁ S ₆	6.60	6.58	6.53	6.34	6.27	6.14
P ₁ S ₇	6.75	6.72	6.70	6.56	6.41	6.27
P ₂ S ₁	6.59	6.59	6.57	6.40	6.22	6.13
P ₂ S ₂	6.73	6.73	6.71	6.55	6.44	6.31
P ₂ S ₃	7.03	7.03	7.00	6.76	6.63	6.51
P ₂ S ₄	6.78	6.78	6.75	6.62	6.49	6.36
P ₂ S ₅	6.87	6.87	6.85	6.71	6.59	6.45
P ₂ S ₆	6.66	6.66	6.63	6.45	6.35	6.22
P ₂ S ₇	6.82	6.82	6.79	6.67	6.56	6.40
S.Em+	0.11	0.11	0.12	0.11	0.11	0.10
C.D. at 5%	NS	NS	NS	NS	NS	NS
CV %	2.97	2.98	3.14	3.15	3.07	2.98

other seed quality parameters was significant throughout all the storage period. However, after twelve months of storage, significantly the maximum germination (85.67%), root length (7.53 cm), shoot length (13.24 cm), seedling length (20.78 cm), seedling fresh weight (279.67 mg), seedling dry weight (26.04 mg), seedling vigour index I (1790.95) and seedling vigour index II (2252.96) were recorded in seeds treated with sweet flag@ 10g/kg seed (S_3), while significantly the minimum germination (76.33%), root length (6.46 cm), shoot length (10.38 cm), seedling length (16.84 cm), seedling fresh weight (240.67 mg), seedling dry weight (20.40 mg), seedling vigour index I (1292.88) and seedling vigour index II (1590.49) were recorded in control (S_1) (Table 2 to 9). There was decrease in germination percent and all other seed quality parameters with increase in storage period. These findings are in conformity with findings of Nwangburuka *et al.* [2], Roy *et al.* [3], Sultana *et al.* [4] and Girase *et al.* [5].

The effect of seed treatments on seed moisture was non-significant after two and four months of storage, and was significant after six, eight, ten and twelve months of storage. After twelve months of storage, significantly the highest seed moisture content (11.87%) was observed in control (S_1), while significantly the lowest seed moisture content (11.14%) was noticed in seeds treated with sweet flag @ 10g/kg seed (S_3). These findings are in conformity with earlier findings [3, 4, 5].

The effect of seed treatments on electrical conductivity of seed leachate was significant in all the storage period. However, after twelve months of storage, significantly the highest electrical conductivity of seed leachate (0.90 dS/m) was observed in control (S_1), while significantly the lowest electrical conductivity of seed leachate (0.57 dS/m) was noticed in seeds treated with sweet flag@ 10g/kg seed (S_3). These findings are in conformity with the previous studies [3, 4, 5].

Effect of containers on seed storability

The effect of containers on hundred seed weight was non-significant in all the storage period (Table 1). These findings are in conformity with findings of Mashooda *et al.* [6], Aktaruzzaman *et al.* [7] and Sultana *et al.* [8].

The effect of containers on seed germination was non-significant through all storage period expect during the initial month. After twelve months of storage, the seeds stored in aluminium foil bag (P_2) recorded significantly the maximum seed germination (91.38%) as compared to cloth bag (P_1) (72.00%) (Table 2). Germination was higher in aluminium foil bag which is attributed to the ability of the packaging material to prevent the entry of external moisture and the maintenance of moisture content to the original level. These findings are in conformity with findings of Mashooda *et al.* [6], Aktaruzzaman *et al.* [7] and Sultana *et al.* [8].

Table 2. Effect of seed treatments and containers on seed germination (%) in okra seeds during storage

Treatments	2 month after storage	4 month after storage	6 month after storage	8 month after storage	10 month after storage	12 month after storage
Seed treatments (S)						
S_1	90.00	88.50	84.00	82.17	79.67	76.33
S_2	93.67	92.17	87.17	84.83	82.83	81.00
S_3	98.17	96.33	91.67	90.00	88.00	85.67
S_4	94.50	93.00	88.33	86.17	84.17	81.83
S_5	97.33	95.33	90.50	88.67	86.67	84.67
S_6	92.17	90.67	85.17	83.50	81.50	79.00
S_7	96.17	94.17	89.33	87.33	85.83	83.33
S.Em+	0.83	0.54	0.61	0.39	0.38	0.49
C.D. at 5%	2.42	1.59	1.77	1.12	1.12	1.43
Containers (P)						
P_1	94.14	90.76	81.05	79.52	76.52	72.00
P_2	95.00	95.00	95.00	92.67	91.67	91.38
S.Em+	0.44	0.29	0.32	0.21	0.20	0.26
C.D. at 5%	NS	0.85	0.94	0.60	0.60	1.76

Contd...

Seed treatments (S) x Containers (P)						
P ₁ S ₁	88.33	85.33	76.33	75.33	71.33	65.33
P ₁ S ₂	93.33	90.33	80.33	78.67	75.67	72.00
P ₁ S ₃	98.00	94.33	85.00	83.67	80.67	76.00
P ₁ S ₄	94.33	91.33	82.00	80.67	77.67	73.33
P ₁ S ₅	97.00	93.00	83.33	81.67	78.67	74.67
P ₁ S ₆	92.00	89.00	78.00	76.67	73.67	69.00
P ₁ S ₇	96.00	92.00	82.33	80.00	78.00	73.67
P ₂ S ₁	91.67	91.67	91.67	89.00	88.00	87.33
P ₂ S ₂	94.00	94.00	94.00	91.00	90.00	90.00
P ₂ S ₃	98.33	98.33	98.33	96.33	95.33	95.33
P ₂ S ₄	94.67	94.67	94.67	91.67	90.67	90.33
P ₂ S ₅	97.67	97.67	97.67	95.67	94.67	94.67
P ₂ S ₆	92.33	92.33	92.33	90.33	89.33	89.00
P ₂ S ₇	96.33	96.33	96.33	94.67	93.67	93.00
S.Em+	1.18	0.77	0.86	0.55	0.55	0.70
C.D. at 5%	NS	NS	NS	1.60	1.60	2.03
CV %	2.17	1.45	1.70	1.10	1.13	1.49

Table 3. Effect of seed treatments and containers on root length (cm) in okra seeds during storage

Treatments	2 month after storage	4 month after storage	6 month after storage	8 month after storage	10 month after storage	12 month after storage
Seed treatments (S)						
S ₁	7.53	7.52	7.50	7.44	6.93	6.46
S ₂	7.63	7.60	7.59	7.53	7.47	6.95
S ₃	8.16	8.15	8.11	8.06	7.80	7.53
S ₄	7.67	7.65	7.63	7.56	7.52	7.25
S ₅	8.09	8.08	8.04	7.98	7.67	7.47
S ₆	7.55	7.54	7.48	7.40	7.22	6.75
S ₇	7.95	7.93	7.90	7.85	7.56	7.32
S.Em+	0.11	0.12	0.12	0.10	0.08	0.03
C.D. at 5%	0.33	0.34	0.34	0.30	0.25	0.10
Containers (P)						
P ₁	7.53	7.50	7.44	7.37	6.93	6.47
P ₂	8.06	8.06	8.07	8.02	7.98	7.74
S.Em+	0.06	0.06	0.06	0.05	0.04	0.02
C.D. at 5%	0.18	0.18	0.18	0.16	0.13	0.05
Seed treatments (S) x Containers (P)						
P ₁ S ₁	7.16	7.13	7.10	7.02	6.01	5.84
P ₁ S ₂	7.23	7.19	7.16	7.10	7.02	6.14
P ₁ S ₃	8.06	8.04	7.96	7.90	7.45	6.97
P ₁ S ₄	7.30	7.26	7.21	7.14	7.08	6.65
P ₁ S ₅	8.02	8.00	7.93	7.86	7.26	6.90
P ₁ S ₆	7.11	7.08	6.97	6.88	6.56	6.03
P ₁ S ₇	7.83	7.79	7.74	7.66	7.13	6.75
P ₂ S ₁	7.91	7.91	7.91	7.87	7.84	7.08
P ₂ S ₂	8.02	8.02	8.02	7.96	7.92	7.76
P ₂ S ₃	8.25	8.25	8.25	8.22	8.15	8.10
P ₂ S ₄	8.04	8.04	8.05	8.00	7.96	7.86
P ₂ S ₅	8.16	8.16	8.16	8.12	8.09	8.05
P ₂ S ₆	8.00	8.00	8.00	7.92	7.88	7.47
P ₂ S ₇	8.07	8.07	8.07	8.04	8.00	7.90
S.Em+	0.16	0.17	0.17	0.14	0.12	0.05
C.D. at 5%	NS	NS	NS	0.41	0.35	0.14
CV %	3.64	3.71	3.73	3.25	2.81	1.22

Table 4. Effect of seed treatments and containers on shoot length (cm) in okra seeds during storage

Treatments	2 month after storage	4 month after storage	6 month after storage	8 month after storage	10 month after storage	12 month after storage
Seed treatments (S)						
S ₁	12.41	12.37	12.32	12.08	11.30	10.38
S ₂	13.37	13.28	13.24	13.10	11.93	11.38
S ₃	14.94	14.76	14.73	14.34	13.74	13.24
S ₄	13.63	13.58	13.53	13.23	12.61	11.91
S ₅	14.66	14.49	14.43	14.23	13.62	12.65
S ₆	13.05	12.91	12.87	12.64	11.64	10.94
S ₇	14.47	14.30	14.21	14.05	13.10	12.37
S.Em+	0.15	0.14	0.14	0.12	0.11	0.08
C.D. at 5%	0.45	0.40	0.41	0.35	0.32	0.25
Containers (P)						
P ₁	13.44	13.21	13.11	12.85	12.19	11.55
P ₂	14.13	14.13	14.13	13.92	12.94	12.12
S.Em+	0.08	0.07	0.07	0.06	0.06	0.04
C.D. at 5%	0.23	0.21	0.22	0.19	0.17	0.14
Seed treatments (S) x Containers (P)						
P ₁ S ₁	12.06	12.00	11.90	11.73	11.13	10.28
P ₁ S ₂	13.19	13.01	12.93	12.76	11.83	11.14
P ₁ S ₃	14.35	14.00	13.94	13.55	13.31	12.66
P ₁ S ₄	13.22	13.13	13.03	12.83	12.07	11.57
P ₁ S ₅	14.26	13.93	13.81	13.48	13.20	12.26
P ₁ S ₆	12.88	12.61	12.53	12.20	11.21	10.82
P ₁ S ₇	14.14	13.81	13.63	13.39	12.57	12.14
P ₂ S ₁	12.75	12.75	12.75	12.44	11.46	10.47
P ₂ S ₂	13.55	13.55	13.55	13.43	12.03	11.62
P ₂ S ₃	15.53	15.53	15.53	15.12	14.16	13.83
P ₂ S ₄	14.03	14.03	14.03	13.63	13.15	12.26
P ₂ S ₅	15.05	15.05	15.05	14.98	14.05	13.05
P ₂ S ₆	13.22	13.22	13.22	13.09	12.08	11.05
P ₂ S ₇	14.80	14.80	14.80	14.71	13.63	12.60
S.Em+	0.21	0.20	0.21	0.17	0.16	0.12
C.D. at 5%	NS	NS	NS	0.50	0.45	0.36
CV %	2.74	2.50	2.60	2.24	2.15	1.82

Table 5. Effect of seed treatments and containers on seedling length (cm) in okra seeds during storage

Treatments	2 month after storage	4 month after storage	6 month after storage	8 month after storage	10 month after storage	12 month after storage
Seed treatments (S)						
S ₁	19.94	19.90	19.83	19.53	18.23	16.84
S ₂	20.99	20.88	20.83	20.63	19.40	18.33
S ₃	23.10	22.91	22.84	22.40	21.54	20.78
S ₄	21.29	21.23	21.15	20.80	20.13	19.17
S ₅	22.75	22.57	22.48	22.22	21.30	20.13
S ₆	20.60	20.45	20.36	20.04	18.86	17.69
S ₇	22.42	22.23	22.12	21.90	20.67	19.70
S.Em+	0.19	0.18	0.20	0.16	0.13	0.10
C.D. at 5%	0.55	0.52	0.56	0.47	0.39	0.28
Containers (P)						
P ₁	20.97	20.71	20.55	20.22	19.12	18.02
P ₂	22.19	22.19	22.20	21.93	20.91	19.87
S.Em+	0.10	0.10	0.10	0.09	0.07	0.05
C.D. at 5%	0.30	0.27	0.30	0.25	0.21	0.15

Contd...

Seed treatments (S) x Containers (P)						
P ₁ S ₁	19.22	19.14	19.00	18.75	17.15	16.12
P ₁ S ₂	20.42	20.20	20.09	19.86	18.85	17.28
P ₁ S ₃	22.41	22.05	21.90	21.46	20.76	19.63
P ₁ S ₄	20.52	20.38	20.24	19.97	19.15	18.22
P ₁ S ₅	22.28	21.93	21.75	21.34	20.46	19.15
P ₁ S ₆	19.99	19.68	19.50	19.08	17.77	16.85
P ₁ S ₇	21.97	21.59	21.36	21.05	19.70	18.90
P ₂ S ₁	20.65	20.65	20.65	20.31	19.30	17.55
P ₂ S ₂	21.56	21.56	21.56	21.39	19.95	19.38
P ₂ S ₃	23.78	23.78	23.78	23.34	22.31	21.92
P ₂ S ₄	22.07	22.07	22.07	21.63	21.11	20.12
P ₂ S ₅	23.21	23.21	23.21	23.10	22.13	21.10
P ₂ S ₆	21.22	21.22	21.22	21.01	19.96	18.52
P ₂ S ₇	22.87	22.87	22.87	22.75	21.63	20.50
S.Em+	0.27	0.25	0.27	0.23	0.19	0.14
C.D. at 5%	NS	NS	NS	NS	NS	NS
CV %	2.17	2.04	2.22	1.91	1.64	1.25

Table 6. Effect of seed treatments and containers on seedling fresh weight (mg) in okra seeds during storage

Treatments	2 month after storage	4 month after storage	6 month after storage	8 month after storage	10 month after storage	12 month after storage
Seed treatments (S)						
S ₁	253.17	248.50	245.00	243.33	242.50	240.67
S ₂	269.17	266.83	258.67	257.17	256.17	254.83
S ₃	291.00	287.33	283.83	282.00	280.83	279.67
S ₄	276.83	271.33	265.17	263.67	262.67	261.33
S ₅	285.17	279.83	275.83	274.17	272.50	270.83
S ₆	259.67	256.17	252.50	251.00	250.17	249.00
S ₇	281.33	274.83	270.33	268.67	267.83	266.00
S.Em+	1.97	2.07	2.76	2.73	1.34	1.33
C.D. at 5%	5.70	5.99	7.99	7.91	3.89	3.88
Containers (P)						
P ₁	269.52	260.52	250.95	248.90	247.71	245.95
P ₂	278.00	278.00	278.00	276.81	275.90	274.71
S.Em+	1.05	1.11	1.47	1.46	0.71	0.71
C.D. at 5%	3.05	3.20	4.27	4.23	2.08	2.07
Seed treatments (S) x Containers (P)						
P ₁ S ₁	246.00	236.67	229.67	227.33	226.33	224.00
P ₁ S ₂	264.00	259.33	243.00	241.00	240.33	238.67
P ₁ S ₃	289.67	282.33	275.33	273.33	272.00	270.67
P ₁ S ₄	273.67	262.67	250.33	248.33	247.33	245.00
P ₁ S ₅	283.67	273.00	265.00	263.00	261.00	259.00
P ₁ S ₆	251.33	244.33	237.00	235.00	234.00	232.33
P ₁ S ₇	278.33	265.33	256.33	254.33	253.00	252.00
P ₂ S ₁	260.33	260.33	260.33	259.33	258.67	257.33
P ₂ S ₂	274.33	274.33	274.33	273.33	272.00	271.00
P ₂ S ₃	292.33	292.33	292.33	290.67	289.67	288.67
P ₂ S ₄	280.00	280.00	280.00	279.00	278.00	277.67
P ₂ S ₅	286.67	286.67	286.67	285.33	284.00	282.67
P ₂ S ₆	268.00	268.00	268.00	267.00	266.33	265.67
P ₂ S ₇	284.33	284.33	284.33	283.00	282.67	280.00
S.Em+	2.78	2.97	3.90	3.86	1.89	1.89
C.D. at 5%	NS	NS	NS	NS	5.50	5.48
CV %	1.76	1.88	2.56	2.54	1.25	1.26

Table 7. Effect of seed treatments and containers on seedling dry weight (mg) in okra seeds during storage

Treatments	2 month after storage	4 month after storage	6 month after storage	8 month after storage	10 month after storage	12 month after storage
Seed treatments (S)						
S ₁	27.25	25.40	24.83	23.18	22.34	20.40
S ₂	27.86	26.72	26.21	25.22	24.34	22.20
S ₃	31.56	30.48	30.06	28.85	27.89	26.04
S ₄	28.40	27.36	26.71	25.97	25.07	22.99
S ₅	30.31	29.37	28.81	27.72	26.81	24.58
S ₆	27.54	26.04	25.48	24.07	23.54	21.36
S ₇	29.49	28.68	28.12	26.93	26.15	23.83
S.Em+	0.19	0.23	0.26	0.16	0.12	0.17
C.D. at 5%	0.55	0.68	0.75	0.46	0.40	0.50
Containers (P)						
P ₁	27.77	25.39	24.29	23.23	22.45	20.35
P ₂	30.06	30.06	30.06	28.76	27.88	25.76
S.Em+	0.10	0.12	0.14	0.08	0.06	0.10
C.D. at 5%	0.30	0.36	0.40	0.24	0.18	0.27
Seed treatments (S) x Containers (P)						
P ₁ S ₁	26.16	22.45	21.32	20.19	19.34	17.39
P ₁ S ₂	26.61	24.34	23.32	22.29	21.16	19.13
P ₁ S ₃	30.67	28.51	27.67	26.30	25.11	23.73
P ₁ S ₄	27.39	25.31	24.01	23.26	22.41	20.11
P ₁ S ₅	29.13	27.26	26.13	25.19	24.48	22.16
P ₁ S ₆	26.35	23.36	22.24	21.11	20.73	18.65
P ₁ S ₇	28.11	26.47	25.36	24.26	23.88	21.32
P ₂ S ₁	28.34	28.34	28.34	26.18	25.35	23.41
P ₂ S ₂	29.10	29.10	29.10	28.15	27.51	25.26
P ₂ S ₃	32.44	32.44	32.44	31.41	30.67	28.35
P ₂ S ₄	29.41	29.41	29.41	28.67	27.72	25.88
P ₂ S ₅	31.48	31.48	31.48	30.26	29.13	27.01
P ₂ S ₆	28.73	28.73	28.73	27.04	26.35	24.06
P ₂ S ₇	30.88	30.88	30.88	29.60	28.42	26.34
S.Em+	0.27	0.33	0.36	0.22	0.17	0.24
C.D. at 5%	NS	NS	NS	NS	0.48	0.70
CV %	1.61	2.07	2.32	1.49	1.14	1.83

Table 8. Effect of seed treatments and containers on seedling vigour index I in okra seeds during storage

Treatments	2 month after storage	4 month after storage	6 month after storage	8 month after storage	10 month after storage	12 month after storage
Seed treatments (S)						
S ₁	1795.94	1763.43	1672.20	1610.10	1460.99	1292.88
S ₂	1966.78	1926.07	1820.55	1754.80	1610.96	1493.86
S ₃	2267.35	2209.12	2100.11	2021.72	1900.73	1790.95
S ₄	2012.30	1957.33	1874.98	1796.67	1700.77	1576.62
S ₅	2214.17	2153.02	2039.60	1976.34	1852.34	1713.61
S ₆	1898.80	1855.17	1739.58	1680.26	1545.97	1405.46
S ₇	2156.13	2095.20	1981.27	1919.00	1781.31	1648.91
S.Em+	22.72	22.14	22.12	18.16	14.26	9.16
C.D. at 5%	65.83	64.12	64.08	52.61	41.30	26.54
Containers (P)						
P ₁	1977.96	1882.50	1668.26	1610.04	1466.70	1301.30
P ₂	2111.03	2111.03	2111.03	2035.36	1919.89	1819.35
S.Em+	12.14	11.83	11.82	9.71	7.62	4.89
C.D. at 5%	35.19	34.27	34.23	28.12	22.07	14.18

Contd...

Seed treatments (S) x Containers (P)						
P ₁ S ₁	1698.02	1633.00	1450.55	1412.15	1223.13	1053.17
P ₁ S ₂	1906.45	1825.04	1614.00	1562.54	1426.57	1243.90
P ₁ S ₃	2196.25	2079.79	1861.79	1795.07	1674.58	1491.89
P ₁ S ₄	1935.70	1861.78	1659.52	1610.62	1487.55	1335.99
P ₁ S ₅	2161.48	2039.18	1812.33	1743.06	1609.41	1430.11
P ₁ S ₆	1839.08	1751.82	1520.64	1462.84	1309.09	1162.35
P ₁ S ₇	2108.74	1986.87	1759.02	1684.00	1536.60	1391.71
P ₂ S ₁	1893.86	1893.86	1893.86	1808.03	1698.85	1532.60
P ₂ S ₂	2027.11	2027.11	2027.11	1947.05	1795.34	1743.82
P ₂ S ₃	2338.45	2338.45	2338.45	2248.38	2126.88	2090.01
P ₂ S ₄	2088.89	2088.89	2088.89	1982.73	1913.99	1817.25
P ₂ S ₅	2266.86	2266.86	2266.86	2209.62	2095.27	1997.12
P ₂ S ₆	1958.52	1958.52	1958.52	1897.69	1782.86	1648.58
P ₂ S ₇	2203.53	2203.53	2203.53	2154.00	2026.02	1906.11
S.Em+	32.14	31.30	31.26	25.68	20.16	12.96
C.D. at 5%	NS	NS	NS	NS	NS	37.54
CV %	2.72	2.71	2.86	2.44	2.06	1.44

Table 9. Effect of seed treatments and containers on seedling vigour index II in okra seeds during storage

Treatments	2 month after storage	4 month after storage	6 month after storage	8 month after storage	10 month after storage	12 month after storage
Seed treatments (S)						
S ₁	2454.68	2257.09	2112.66	1925.08	1805.44	1590.49
S ₂	2609.70	2467.43	2304.60	2157.52	2038.73	1825.45
S ₃	3098.13	2939.79	2771.29	2613.00	2474.67	2252.96
S ₄	2684.35	2547.02	2375.20	2252.58	2127.04	1906.20
S ₅	2950.34	2805.13	2626.33	2475.90	2341.93	2105.48
S ₆	2538.28	2365.71	2193.57	2030.39	1940.43	1714.12
S ₇	2836.77	2704.97	2531.58	2371.35	2262.41	2010.35
S.Em+	26.63	23.79	24.52	17.54	13.71	19.01
C.D. at 5%	77.14	68.91	71.03	50.81	39.72	55.07
Containers (P)						
P ₁	2619.10	2309.07	1974.24	1852.46	1723.37	1471.82
P ₂	2858.68	2858.68	2858.68	2669.20	2559.67	2358.19
S.Em+	14.23	12.71	13.10	9.37	7.33	10.16
C.D. at 5%	41.23	36.84	37.97	27.16	21.23	29.44
Seed treatments (S) x Containers (P)						
P ₁ S ₁	2311.10	1915.93	1627.08	1520.56	1379.87	1135.69
P ₁ S ₂	2483.96	2199.42	1873.76	1753.67	1601.40	1377.07
P ₁ S ₃	3006.02	2689.35	2352.34	2200.25	2025.46	1803.42
P ₁ S ₄	2584.43	2309.77	1966.13	1876.45	1740.90	1474.59
P ₁ S ₅	2825.61	2535.18	2177.60	2057.19	1926.22	1654.55
P ₁ S ₆	2423.89	2078.74	1734.47	1618.33	1527.11	1286.62
P ₁ S ₇	2698.70	2435.09	2088.32	1940.80	1862.64	1570.79
P ₂ S ₁	2598.25	2598.25	2598.25	2329.61	2231.01	2045.29
P ₂ S ₂	2735.44	2735.44	2735.44	2561.37	2476.06	2273.82
P ₂ S ₃	3190.23	3190.23	3190.23	3025.76	2923.88	2702.50
P ₂ S ₄	2784.26	2784.26	2784.26	2628.70	2513.17	2337.80
P ₂ S ₅	3075.07	3075.07	3075.07	2894.60	2757.65	2556.41
P ₂ S ₆	2652.67	2652.67	2652.67	2442.46	2353.74	2141.62
P ₂ S ₇	2974.85	2974.85	2974.85	2801.90	2662.18	2449.91
S.Em+	37.66	33.64	34.68	24.81	19.39	26.88
C.D. at 5%	NS	NS	NS	NS	56.17	NS
CV %	2.38	2.25	2.48	1.90	1.57	2.43

The effect of containers on root length, shoot length, seedling length, seedling fresh weight, seedling dry weight, seedling vigour index I and seedling vigour index II was significant in all the storage period. However, after twelve months of storage, the seeds stored in aluminium foil bag (P_2) recorded significantly the maximum root length (7.74 cm), shoot length (12.12 cm), seedling length (19.87 cm), seedling fresh weight (274.71 mg), seedling dry weight (25.76 mg), seedling vigour index I (1819.35) and seedling vigour index II (2358.19), while seeds stored in cloth bag (P_1) recorded significantly the minimum root length (6.47 cm), shoot length (11.55 cm), seedling length (18.02 cm), seedling fresh weight (245.95 mg), seedling dry weight (20.35 mg), seedling vigour index I (1301.30) and seedling vigour index II (1471.82) was recorded in control (S_1) (Table 3 to 9). These findings are in conformity with findings of Mashooda *et al.* [6], Aktaruzzaman *et al.* [7] and Sultana *et al.* [8].

The effect of container on seed moisture was non-significant during two and four months, and was significant during six, eight, ten and twelve months. After twelve months of storage, the seed stored in cloth bag (P_1) recorded significantly the maximum seed moisture content (12.50%) as compared to aluminium foil bag (P_2) (10.47%) (Table 10). Cloth bag being a pervious container, moisture exchange took place frequently until it reached the equilibrium status with environment, thereby this recorded higher moisture at the end of storage period. Aluminium foil bag which is impervious in nature to moisture vapour hence it has caused less fluctuation in seed moisture content and it eliminates dampness, deterioration, microorganisms and enhance the seed longevity. These findings are in conformity with findings of Mashooda *et al.* [6], Aktaruzzaman *et al.* [7] and Sultana *et al.* [8].

The effect of container on electrical conductivity of seed leachate was significant in all the storage period. After twelve months of storage, the seeds stored in cloth bag (P_1) recorded significantly the maximum electrical conductivity of seed leachate (0.81 dS/m) as compared to aluminium foil bag (P_2) (0.70 dS/m). These findings are in conformity with findings of Mashooda *et al.* [6], Aktaruzzaman *et al.* [7] and Sultana *et al.* [8].

Effect of seed treatments and containers ($S \times P$) on seed storability

The interaction effect between seed treatments and containers was non-significant in all storage period for

hundred seed weight (Table 1). The interaction effect between seed treatments and containers was non-significant during two, four and six months and was significant during eight, ten and twelve months for seed germination percent. At twelve months of storage, significantly the maximum seed germination (95.33%) was noticed in seeds packed in aluminium foil bag and treated with sweet flag@ 10g/kg seed (P_2S_3), while the minimum seed germination (65.33%) was noticed in untreated seeds packed in cloth bag (P_1S_1) (Table 2). These findings are in conformity with previous findings [5, 7, 8].

The interaction effects between seed treatments and containers were non-significant during two, four and six months and significant during eight, ten and twelve months of storage for root and shoot length. At twelve months of storage, significantly the maximum root length (8.10 cm) and shoot length (13.83 cm) was noticed in seeds packed in aluminium foil bag and treated with sweet flag@ 10 g/kg seed (P_2S_3), while significantly the minimum root length (5.84 cm) and shoot length (10.28 cm) was noticed in untreated seeds packed in cloth bag (P_1S_1) (Table 3 and 4). These findings are in conformity with earlier reports [5, 7, 8]. The interaction effect between seed treatments and containers was non-significant during two, four, six and eight months and was significant during ten and twelve months of storage for seedling fresh and dry weight. At twelve months of storage, significantly the maximum seedling fresh weight (288.67 mg) and seedling dry weight (28.35 mg) was noticed in seeds packed in aluminium foil bag and treated with sweet flag@ 10g/kg seed (P_2S_3), while significantly the minimum seedling fresh weight (224.00 mg) and seedling dry weight (17.39 mg) was noticed in untreated seeds packed in cloth bag (P_1S_1) (Table 6 and 7). The interaction effect between seed treatments and containers was non-significant through all storage period except at twelve months of storage for seedling vigour index I, while in seedling vigour index II, it was significant during ten months. At twelve months of storage, the maximum seedling vigour index I (2090.01) and seedling vigour index II (2702.50) was noticed in seeds packed in aluminium foil bag and treated with sweet flag@ 10 g/kg seed (P_2S_3), while the minimum seedling vigour index I (1053.17) and seedling vigour index II (1135.69) was noticed in untreated seeds packed in cloth bag (P_1S_1) (Table 8 and 9). These findings are similar to some earlier reports [5, 7, 8]. The interaction effects between seed

Table 10. Effect of seed treatments and containers on seed moisture content (%) in okra seeds during storage

Treatments	2 month after storage	4 month after storage	6 month after storage	8 month after storage	10 month after storage	12 month after storage
Seed treatments (S)						
S ₁	7.53	7.54	8.62	9.90	10.81	11.87
S ₂	7.41	7.43	8.46	9.72	10.60	11.59
S ₃	7.12	7.14	8.20	9.14	10.13	11.14
S ₄	7.35	7.36	8.39	9.61	10.49	11.48
S ₅	7.17	7.18	8.24	9.38	10.23	11.22
S ₆	7.46	7.48	8.55	9.83	10.72	11.74
S ₇	7.29	7.30	8.31	9.48	10.39	11.37
S.Em+	0.115	0.11	0.09	0.08	0.11	0.08
C.D. at 5%	NS	NS	0.27	0.24	0.31	0.25
Containers (P)						
P ₁	7.40	7.43	9.54	10.51	11.50	12.50
P ₂	7.26	7.26	7.26	8.65	9.46	10.47
S.Em+	0.06	0.06	0.05	0.04	0.06	0.04
C.D. at 5%	NS	NS	0.15	0.13	0.16	0.13
Seed treatments (S) x Containers (P)						
P ₁ S ₁	7.64	7.67	9.84	10.81	11.81	12.88
P ₁ S ₂	7.51	7.54	9.62	10.61	11.66	12.62
P ₁ S ₃	7.13	7.17	9.31	10.14	11.16	12.17
P ₁ S ₄	7.42	7.44	9.51	10.53	11.50	12.49
P ₁ S ₅	7.20	7.23	9.34	10.36	11.25	12.24
P ₁ S ₆	7.58	7.61	9.77	10.74	11.76	12.72
P ₁ S ₇	7.34	7.37	9.40	10.42	11.39	12.37
P ₂ S ₁	7.41	7.41	7.41	8.99	9.81	10.86
P ₂ S ₂	7.32	7.32	7.32	8.84	9.54	10.56
P ₂ S ₃	7.10	7.10	7.10	8.14	9.11	10.10
P ₂ S ₄	7.28	7.28	7.28	8.70	9.49	10.47
P ₂ S ₅	7.14	7.14	7.14	8.40	9.21	10.19
P ₂ S ₆	7.35	7.35	7.35	8.91	9.68	10.75
P ₂ S ₇	7.23	7.23	7.23	8.55	9.39	10.36
S.Em+	0.16	0.16	0.13	0.11	0.15	0.12
C.D. at 5%	NS	NS	NS	NS	NS	NS
CV %	3.85	3.85	2.79	2.16	2.48	1.91

Table 11. Effect of seed treatments and containers on electrical conductivity of seed leachates (dS/m) in okra seeds during storage

Treatments	2 month after storage	4 month after storage	6 month after storage	8 month after storage	10 month after storage	12 month after storage
Seed treatments (S)						
S ₁	0.61	0.64	0.65	0.77	0.82	0.90
S ₂	0.56	0.57	0.59	0.69	0.75	0.83
S ₃	0.39	0.41	0.43	0.48	0.52	0.57
S ₄	0.52	0.54	0.56	0.64	0.71	0.78
S ₅	0.41	0.43	0.45	0.52	0.58	0.65
S ₆	0.59	0.62	0.63	0.73	0.78	0.86
S ₇	0.49	0.51	0.53	0.58	0.64	0.71
S.Em+	0.006	0.006	0.005	0.005	0.005	0.005
C.D. at 5%	0.01	0.01	0.01	0.01	0.01	0.01
Containers (P)						
P ₁	0.54	0.58	0.61	0.71	0.76	0.81
P ₂	0.48	0.48	0.48	0.54	0.60	0.70
S.Em+	0.003	0.003	0.003	0.003	0.002	0.003
C.D. at 5%	0.01	0.01	0.008	0.008	0.008	0.008
Contd...						

Seed treatments (S) x Containers (P)

P ₁ S ₁	0.63	0.68	0.71	0.87	0.91	0.97
P ₁ S ₂	0.58	0.61	0.66	0.79	0.84	0.89
P ₁ S ₃	0.42	0.46	0.49	0.53	0.58	0.63
P ₁ S ₄	0.55	0.58	0.63	0.72	0.79	0.84
P ₁ S ₅	0.45	0.48	0.52	0.58	0.64	0.69
P ₁ S ₆	0.61	0.66	0.68	0.84	0.87	0.92
P ₁ S ₇	0.52	0.56	0.59	0.64	0.72	0.76
P ₂ S ₁	0.60	0.60	0.60	0.66	0.72	0.83
P ₂ S ₂	0.53	0.53	0.53	0.58	0.66	0.76
P ₂ S ₃	0.36	0.36	0.36	0.42	0.46	0.51
P ₂ S ₄	0.49	0.49	0.49	0.55	0.62	0.72
P ₂ S ₅	0.38	0.38	0.38	0.45	0.51	0.62
P ₂ S ₆	0.57	0.57	0.57	0.63	0.69	0.81
P ₂ S ₇	0.46	0.46	0.46	0.51	0.56	0.66
S.Em+	0.009	0.009	0.008	0.008	0.007	0.007
C.D. at 5%	NS	NS	NS	0.02	0.02	0.02
CV %	3.20	3.04	2.60	2.23	1.86	1.63

treatments and containers were non-significant during two, four and six months and were significant during eight, ten and twelve months of storage for electrical conductivity of seed leachate. At twelve months of storage, significantly high and maximum electrical conductivity of seed leachate (0.51 dS/m) was recorded in untreated seeds packed in cloth bag (P₁S₁), while significantly low and minimum electrical conductivity of seed leachate was recorded in seeds packed in aluminium foil bag and treated with sweet flag powder @ 10 g/kg seed (P₂S₃) (0.51 dS/m). There was an increase in the electrical conductivity of seed leachates with the increase in storage period, irrespective of the treatments, which was attributed to the degradation of cellular membranes with seed ageing.

CONCLUSION

Seeds of okra treated with sweet flag powder @ 10 g/kg seed and stored in aluminium foil bag recorded best storability under ambient conditions with highest germination percentage (95.33%), root length (8.10 cm), shoot length (13.83 cm), seedling fresh weight (288.67 mg), seedling dry weight (28.35 mg) and seedling vigour index II (2702.50) after twelve months of storage.

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