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Influence of seed treatment chemicals and packing materials on storage potential of hybrids in sunflower (*Helianthus annuus* L.)

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Abstract
A laboratory experiment was conducted to study the influence of seed treatment chemicals and packing materials on storage potential of sunflower hybrids at the Department of Seed Science and Technology, Gandhi Krishi Vignana Kendra, University of Agricultural Sciences, Bangalore during August 2010 to July 2011. Freshly harvested seeds of sunflower hybrids *viz.*, KBSH-41, KBSH-44 and KBSH-53 were treated with Thiram 75% WP. @ 2.5g per kg, Imidacloprid-powder form @ 5g/kg, Imidacloprid-liquid form @ 5 ml/ kg of seed and untreated seeds used as control. Then they were packed in cloth bag, super grain bag and polypouches and stored under ambient conditions of Bangalore. The results revealed that KBSH-44 hybrid maintained prescribed germination standards (70.0%) up to ten months when compared to KBSH-41 (eight months) and KBSH-53 (seven months) and seeds packed in polypouches maintained prescribed minimum certification standards of germination up to nine months. Seed treated with Imidacloprid, powder form (WP) @ 5g/kg or Thiram @ 3 g /kg could be stored up to nine months with the prescribed germination of minimum seed certification standards. Seedling vigour index was superior in KBSH-44 (1478) compared to lowest registered in KBSH-53 (369) at the end of storage. Among packing materials, polypouches recorded higher seedling vigour index followed by super grain bag at the end of storage period. Besides, KBSH-44 hybrid recorded minimum seed infection (18.36%) and seeds treated with Thiram showed significantly lower infection (23.59%).

Keywords: Sunflower hybrids, chemicals, packing materials, storage period, seed quality parameters, seed infection

1. Introduction
Sunflower being an oilseed crop, maintenance of seed vigour and viability during storage pose severe problem especially under Indian condition where better seed storage facilities with controlled environmental conditions are rarely available. Seeds are prone to deterioration when stored under ambient conditions. Seed deterioration accelerates especially under high temperature coupled with high relative humidity conditions. A widely promoted hypothesis related to deterioration of seeds during ageing is lipid peroxidation (Wilson and Mcdonald, 1986) [31], which results in production of free radicals intermediaries, which damage the membrane, decreases the activity of enzymes and brings aberrations in nucleic acid compositions. Hence, storage of seed after harvest till next cropping season is an important for successful crop production.

During storage, the viability of seed is affected by various factors such as genetic background, pre-harvest climatic conditions, seed characters, seed health, temperature and relative humidity of storage conditions, seed moisture content, seed treatments etc. Among these, seed moisture content, temperature, relative humidity and packaging materials are considered to be most important. The incidence of mycoflora is mainly responsible for the degradation of protein and other food reserves resulting in reduction of germination and vigour. As the seed is one of the efficient media for survival and dissemination of pathogens, to reduce the losses due to these pathogens and preserve viability, it is advisable to store seeds in suitable containers and use of seed treatment chemicals in order to preserve them for considerable time without significant reduction in seed quality. In view of these facts, a study was undertaken to probe the effect of seed treatment chemicals and packing materials on storage potential of sunflower seeds.

2. Material and Methods

Freshly harvested seeds of sunflower hybrids *viz.*, KBSH-41, KBSH-44 and KBSH-53 obtained from the National Seed Project (Crops), University of Agricultural Sciences, GKVK, Bangalore, dried to safe level of moisture (<9%), graded manually to uniform size and then used for the storage study. The seeds were subjected to manual treatment with different chemicals *viz.*, Imidacloprid-powder form @ 5g/kg and Imidacloprid-liquid form @ 5 ml/ kg of seed. Further, the seeds of all hybrids were treated with powder formulation of Thiram 75% WP. @ 2.5g per kg of seeds and untreated seeds used as control. Treated seeds were shade dried and then packed in three packing materials *viz.*, cloth bag, super grain bag [polypropylene < 300 gauge] and polypouches (500 gauge). The packed seeds were stored at the Department of Seed Science and Technology, University of Agricultural Sciences, GKVK, Bangalore for a period of twelve months (from August, 2010 to July, 2011) under ambient conditions of Bangalore where the temperature and the relative humidity was ranging from 17.79 to 29.18 ºC and 59.00 to 76.50 per cent, respectively. Seed samples were drawn at monthly intervals for various seed quality attributes, bimonthly for fungal infection and evaluated as per the procedures prescribed by ISTA (2010) [11]. Germination test was conducted in laboratory using between paper (BP) method. Among the germinated seedlings, ten normal seedlings were selected at random in each replication on 10th day. The shoot length was measured from the base of primary leaf to the base of hypocotyl. Similarly, the root length was measured from the base of the hypocotyl to the tip of the primary root. The mean seedling length was computed by adding both shoot and root lengths and expressed in centimeters. The seedling vigour index was computed by adopting the formula as suggested by Abdul-Baki and Anderson (1973) [1], seedling vigour index = {germination (%) × Mean seedling length (cm)} and expressed as whole number. Detection and identification of seed mycoflora was done by blotter paper method (TP) as per ISTA (2010) [11]. Twenty five seeds of three replicates were placed equidistantly in sterile glass petridishes of 12.5 cm diameter containing three moist blotter papers (Whatman No.1). Then the petridishes were incubated at 20±1°C for ten days with 12 hours light and 12 hours dark cycles. After incubation, seeds were examined under stereo binocular microscope for the presence of seed mycoflora and the different fungi found on the seeds were recorded as number of seeds infected by storage fungi and expressed in percentage. The results were statistically analysed by using Factorial CRD (Snedecor and Cochran, 1967) [28].

3. Results and Discussion

The hundred seed weight which would indicate the amount of chemical constituents probably determines the storage potential of seeds besides its vigour. The results of the present study observed that hundred seed weight differed significantly between the hybrids, both at the beginning and subsequent months of storage (Table 1). It was significantly higher in KBSH-44 (6.29 g) followed by KBSH-41 (5.69 g) and lesser in KBSH-53 (3.52 g) initially. Similarly at the end of storage period, higher hundred seed weight was recorded in KBSH-44 (6.06 g) and KBSH-53 (3.28 g) recorded lower values. Highest 100 seed weight was noticed Imidacloprid, liquid form (EC) @ 5ml/kg (5.04 g) followed by Imidacloprid, powder form (WP) @ 5g/kg (4.96 g) and it was lowest in control (4.82 g) at the end of storage period. Probably in treated seeds loss in weight was minimized. Among packing materials, highest 100 seed weight (4.99 g) was in polypouches followed by super grain bag (4.94 g) and lowest was in cloth bag (4.86 g) at the end of storage period. The reduction in 100 seed weight over storage is presumably due to chemical effects, higher activities of fungi, insect damage, more respiration in seeds stored in cloth bags which might have ultimately responsible for loss in weight. The rate of decline in test weight differed between the hybrids indicating that the reduction is influenced by the hybrids. Similar reduction in seed weight was also noticed upon storage by Nataraj (2008) [19] and Balakrishna (2010) [2] in sunflower.

The seed moisture is an important factor, which decides the quality of stored seeds (Copeland and McDonald, 1995) [8]. Low seed moisture maintains the viability and vigour of seed in storage; whereas, high seed moisture increases the metabolic rate and invasion of seeds by storage fungi (Justice and Bass, 1978) [13]. In general as the storage period increases, the seed moisture content progressively increases depending upon the weather conditions. In the present study also, moisture content (%) differed significantly between the hybrids throughout the storage period (Table 2). Initially, it was low in all hybrids with lowest recorded in KBSH-53 (7.0%) but it was slightly higher in KBSH-44 (7.09%). Thereafter, there was an increasing trend in moisture content till the end of storage. After twelve months of storage, KBSH-44 recorded the highest moisture content (9.37%) and lowest was recorded in KBSH-53 (8.82%). However, all hybrids treated with Imidacloprid, liquid form (EC) @ 5ml/kg and untreated control recorded slightly higher moisture (9.44 and 9.40%, respectively). Among the packing materials, cloth bag recorded high moisture content (9.19%) than polypouches (9.05%). This may be due to fluctuation in relative humidity existed during storage period (59.00% to 76.50%). These results are in agreement with the findings of Bhattacharyya *et al*. (1983) [6]; Balamurugan *et al.* (1989) [3]; Patra *et al*. (2000) [20]; Lakshmi (2004) [15] and Nataraj (2008) [19] while on they also reported such variations in sunflower.

Decline in germination with advance in storage period may be attributed to ageing effect, leading to depletion of food reserves and decline in synthetic activity of embryo that leads to loss of viability and vigour. In the present study, a decline in per cent germination was observed in all the hybrids with the advancement of storage period (Table 3). However, the extent of reduction over initial was highest in KBSH-53 (79.67%) and it was lowest in KBSH-44 (34.21%). At the end of 12th month of storage, germination was highest in KBSH-44 (60.67%) followed by KBSH-41 (34.81%) but KBSH-53 recorded significantly lower germination (18.83%). Sen and Pal (1979) [25], Charjan and Tarar (1992) [7], Lakshmi (2004) [15], Balakrishna (2010) [2] noticed that temperature, seed moisture and concentration of carbon dioxide are intimately related with maintenance of viability and vigour in sunflower. Such results were also reported by Sharma *et al*. (1998) [27], Jawale *et al.* (2002) [12], Mohammad Safar (2011) [16] in soybean; Krishnappa (1997) [14] and Narayanaswamy (2002) in groundnut.

Sunflower hybrid KBSH-44 maintained minimum seed certification standards of germination (75.58%) up to ten months whereas KBSH-1 (80.00%) up to eight months but germination per cent decreased drastically in KBSH-53 sunflower hybrid (63.83%) due to insect damage and fungal

infection from 8th months onwards and at the end of 12 months of storage it was hardly 18.83 per cent, irrespective of treatments. Among the seed treatment chemicals, Imidacloprid powder form and Thiram treated seeds maintained prescribed standards of germination (70.0%) up to nine months. Imidacloprid, powder form (WP) @ 5g/kg seed dressing helped in extending the viability and found effective in maintaining germination (46.11%) followed by Thiram @ 2.5 g/kg (42.30%) and but Imidacloprid, liquid form (EC) @ 5ml/kg recorded lower germination (25.22%) at the end of storage period. Effect of containers on viability and vigour during storage period clearly suggested that the packing materials are more important for preserving the seed quality for longer period. Seeds packed in polypouches maintained prescribed minimum certification standards of germination up to nine months. Germination was highest in polypouches (46.42%) followed by super grain bag (35.89%) as against lowest recorded in cloth bag (32.00%) at the end of 12th month storage. Naphade and Sagare (1983) [17], Elementry (1993) [9], Suneeta *et al.* (2002) [29], Shakuntala (2009) [26] have also reported faster decline in germination.

Significant differences were observed among hybrids pertaining to mean seedling length during storage (Table 4). Mean seedling length followed a decreasing trend with the increase in storage period. At the end of storage, higher mean seedling length was obtained in KBSH-44 (24.29 cm) and lower was recorded in KBSH-53 (15.47 cm). Imidacloprid, powder form (WP) @ 5g/kg recorded higher mean seedling length (23.95 cm) followed by Thiram @ 2.5 g/kg (22.77 cm) and lowest was recorded in Imidacloprid, liquid form (EC) @ 5ml/kg (14.75 cm) at the end of storage period. Among the packing materials, polypouches recorded higher mean seedling length (21.64 cm) followed by super grain bag (20.93 cm) and cloth bag recorded the lowest seedling length (18.19 cm) at the end of storage period. The differences in seedling growth attributes due to packing materials and seed treatments may be attributed to the inherent genotypic differences and the amount of reserve food material mobilized during seedling growth which ultimately contributed to seedling growth and dry weight. The decline in seedling length in storage may also be due to depletion of food reserves resulted in loss of seed viability and capacity to germinate (Barton, 1961) [4]. Harrington (1967) [10] also suggested that depletion of available oxidizable material in meristematic cells (embryonic axis) might cause deterioration, even when adjacent tissues such as cotyledons and endosperms still contained abundant food material. In such case, the lack of mobilization of food in dry seeds would lead to starvation of these meristematic cells. Thus, it was speculated that perhaps the meristematic cells exhausted their energy supply with no way to convert ADP to ATP.

Seedling vigour index is another aspect related to quality of seeds. It decreased in all the treatment combinations with increase in the storage duration. But extent of decrease varied with hybrids, containers and seed treatment chemicals (Table 5). Seedling length, dry matter production and vigour index are considered to be the best indicator of seedling vigour. Higher vigour index based on seedling length observed in KBSH-44 (1478) followed by KBSH-41 (770) and less in KBSH-53 (369) at the end of 12th month of storage which is mainly due to higher amount of food reserves. Among seed treatment chemicals, in Imidacloprid, powder form (WP) @ 5g/kg recorded higher vigour index (1140) followed by Thiram @ 2.5 g/kg (1005) and it was lower in Imidacloprid, liquid form (EC) @ 5ml/kg (546). Vigour index based on mean seedling length was highest in polypouches (1126) as against lowest recorded in cloth bag (678) at the end of 12th months of storage. The decrease in the vigour index can be ascribed to decreased shoot length and root length. Similar findings were also reported by Rame Gowda (1981) [23], Bhaskar (1988) [5], Lakshmi, (2004) [15] and Nataraja (2008) [19] in sunflower.

Generally, storage fungi increased with the increase in storage period and field fungi reduced. Similar trend of reduction in field fungi has been observed by Prasanna (1994) [21]. However, the percentage infection differed with cultivars, containers, treatment, storage period and several other factors. Storage fungi have been reported to invade and destroy seeds of many kinds (Rame Gowda, 1981; Charjan and Tarar, 1992; Vamadevappa, 1998; Lakshmi 2004) [23, 7, 30, 15]. Under favorable conditions, they invade any kind of seeds leading to loss of viability, development of musty odor and discoloration of seeds. In the present study, the fungi associated with sunflower seeds during storage were *Aspergillus, Rhizopus, Penicillium Alternaria and Fusarium* and infection due to these fungi varied significantly among the treatments during storage (Table 6, Plate 1). It showed an increasing trend with the advancement of storage. After 12th months of storage, KBSH-44 recorded minimum infection (18.36%) and it was significantly higher in KBSH-53 (43.39%). However seeds treated with Thiram showed significantly lower infection (23.59%) followed by Imidacloprid, powder form (WP) @ 5g/kg (25.57%) while higher infection was registered in Imidacloprid, liquid form (EC) @ 5ml/kg (40.98%) at the end of storage. Further, the infection was significantly lower in polypouches (30.11%) compared to cloth bag (33.71%). The differences in infection levels may be attributed to the fluctuations in seed moisture especially in cloth bag. Similar increase in fungal infection during storage with the fluctuations in seed moisture has also been reported by several workers. These results are in lineage with the findings of Rame Gowda (1981) [23], Ramaiah (1994) [22], Savitri *et al.* (1998) [24] and Nataraj (2008) [19].

Table 1: Hundred seed weight (g) as influenced by hybrids, packing materials and seed treatments during storage of sunflower

Treatments	Storage period in months (August, 2010 to July, 2011)												Mean
	1	2	3	4	5	6	7	8	9	10	11	12	
	Hybrids												
H_1	5.69	5.67	5.66	5.64	5.63	5.56	5.54	5.54	5.52	5.53	5.51	5.45	5.58
H_2	6.29	6.27	6.26	6.25	6.24	6.16	6.14	6.14	6.12	6.11	6.09	6.06	6.18
H_3	3.52	3.50	3.49	3.47	3.46	3.38	3.37	3.37	3.35	3.34	3.33	3.28	3.40
Mean	5.16	5.15	5.14	5.12	5.11	5.03	5.02	5.02	5.00	4.99	4.98	4.93	5.05
SEm±	0.008	0.009	0.008	0.009	0.009	0.009	0.015	0.011	0.012	0.014	0.009	0.009	-
CD(0.05P)	0.023	0.024	0.022	0.026	0.024	0.027	0.029	0.030	0.034	0.039	0.026	0.024	-

	Packaging												
P_1	5.10	5.08	5.07	5.05	5.04	4.97	4.95	4.96	4.93	4.94	4.91	4.86	4.99
P_2	5.18	5.16	5.15	5.14	5.12	5.05	5.03	5.02	5.01	5.00	4.99	4.94	5.07
P_3	5.21	5.20	5.19	5.18	5.17	5.08	5.07	5.07	5.06	5.05	5.03	4.99	5.11
Mean	5.16	5.15	5.14	5.12	5.11	5.03	5.02	5.02	5.00	5.00	4.98	4.93	5.05
SEm±	0.008	0.009	0.008	0.009	0.009	0.009	0.015	0.011	0.012	0.014	0.009	0.009	-
CD(0.05P)	0.023	0.024	0.022	0.026	0.024	0.027	0.029	0.030	0.034	0.039	0.026	0.024	-
	Treatments												
T_1	5.08	5.06	5.04	5.02	5.00	4.94	4.91	4.90	4.88	4.88	4.87	4.82	4.95
T_2	5.12	5.11	5.10	5.09	5.08	4.99	4.98	4.99	4.97	4.97	4.94	4.90	5.02
T_3	5.18	5.16	5.15	5.15	5.14	5.06	5.05	5.04	5.03	5.02	5.01	4.96	5.08
T_4	5.28	5.26	5.25	5.23	5.22	5.15	5.13	5.13	5.12	5.11	5.08	5.04	5.17
Mean	5.16	5.15	5.14	5.12	5.11	5.04	5.02	5.02	5.00	5.00	4.98	4.93	5.05
SEm±	0.009	0.010	0.009	0.011	0.010	0.011	0.012	0.012	0.014	0.016	0.011	0.010	-
CD(0.05P)	0.026	0.028	0.026	0.030	0.028	0.031	0.034	0.035	0.039	0.045	0.030	0.028	-

Hybrids (H)
H1: KBSH-41
H2: KBSH-44
H3: KBSH-53

Packaging (P)
P1: Cloth bag
P2: Super grain bag
P3: Polypouches

Treatments (T)
T1: Control (untreated)
T2: Thiram @ 2.5 g/kg
T3: Imidacloprid powder @ 5 g/kg
T4: Imidacloprid liquid @ 5 ml/kg

Table 2: Seed moisture (%) as influenced by hybrids, packing materials and seed treatments during storage of sunflower

Treatments	**Storage period in months (August, 2010 to July, 2011)**												**Mean**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	
	Hybrids												
H_1	7.02	7.09	7.16	7.25	7.35	7.43	7.51	7.81	8.07	8.58	8.88	9.09	7.77
H_2	7.09	7.15	7.53	7.61	7.71	7.78	7.87	8.17	8.44	8.96	9.21	9.37	8.07
H_3	7.00	7.05	7.11	7.20	7.30	7.38	7.47	7.77	8.03	8.54	8.72	8.82	7.70
Mean	7.04	7.10	7.26	7.35	7.45	7.53	7.62	7.92	8.18	8.69	8.94	9.09	7.85
SEm±	0.0048	0.0042	0.0041	0.0060	0.0061	0.0068	0.0068	0.0070	0.0070	0.0076	0.0081	0.0085	-
CD(0.05P)	0.0136	0.0119	0.0115	0.0168	0.0171	0.0192	0.0192	0.0198	0.0196	0.0214	0.0228	0.0239	-
	Packaging												
P_1	7.06	7.12	7.31	7.41	7.52	7.62	7.71	8.01	8.27	8.79	9.04	9.19	7.92
P_2	7.03	7.09	7.24	7.32	7.42	7.48	7.56	7.86	8.12	8.64	8.88	9.04	7.81
P_3	7.03	7.09	7.23	7.33	7.43	7.49	7.59	7.89	8.15	8.66	8.90	9.05	7.82
Mean	7.04	7.10	7.26	7.35	7.45	7.53	7.62	7.92	8.18	8.69	8.94	9.09	7.85
SEm±	0.0048	0.0042	0.0041	0.0060	0.0061	0.0068	0.0068	0.0070	0.0070	0.0076	0.0081	0.0085	-
CD(0.05P)	0.0136	0.0119	0.0115	0.0168	0.0171	0.0192	0.0192	0.0198	0.0196	0.0214	0.0228	0.0239	-
	Treatments												
T_1	7.09	7.16	7.31	7.42	7.52	7.61	7.72	8.02	8.47	8.99	9.24	9.40	8.00
T_2	6.99	7.05	7.20	7.29	7.39	7.45	7.55	7.85	7.89	8.40	8.65	8.80	7.71
T_3	6.96	7.02	7.16	7.24	7.34	7.39	7.45	7.75	7.79	8.31	8.55	8.72	7.64
T_4	7.12	7.17	7.38	7.46	7.56	7.66	7.75	8.05	8.58	9.07	9.31	9.45	8.05
Mean	7.04	7.10	7.26	7.35	7.45	7.53	7.62	7.92	8.18	8.69	8.94	9.09	7.85
SEm±	0.0058	0.0049	0.0047	0.0069	0.0070	0.0079	0.0079	0.0081	0.0080	0.0088	0.0094	0.0098	-
CD(0.05P)	0.0157	0.0137	0.0133	0.0194	0.0197	0.0221	0.0222	0.0228	0.0227	0.0247	0.0264	0.0275	-

Hybrids (H)
H1: KBSH-41
H2: KBSH-44
H3: KBSH-53

Packaging (P)
P1: Cloth bag
P2: Super grain bag
P3: Polypouches

Treatments (T)
T1: Control (untreated)
T2: Thiram @ 2.5 g/kg
T3: Imidacloprid powder @ 5 g/kg
T4: Imidacloprid liquid @ 5 ml/kg

Table 3: Germination (%) as influenced by hybrids, packing materials and seed treatments during storage of sunflower

Treatments	**Storage period in months (August, 2010 to July, 2011)**												**Mean**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	
	Hybrids												
H_1	94.61 (77.11)	92.78 (75.06)	91.72 (73.83)	89.78 (71.73)	87.83 (70.25)	84.42 (67.25)	84.00 (66.99)	80.00 (63.67)	68.58 (56.10)	59.75 (50.73)	43.67 (40.86)	34.81 (35.62)	76.00
H_2	92.22 (73.98)	93.00 (75.16)	91.83 (73.87)	91.00 (72.89)	90.17 (72.51)	85.67 (68.28)	88.08 (70.57)	86.75 (68.89)	78.08 (62.34)	75.58 (60.65)	67.33 (55.39)	60.67 (51.26)	83.37
H_3	92.64 (74.49)	85.67 (67.99)	84.11 (66.77)	81.39 (64.69)	78.67 (62.94)	77.25 (61.97)	73.75 (59.50)	63.83 (53.15)	57.33 (49.30)	43.33 (40.43)	31.08 (32.91)	18.83 (23.24)	65.66
Mean	93.16	90.48	89.22	87.39	85.56	82.45	81.94	76.86	68.00	59.56	47.36	38.10	75.01
SEm±	0.54	0.60	0.56	0.42	0.53	0.45	0.54	0.42	0.58	0.46	0.44	0.48	-
CD(0.05P)	1.53	1.71	1.36	1.19	1.48	1.27	1.52	1.19	1.62	1.30	1.23	1.34	-
	Packaging												

P_1	92.83 (74.75)	89.33 71.58	88.39 70.63	83.61 (66.55)	78.83 (63.11)	74.00 (59.54)	76.17 (61.20)	74.25 (60.24)	66.92 (55.04)	51.00 (45.33)	39.92 (38.13)	32.00 (32.47)	70.60
P_2	93.22 (75.20)	90.00 (72.25)	88.83 (71.12)	88.87 (71.01)	88.92 (71.23)	87.33 (69.53)	84.58 (67.81)	79.58 (63.43)	65.08 (54.21)	61.58 (51.89)	47.00 (43.11)	35.89 (36.03)	75.91
P_3	93.42 (75.62)	92.11 (74.38)	90.44 (72.71)	89.68 (71.75)	88.92 (71.37)	86.00 (68.43)	85.08 (68.05)	76.75 (62.04)	72.00 (58.48)	66.08 (54.59)	55.17 (47.92)	46.42 (41.62)	78.51
Mean	93.16	90.48	89.22	87.39	85.56	82.44	81.94	76.86	68.00	59.56	47.36	38.10	75.01
SEm±	0.54	0.60	0.56	0.42	0.53	0.45	0.54	0.42	0.58	0.46	0.44	0.48	-
CD(0.05P)	NS	1.71	1.36	1.19	1.48	1.27	1.52	1.19	1.62	1.30	1.23	1.34	-
	Treatments												
T_1	91.37 (73.07)	88.96 (71.08)	87.85 (70.03)	86.59 (68.95)	85.33 (68.30)	83.44 (66.49)	84.56 (67.53)	78.67 (63.04)	71.00 (57.73)	62.70 (52.64)	47.33 (43.39)	38.78 (38.04)	75.55
T_2	94.63 (76.86)	92.52 (74.91)	90.96 (73.43)	89.81 (72.14)	88.67 (71.34)	84.22 (67.48)	83.33 (66.79)	79.89 (63.86)	73.00 (59.09)	64.59 (53.83)	54.44 (47.79)	42.30 (40.05)	78.20
T_3	94.59 (76.97)	90.67 (73.05)	89.48 (71.77)	88.02 (70.22)	86.56 (69.17)	83.00 (65.96)	83.56 (66.85)	78.33 (62.80)	70.44 (57.28)	68.26 (56.22)	55.00 (47.96)	46.11 (42.61)	77.84
T_4	92.04 (73.86)	89.78 (71.90)	88.59 (70.73)	85.13 (67.78)	81.67 (65.46)	79.11 (63.40)	76.33 (61.57)	70.56 (57.91)	57.56 (49.55)	42.67 (39.73)	32.67 (33.07)	25.22 (26.12)	68.44
Mean	93.16	90.48	89.22	87.39	85.56	82.44	81.95	76.86	68.00	59.56	47.36	38.10	75.01
SEm±	0.63	0.70	0.66	0.49	0.61	0.52	0.62	0.49	0.66	0.53	0.51	0.55	-
CD(0.05P)	1.77	1.97	1.85	1.37	1.71	1.46	1.76	1.37	1.87	1.50	1.42	1.55	-

NS: Non Significant; Figures in parentheses are *Arc* sine transformed values

Hybrids (H)
H1: KBSH-41
H2: KBSH-44
H3: KBSH-53

Packaging (P)
P1: Cloth bag
P2: Super grain bag
P3: Polypouches

Treatments (T)
T1: Control (untreated)
T2: Thiram @ 2.5 g/kg
T3: Imidacloprid powder @ 5 g/kg
T4: Imidacloprid liquid @ 5 ml/kg

Table 4: Mean seedling length (cm) as influenced by hybrids, packing materials and seed treatments during storage of sunflower

Treatments	**Storage period in months (August, 2010 to July, 2011)**												**Mean**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	
	Hybrids												
H_1	31.30	30.59	30.01	28.80	28.06	27.30	26.86	26.07	25.61	25.17	21.45	21.00	26.85
H_2	30.06	29.26	28.77	27.56	26.77	26.06	25.46	24.83	24.37	23.94	23.39	24.29	26.23
H_3	29.07	27.70	26.53	25.32	24.53	23.82	23.22	22.59	22.14	21.70	18.40	15.47	23.37
Mean	30.14	29.19	28.44	27.23	26.45	25.73	25.18	24.50	24.04	23.60	21.08	20.25	25.49
SEm±	0.20	0.21	0.21	0.23	0.24	0.25	0.25	0.23	0.24	0.23	0.24	0.29	-
CD(0.05P)	0.56	0.58	0.59	0.65	0.68	0.69	0.71	0.63	0.67	0.64	0.67	0.82	-
	Packaging												
P_1	28.76	27.98	27.58	26.33	25.83	25.26	24.93	24.20	23.83	23.26	19.49	18.19	24.64
P_2	29.84	29.04	28.30	26.93	26.23	25.30	24.74	24.24	23.74	23.36	21.67	20.93	25.36
P_3	31.83	30.54	29.43	28.43	27.31	26.62	25.87	25.06	24.56	24.18	22.08	21.64	26.46
Mean	30.14	29.19	28.44	27.23	26.45	25.73	25.18	24.50	24.04	23.60	21.08	20.25	25.49
SEm±	0.20	0.21	0.21	0.23	0.24	0.25	0.25	0.23	0.24	0.23	0.24	0.29	-
CD(0.05P)	0.56	0.58	0.59	0.65	0.68	0.69	0.71	0.63	0.67	0.64	0.67	0.82	-
	Treatments												
T_1	28.26	27.62	27.01	25.76	24.93	24.43	23.93	23.26	22.93	22.68	20.16	19.54	24.21
T_2	30.28	29.52	28.94	27.78	26.94	26.19	25.53	25.11	24.61	24.11	23.05	22.77	26.24
T_3	32.43	31.52	31.18	30.01	29.33	28.43	28.15	27.26	26.76	25.76	23.75	23.95	28.21
T_4	29.61	28.08	26.61	25.36	24.61	23.86	23.11	22.36	21.86	21.86	17.36	14.75	23.29
Mean	30.14	29.19	28.44	27.23	26.45	25.73	25.18	24.50	24.04	23.60	21.08	20.25	25.49
SEm±	0.23	0.24	0.24	0.27	0.28	0.28	0.29	0.26	0.27	0.26	0.27	0.34	-
CD(0.05P)	0.64	0.67	0.68	0.75	0.79	0.80	0.82	0.73	0.77	0.74	0.77	0.94	-

Hybrids (H)
H1: KBSH-41
H2: KBSH-44
H3: KBSH-53

Packaging (P)
P1: Cloth bag
P2: Super grain bag
P3: Polypouches

Treatments (T)
T1: Control (untreated)
T2: Thiram @ 2.5 g/kg
T3: Imidacloprid powder @ 5 g/kg
T4: Imidacloprid liquid @ 5 ml/kg

Table 5: Seedling vigour index based on mean seedling length (cm) as influenced by hybrids, packing materials and seed treatments during storage of sunflower

Treatments	Storage period in months (August, 2010 to July, 2011)												Mean
	1	2	3	4	5	6	7	8	9	10	11	12	
	Hybrids												
H_1	2963	2842	2761	2575	2475	2320	2259	2093	1761	1515	979	770	2109
H_2	2775	2726	2646	2514	2421	2235	2246	2156	1906	1813	1579	1478	2208
H_3	2695	2374	2233	2062	1929	1839	1720	1460	1307	980	641	369	1634
Mean	2811	2647	2547	2384	2275	2131	2075	1903	1658	1436	1066	872	1984
SEm±	24	28	31	25	26	25	27	27	31	19	19	20	-
CD(0.05P)	68	79	87	72	72	72	76	75	86	54	54	55	-
	Packaging												
P_1	2673	2502	2448	2198	2051	1880	1903	1812	1599	1189	859	678	1816
P_2	2784	2621	2520	2397	2343	2225	2100	1941	1573	1462	1060	814	1987
P_3	2976	2819	2672	2557	2431	2289	2222	1955	1802	1657	1279	1126	2149
Mean	2811	2647	2547	2384	2275	2131	2075	1903	1658	1436	1066	873	1984
SEm±	24	28	31	25	26	25	27	27	31	19	19	20	-
CD(0.05P)	68	79	87	72	72	72	76	75	86	54	54	55	-
	Treatments												
T_1	2583	2460	2387	2226	2142	2051	2024	1840	1629	1417	975	799	1878
T_2	2866	2736	2638	2502	2398	2216	2139	2014	1807	1572	1276	1005	2097
T_3	3068	2864	2795	2641	2549	2370	2357	2138	1891	1769	1328	1140	2243
T_4	2727	2528	2367	2165	2011	1889	1779	1620	1306	986	686	546	1718
Mean	2811	2647	2547	2384	2275	2132	2075	1903	1658	1436	1066	873	1984
SEm±	28	32	36	29	30	29	31	31	35	22	22	23	-
CD(0.05P)	78	91	100	83	84	83	87	87	99	62	63	64	-

Hybrids (H)
H1: KBSH-41
H2: KBSH-44
H3: KBSH-53

Packaging (P)
P1: Cloth bag
P2: Super grain bag
P3: Polypouches

Treatments (T)
T1: Control (untreated)
T2: Thiram @ 2.5 g/kg
T3: Imidacloprid powder @ 5 g/kg
T4: Imidacloprid liquid @ 5 ml/kg

Table 6: Seed infection (%) as influenced by hybrids, packing materials and seed treatments during storage of sunflower

Treatments	Storage period in months (August, 2010 to July, 2011)						Mean
	1	3	5	7	9	11	
	Hybrids						
H_1	1.78(5.73)	4.86(12.16)	8.03(16.01)	9.93(18.04)	14.40(22.14)	32.40(34.65)	11.90
H_2	1.31(4.95)	2.07(6.20)	4.64(11.88)	7.39(15.49)	12.03(20.16)	18.36(25.15)	7.63
H_3	2.63(7.95)	7.47(14.78)	11.32(19.15)	12.19(20.04)	19.42(26.00)	43.39(41.05)	16.07
Mean	1.90	4.80	8.00	9.84	15.28	31.38	11.87
SEm±	0.21	0.16	0.20	0.10	0.08	0.14	-
CD(0.05P)	0.58	0.44	0.56	0.28	0.24	0.40	-
	Packaging						
P_1	2.69(8.31)	6.25(13.27)	10.86(18.79)	12.51(20.42)	17.64(24.63)	33.71(35.16)	13.94
P_2	1.67(5.62)	4.53(10.72)	7.39(15.08)	9.28(17.39)	14.74(22.36)	30.33(32.98)	11.32
P_3	1.35(4.70)	3.63(9.14)	5.74(13.17)	7.72(15.76)	13.47(21.31)	30.11(32.71)	10.33
Mean	1.90	4.80	8.00	9.84	15.28	31.38	11.87
SEm±	0.21	0.16	0.20	0.10	0.08	0.14	-
CD(0.05P)	0.58	0.44	0.56	0.28	0.24	0.40	-
	Treatments						
T_1	3.17(10.06)	6.94(14.85)	9.04(17.02)	11.37(19.53)	16.82(24.05)	35.39(36.18)	13.79
T_2	0.30(1.33)	1.26(4.65)	3.81(10.75)	5.67(13.59)	11.43(19.61)	23.59(28.64)	7.68
T_3	0.70(2.85)	3.26(9.01)	7.46(15.47)	8.26(16.50)	13.54(21.44)	25.57(30.09)	9.80
T_4	3.44(10.60)	7.74(15.68)	11.67(19.48)	14.06(21.80)	19.35(25.96)	40.98(39.55)	16.21
Mean	1.90	4.80	8.00	9.84	15.29	31.38	11.87
SEm±	0.24	0.18	0.23	0.12	0.10	0.17	-
CD(0.05P)	0.67	0.51	0.64	0.33	0.28	0.47	-

Figures in parentheses are *Arc* sine transformed values

Hybrids (H)
H1: KBSH-41
H2: KBSH-44
H3: KBSH-53

Packaging (P)
P1: Cloth bag
P2: Super grain bag
P3: Polypouches

Treatments (T)
T1: Control (untreated)
T2: Thiram @ 2.5 g/kg
T3: Imidacloprid powder @ 5 g/kg
T4: Imidacloprid liquid @ 5 ml/kg

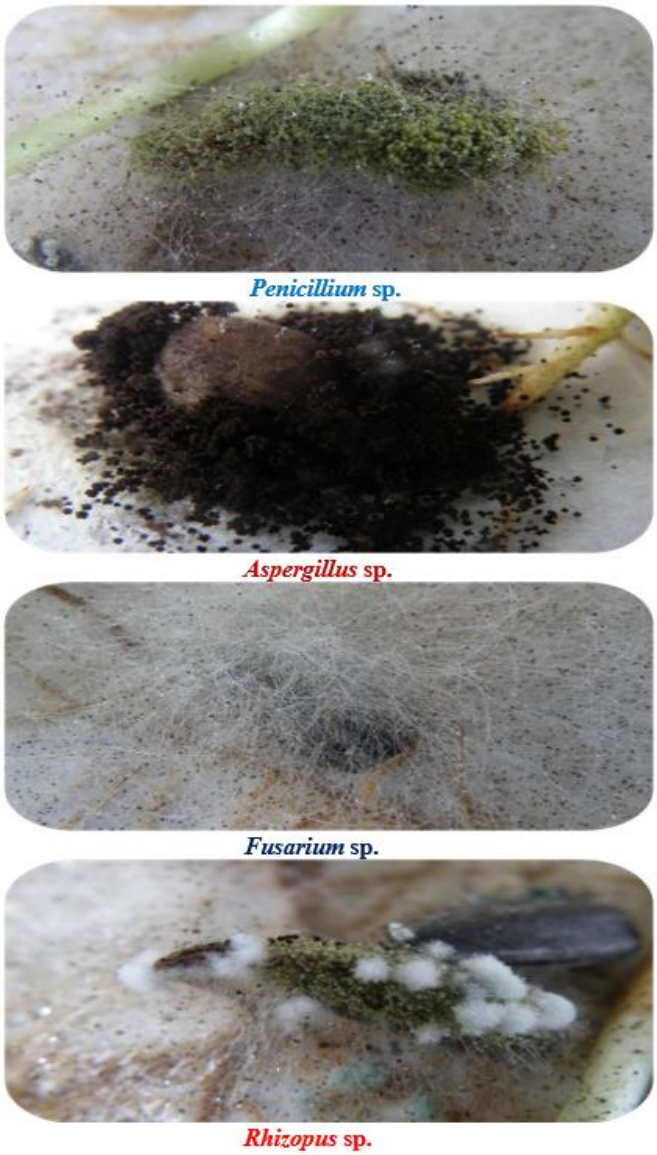

Plate 1: Sunflower seeds infected with *Fungal* sp. during germination of stored seeds

4. Conclusion

Based on the results of the present study, it may be concluded that conventional chemical seed treatment could be useful to prolong the storage life and preserve the quality of sunflower seeds. KBSH-44 hybrid maintained prescribed germination standards (70.0%) up to ten months when compared to KBSH-41 (eight months) and KBSH-53 (seven months). Seeds packed in polypouches maintained prescribed minimum certification standards of germination up to nine months. Therefore, poly pouches and super grain bag (polypropylene) could be safely used for better preservation of sunflower seeds. Seed treated with Imidacloprid, powder form (WP) @ 5g/kg or Thiram @ 3 g /kg could be stored up to nine months with the prescribed germination of minimum seed certification standards.

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