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Impact of Storage Material on Seed Quality and Seed Health Parameters of Treated Seeds of Soybean [Glycine *max* L Merill]

M. Madhavi[1], B. Pushapavathi[2], V. Bharathi[1], M. V. Nagesh Kumar[3], P. Jagan Mohan Rao[1]

[1]Seed Research and Technology Centre, PJTSAU, Hyderabad, Telangana State, India.
[2]Agricultural College, Palem - Telangana State, India.
[3]Maize Research Centre, PJTSAU, Hyderabad, Telangana State, India.

ABSTRACT

Soybean [Glycine max L Merill] is an important oil seed crops known for its richest protein source and is a miracle crop of the twenty century as it plays a pivotal role in agriculture, industry, and export trade of India. Maintenance of seed viability from harvest to next planting season is a major constraint in soybean production. Among the three storage materials viz., gunny bag, poly lined gunny bag and Purdue Improved Crop Storage (PICS) bag evaluated with the seeds treated with carboxin+thiram @3g/kg, pyraclostrobin+ metiram @ 2g/kg and carbendazim +mancozeb @ 2g/kg with untreated control for seed viability, soybean seeds when treated with carboxin 37.5% +thiram 37.5% @3g/kg and stored in polylined gunny bag was found significantly superior in maintaining germination (77.17%) at above IMSCS with highest seedling vigour (1871) and absolutely nil seed infections up to eight months of storage followed by seeds treated with pyraclostrobin+ metiram @ 2g/kg and stored in polylined gunny bag under ambient conditions. Similarly, in case of untreated soybean seeds the polylined gunny bag exhibited improved germination (14.01%) and seedling vigour (19.77%) with reduced seed infections (46.5%) when compared to gunny bags at six months after storage.The present research findings revealed that of the storage materials, the polylined gunny bag was found effective to maintain the seed health and quality of soybean seeds during storage.

Keywords: *Soybean seed, packing material, seed treatment, fungicides, storage, seed quality, seed infections, seed rot.*

Introduction

Soybean [*Glycine max* (L.) Merrill] is the most valuable oilseed legume (20% oil and 40% protein) in the world contributing nearly 28% towards the global vegetable oil production in addition to more than two-thirds of the world's protein requirement for livestock and aquaculture. The crop serves as a good source of protein for the human diet and as a biofuel feedstock. Apart from these nutrients, soybean also contains carbohydrates, vitamins, and minerals which plays significant role in treating chronic diseases such as heart ailments, osteoporosis, cancer, kidney ailments and menopausal syndromes. The crop adapts to diverse agro-climatic conditions and due to its richest source of protein content, in South East Asia, Africa, the United States of America and in many other countries, sometimes it is referred as a *miracle crop* or *golden bean.* Globally, USA, Brazil and Argentina are the major soybean-producing countries where Brazil is the largest producer of soybean accounting for about 33% of global production of soybean followed by USA (32%) and Argentina (14%) during 2021-22 (FAO Statistics and AMIS-FAO. * Estimates).

The crop is grown in 129.18 lakh hectares in India with a production of 12.6 mt and 9.76 q/ha of productivity (INDIASTAT, 2020–21). The major states in India that grow soybeans are Madhya Pradesh, Maharashtra, Karnataka, Tamil Nadu, Rajasthan, Gujarat, Uttar Pradesh, Punjab and Haryana. However, the state, Madhya Pradesh is referred to as the "Soya-Bowl" of the nation since the state contains the majority of the nation's soybean acreage between 80 and 85 percent. The main districts in Telangana cultivating soybean crop are Adilabad, Nirmal, Nizamabad, Kamareddy and Asifabad. These districts have a cultivable area of 1.62 lakh ha,with a production and productivity of 0.243 mt and 15.03 q/ha, respectively[1].

Soybean seed looses its viability much faster than other crop seeds. Maintenance of seed viability from harvest to next planting season is a major constraint in soybean seed production. Seedborne infections is one of the factors for seed deterioration resulting in viability loss during storage under ambient conditions. The biochemical activities within the seed during the storage of seed after harvest leads to seed deterioration and reduction in seed quality affecting the germination capacity within two months of storage at ambient conditions. The seed moisture content, storage temperature, storage pests, mechanical damage, storage period and packing materials are the other factors that affect the soybean seed during storage. On the other hand deterioration of seed is accompanied with ageing phenomenon which is an irreversible degradation change in the quality of a seed after attaining to that stage.

Deterioration of soybean seeds commences after the attainment of the physiological maturity in the field [2]. It further aggravates after harvesting through processing to storage. As the seed passes through the hot summer months, the high temperatures coupled with seed infection by storage fungi exhibit drastic effect on seed viability. This leads to non-availability of sufficient quantities of seed lots with desired

*Corresponding Author: ***M. Madhavi***

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germinability during next planting season. Several techniques such as seed treatment with appropriate chemicals or botanicals and keeping them in safe containers are being used to prevent both quantitative and qualitative losses caused by various biotic and abiotic variables during storage. Numerous seed quality enhancement techniques., *viz*., pre-sowing treatments, pre-storage seed treatments of seeds are now available are now used to the seeds. Though fungicidal seed treatments offer protection to some extent against storage fungus, packaging material also plays an important role in conferring protection to the seeds in terms of maintaining the seed quality. In addition to the storage containers, the period of seed storage and the conditions of storage also have an influence on the viability and seed quality of soybean. Therefore, a comprehensive study was envisaged to find out a suitable low cost storage container for the storability of soybean seeds.

Materials and Methods

The storage experiment was conducted in the Seed Pathology Laboratory, Seed Research and Technology Centre, PJTSAU, Rajendranagar, Hyderabad during the period 2017 to 2020. The seed of soybean variety JS 335 collected from Agricultural Research Station, Adilabad was used for conducting the experiment in all three years. The three storage material tested in the study was gunny bag, polylined gunny bag and Purdue Improved Crop Storage (PICS) bag. After harvest the soybean seed was cleaned and dried to safe moisture level and was given pre-storage seed treatment with the fungicides *i.e* carboxin+ thiram @ 3g/kg, pyraclostrobin+ metiram @ 2g/kg and carbendazim +mancozeb @ 2g/kg and a control with no fungicidal seed treatment to test their efficacy before placing the seed in the storage material. After placing the seed in respective storage materials including the untreated control, the bags were kept in the storage under ambient storage conditions (28$\pm$2 $^{\circ}$C) upto twelve months. Four hundred seeds were tested for their seed quality parameters by adopting standard method [3] at bimonthly intervals.

The treatments having three storage materials against three test fungicides were replicated four times in completely randomized design. As per ISTA (2016), the standard procedure, rolled paper towel method was followed for conducting germination test. One hundred seeds were placed at equidistant between moist sterile paper towels, rolled and kept in germination chamber at25 ± 1^{0}C and 90 per cent RH. On 8th day of incubation, the seedlings were evaluated and the percentage of germination was expressed based on normal seedling. Observations on various seed quality parameters *viz.*, per cent germination, seedling vigour-I, per cent seed rot and seed infection were calculated by following formula as given by [1] with the mean values expressed in whole numbers. All the data generated were subjected to analysis and experimental results were interpreted as suggested by [4] at P=0.05 significance level.

Results

The interaction effects between packaging materials and seed treatments were significant throughout the storage period. The three years study revealed that, the seed quality parameters, germination and seedling vigour index-I were greatly influenced by different packaging materials and fungicide treatments during the extended storage period. The soybean seed treated with the fungicides (carboxin + thiram, pyraclostrobin+ metiram, carbendazim + mancozeb) and stored in gunny bag, polylined gunny bag and PICS bag under ambient storage conditions revealed that, across the packaging materials, polylined gunny bag was found superior to maintain highest per cent seed germination and seedling vigour with minimum seed infections and was significantly differed with gunny and PICS bags. Of the three fungicides evaluated in the study, soybean seed treated with carboxin + thiram and stored in polylined gunny bag has recorded highest of 77.17 per cent seed germination and was found effective in maintaining germination at above Minimum Seed Certification Standards (MSCS) up to eight months after treatment followed by PICS bag (74.33%). At this storage period, the per cent improvement of seed germination recorded by the seed treated with carboxin + thiram and stored in polylined gunny bag treatment was 10.69 per cent and 33.26 per cent over the treated (68.92%) and untreated seed in gunny bags (51.50%), respectively and thereafter drastic reduction of germination was observed up to 12 months after storage. Followed by this, seed treatment with pyraclostrobin+ metiram and stored in polylined gunny (76.15%) and PICS (74.33%) were effective which showed maximum germination per cent as against the treated seed in gunny bag (68.00%) at eight months after treatment. Whereas, carbendazim +mancozeb treated seed stored in polylined gunny bag has recorded per cent seed germination of MSCS (79.75%) up to six months after storage period followed by PICS bag (76.33%) and gunny bag (74.58%) with a drastic reduction thereafter up to 12 months storage period.

However, the untreated soybean seed when stored in polylined gunny bag significantly differed and recorded 70.00 per cent germination which was MSCS up to six months storage period compared to the other storage materials. It was observed that untreated seed stored in polylined gunny bag had showed 12.25 per cent improvement of per cent seed germination as against the untreated seed in gunny bag (61.42%) (Table 1 and Fig.1).

Table 1: Effect of packaging material on germination of fungicide treated and untreated soybean seed

Storage Period	Carboxin + Thiram				Pyraclostrobin+ Metiram				Carbendazim + Mancozeb				Untreated			
	Gunny bag	Polylin-ed bag	PICS bag	Means	Gunny bag	Polylined bag	PICS bag	Means	Gunny bag	Polylin-ed bag	PICS bag	Means	Gunny bag	Polylin-ed bag	PICS bag	Means
Zero #MAT	92.58 *(74.11)	92.92 (74.66)	92.83 (74.49)	92.78 (74.42)	91.75 (73.55)	92.42 (74.47)	92.33 (74.09)	92.17 (74.07)	91.83 (73.33)	92.58 (74.13)	92.50 (73.84)	92.31 (73.77)	87.58 (69.31)	87.75 (69.52)	87.83 (69.54)	87.72 (69.46)
2MAT	89.33 (70.86)	90.58 (72.31)	90.08 (71.84)	90.00 (71.67)	89.00 (70.40)	89.67 (71.32)	90.00 (71.78)	89.56 (71.20)	87.92 (69.75)	91.25 (73.07)	90.42 (72.05)	89.86 (71.63)	84.83 (67.03)	85.67 (67.62)	85.75 (67.84)	85.42 (67.50)
4MAT	85.08 (67.24)	87.75 (69.52)	86.00 (68.05)	86.28 (68.27)	83.00 (65.65)	86.17 (68.01)	84.83 (67.19)	84.67 (66.98)	81.25 (64.53)	86.25 (68.26)	84.92 (67.22)	84.14 (66.87)	75.00 (60.18)	77.67 (61.86)	76.58 (61.19)	76.42 (61.07)
6MAT	83.75 (66.23)	82.33 (65.09)	80.42 (63.63)	82.17 (64.99)	78.67 (62.53)	80.25 (63.60)	80.42 (63.77)	79.78 (63.33)	74.58 (59.68)	79.75 (63.29)	76.33 (60.84)	76.89 (61.27)	61.42 (51.65)	70.00 (56.48)	63.42 (52.68)	64.81 (53.60)
8MAT	68.92 (56.02)	77.17 (61.70)	74.33 (59.52)	73.47 (59.08)	68.00 (55.38)	76.15 (60.82)	74.33 (59.48)	72.83 (58.59)	64.33 (53.28)	68.92 (56.01)	67.92 (55.55)	67.06 (54.95)	51.50 (45.86)	57.42 (49.17)	52.00 (46.15)	53.64 (47.06)
10MAT	47.75 (43.57)	63.92 (52.98)	61.25 (51.50)	57.64 (49.35)	48.08 (43.97)	63.58 (52.81)	59.08 (50.16)	56.92 (49.01)	50.58 (45.29)	54.92 (47.73)	53.92 (47.15)	53.14 (46.72)	34.08 (35.82)	44.17 (41.55)	39.33 (38.94)	39.19 (38.77)
12MAT	32.58 (34.60)	42.33 (40.54)	38.33 (38.35)	37.75 (37.83)	29.42 (32.88)	40.00 (39.06)	36.08 (37.00)	33.89 (35.59)	29.33 (32.73)	38.08 (38.05)	31.75 (34.45)	33.06 (35.08)	21.08 (27.26)	33.83 (35.51)	28.97 (35.58)	27.96 (31.78)
Means	71.43 (58.9)	76.71 (62.4)	74.75 (61.1)		69.70 (57.7)	75.50 (61.4)	73.87 (60.5)		68.55 (56.9)	73.11 (60.1)	71.11 (58.7)		59.36 (51.0)	65.15 (54.5)	61.98 (52.7)	
CV (%)	1.89				1.88				1.65				2.21			
CD (P= 0.05)	Bag=0.61 Storage period =0.93 Bag X Storage period =1.62				Bag=0.60 Storage period =0.93 Bag X Storage period =1.61				Bag=0.51 Storage period =0.79 Bag X Storage period =1.36				Bag=0.62 Storage period =0.95 Bag X Storage period =1.65			

#MAT- Months After Treatment *Figures in parenthesis are angular transformed values

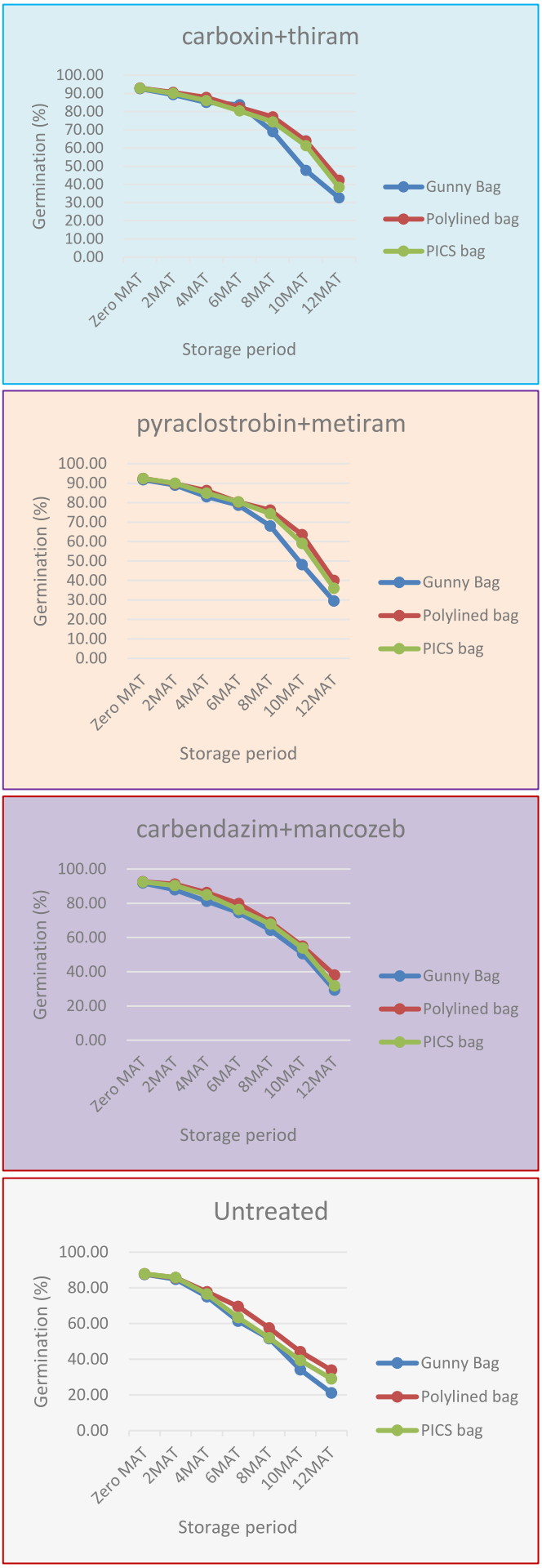


Fig.1. Impact of storage material on seed germination in treated and untreated seed of soybean

The data on seedling vigour index-I in the present study has shown similar trend of percent seed germination recorded in different packaging materials. The soybean seed treated with carboxin+thiram and stored in polylined gunny bags which has shown minimum seed certification standards has recorded highest SVI-I of 1871 and was statistically significant with SVI-I recorded by other two bags at eight months after storage. In case of pyraclostrobin+ metiram treated seed stored in polylined gunny bag, consistence in effectiveness was maintained but at 12 months after storage PICS bag was found comparatively effective. While, the seed treated with carbendazim + mancozeb in polylined gunny bag was effective from zero to 12 months of storage except for eight months which was on par with PICS bag. The per cent improvement of SVI-I by untreated seed in polylined gunny bag was 40.60 percent over the untreated seed in gunny bag at 12 months storage (Table 2).

Table 2: Effect of packaging material on seedling vigour of fungicide treated and untreated soybean seed

Storage Period	Carboxin + Thiram				Pyraclostrobin+ Metiram				Carbendazim + Mancozeb				Untreated			
	Gunny bag	Polylined bag	PICS bag	Means	Gunny ba	Polyli-ned bag	PICS bag	Means	Gunny bag	Polyl-ined bag	PICS bag	Means	Gunny bag	Polyl-ined bag	PICS bag	Means
Zero #MAT	2635	2660	2702	2666	2471	2442	2475	2462	2430	2521	2434	2462	2248	2219	2254	2240
2MAT	2466	2460	2511	2479	2257	2301	2293	2284	2291	2367	2358	2339	2107	2141	2170	2139
4MAT	2217	2228	2135	2193	2076	2175	2142	2131	2067	2087	2073	2075	1687	1853	1845	1795
6MAT	2049	2088	1993	2043	1851	1947	1898	1899	1759	1862	1798	1806	1310	1569	1341	1407
8MAT	1655	1871	1775	1767	1583	1790	1852	1742	1527	1599	1624	1583	1059	1212	1107	1126
10MAT	1025	1398	1345	1256	1039	1429	1256	1241	1012	1228	1115	1118	576	811	691	693
12MAT	654	881	862	799	609	723	795	709	594	778	640	671	395	665	591	550
Means	1815	1941	1903	1886	1698	1830	1816	1781	1669	1777	1720	1722	1340	1496	1428	1421
CV(%)	3.90				3.71				3.29				3.74			
CD (P=0.05)	Bag= 39.36 Storage period =60.12 Bag X Storage period =104.14				Bag=35.30 Storage period =53.92 Bag X Storage period = 93.39				Bag=30.29 Storage period =46.27 Bag X Storage period = 80.15				Bag=28.41 Storage period =43.40 Bag X Storage period = 75.17			

#MAT- Months After Treatment

The per cent seed rot recorded by the seed in different packaging material varied significantly. Soybean seed stored in polylined gunny bag has recorded lowest per cent seed rot except for zero months after treatment followed by PICS bag. The per cent seed rot recorded by the seed treated with carboxin + thiram and stored in polylined gunny bag ranged from 6.83 per cent to 61.25 per cent where the seed rot per cent has drastically increased but proportionately less compared to the other packing material during the extended storage material. Same trend was observed in case of soybean seed treated with pyraclostrobin+ metiram and carbendazim + mancozeb including the untreated seed when stored in polylined gunny bags. However, the per cent seed rot reduction by seed treated with carboxin + thiram and stored in polylined gunny bag over the untreated seed in gunny bag at 12 months after storage was 27.00% and 16.35% by the untreated seed stored in polylined gunny bag over the untreated seed in gunny bag (Table 3).

Table 3: Effect of packaging material on seed rot of fungicide treated and untreated soybean seed

Storage Period	Carboxin + Thiram				Pyraclostrobin+ Metiram				Carbendazim + Mancozeb				Untreated			
	Gunny Bag	Polylined bag	PICS bag	Means	Gunny Bag	Polylined bag	PICS bag	Means	Gunny Bag	Polylined bag	PICS bag	Means	Gunny Bag	Polylined bag	PICS bag	Means
Zero MAT	7.42 (15.79)	6.83 (15.11)	6.75 (15.02)	7.00 (15.30)	7.83 (16.23)	7.42 (15.75)	7.50 (15.87)	7.58 (15.95)	8.17 (16.59)	7.33 (15.70)	7.58 (15.96)	7.69 (16.08)	12.33 (20.55)	12.25 (20.47)	12.33 (20.54)	12.31 (20.52)
2MAT	10.75 (19.13)	9.25 (17.70)	10.08 (18.47)	10.03 (18.43)	10.75 (19.11)	10.33 (18.74)	9.92 (18.35)	10.33 (18.73)	11.92 (20.18)	8.75 (17.19)	9.75 (18.19)	10.14 (18.52)	15.08 (22.82)	14.33 (22.24)	14.25 (22.16)	14.56 (22.40)
4MAT	14.75 (22.56)	11.92 (20.17)	13.50 (21.55)	13.39 (21.43)	16.75 (24.14)	13.42 (21.48)	15.08 (22.84)	15.08 (22.82)	18.67 (26.58)	13.67 (21.69)	15.00 (22.78)	15.78 (23.35)	25.00 (29.99)	22.50 (28.31)	23.50 (28.99)	23.67 (29.10)
6MAT	16.17 (23.69)	17.33 (24.58)	19.17 (25.93)	17.56 (24.73)	21.33 (27.50)	19.33 (26.07)	19.67 (26.32)	20.11 (26.63)	25.50 (30.32)	19.83 (26.42)	23.25 (28.81)	22.86 (28.52)	38.25 (38.20)	30.33 (33.41)	36.75 (37.31)	35.11 (36.31)
8MAT	30.92 (33.78)	22.42 (28.25)	25.83 (30.54)	26.39 (30.86)	32.00 (34.44)	23.75 (29.16)	25.75 (30.48)	27.17 (31.36)	35.58 (36.62)	31.42 (34.08)	32.00 (34.44)	33.00 (35.05)	48.58 (44.18)	42.67 (40.78)	48.00 (43.85)	46.42 (42.94)
10MAT	52.67 (46.52)	36.08 (36.91)	38.67 (38.44)	42.47 (40.63)	52.08 (46.19)	36.25 (37.02)	40.75 (39.66)	43.03 (40.96)	49.50 (44.71)	45.08 (42.17)	46.08 (42.75)	46.89 (43.21)	66.00 (54.33)	55.83 (48.35)	60.67 (51.16)	60.83 (51.28)
12MAT	67.75 (55.40)	57.67 (49.41)	61.25 (51.50)	62.22 (52.10)	70.50 (57.10)	63.67 (52.94)	64.00 (53.13)	66.06 (54.39)	70.42 (57.06)	61.75 (51.80)	68.17 (55.65)	66.78 (54.83)	79.00 (62.73)	66.08 (54.38)	70.83 (57.32)	71.97 (58.14)
Means	28.63 (31.0)	23.07 (27.5)	25.04 (28.8)		30.18 (32.1)	24.88 (32.1)	26.10 (29.5)		31.39 (33.0)	26.83 (29.9)	28.83 (31.2)		40.61 (39.0)	34.86 (35.4)	38.05 (37.3)	
CV (%)	3.65				2.99				3.01				2.53			
CD (P=0.05)	Bag=0.56 Storage period =0.86 Bag X Storage period =1.50				Bag=0.48 Storage period =0.73 Bag X Storage period =1.27				Bag=0.50 Storage period =0.77 Bag X Storage period = 1.33				Bag=0.43 Storage period =0.65 Bag X Storage period = 1.21			

*#MAT- Months After Treatment *Figures in parenthesis are angular transformed values*

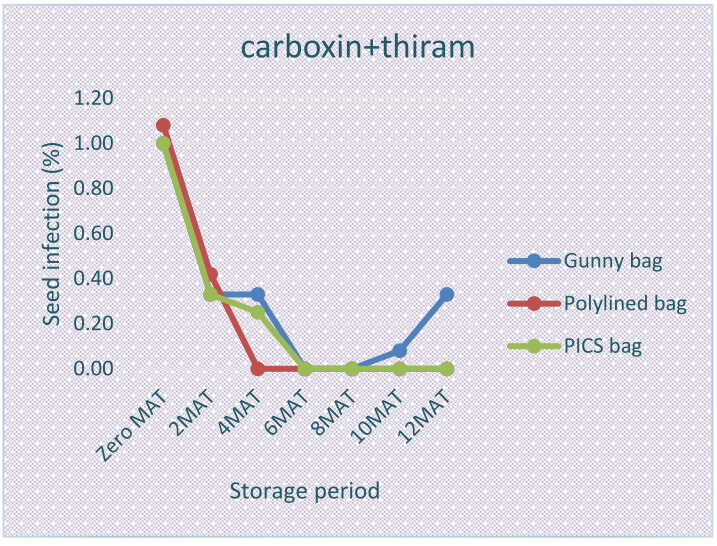
Across the storage period, the data on per cent seed infection recorded with the soybean seeds stored in polylined gunny bag was found significantly less compared to the seeds stored in PICS and gunny bag both in treated and minimum in untreated seeds. During initial storage period, carboxin + thiram treated seed in polylined gunny bag though showed minimal seed infection (1.08 and 0.42%), from four months after treatment recorded absolutely nil per cent seed infection up to 12 months after treatment in storage. While, in case of PICS and gunny bags no seed infection was observed from six months after treatment. Seed treated with pyraclostrobin+ metiram and stored in polylined gunny bag has recorded minimum of 0.25 per cent seed infection and was statistically on par with PICS bag at four months after treatment. Thereafter, both the bags have shown nil seed infection up to 12 months storage period. However, the seed infection was noticed in the seed stored in gunny bag at 10 and 12 months storage period. Carbendazim + mancozeb treated seed when stored in polylined gunny bag has minimum per cent seed infection followed by PICS bag and gunny bag up to six months after treatment with slight increase of seed infections thereafter in all the storage materials but with minimum infections in polylined gunny bag. However, it differed significantly during the immediately after treatment, 10 and 12 months after treatment with other two bags in the study. Untreated seed when tested, irrespective of packaging material, highest per cent seed infection was observed in seed stored in gunny bag from zero months after storage which has gradually increased with the storage period upto12 months.

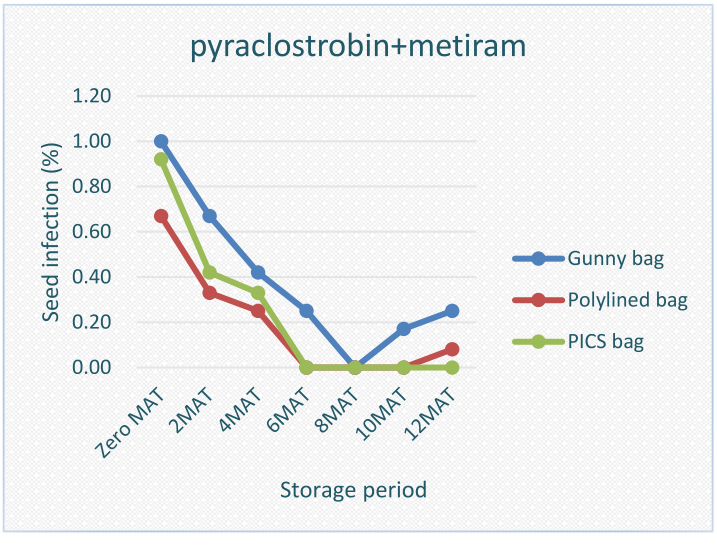
The seed stored in polylined gunny bag has recorded minimum per cent seed infection followed by PICS bag during the extended storage period. While, the seed in gunny bag comparatively has recorded significantly highest per cent seed infection during extended storage period. Since at six months after storage, where the untreated seed stored in polylined gunny bag has recorded minimum seed certification standards, the per cent reduction of seed infection was 46.50% and at 12 months after storage, it was 38.15 % over the seed in gunny bag. Further, it was observed that soybean seed treated with carboxin + thiram and stored in polylined gunny bag has shown cent per cent reduction of seed infection at four months after storage over the untreated seed stored in gunny bag (Table 4 and Fig. 2).

Table 4: Effect of packaging material on per cent seed infection of fungicide treated and untreated soybean seed

Storage Period	Carboxin + Thiram				Pyraclostrobin+ Metiram				Carbendazim + Mancozeb				Untreated			
	Gunny bag	Polylined bag	PICS bag	Means	Gunny bag	Polylined bag	PICS bag	Means	Gunny bag	Polylined bag	PICS bag	Means	Gunny bag	Polylined bag	PICS bag	Means
Zero #MAT	1.00 *(5.69)	1.08 (5.92)	1.00 (5.69)	1.03 (5.77)	1.00 (5.69)	0.67 (4.79)	0.92 (5.43)	0.86 (5.31)	0.92 (5.43)	0.42 (4.21)	0.67 (4.69)	0.67 (4.78)	3.42 (10.64)	2.92 (9.81)	3.08 (10.09)	3.14 (10.18)
2MAT	0.33 (4.05)	0.42 (4.21)	0.33 (4.21)	0.36 (4.16)	0.67 (4.79)	0.33 (4.21)	0.42 (4.21)	0.47 (4.40)	0.33 (4.21)	0.33 (4.47)	0.33 (4.21)	0.33 (4.30)	4.83 (12.69)	4.33 (11.99)	4.08 (11.63)	4.42 (12.10)
4MAT	0.33 (4.05)	0.00 (4.05)	0.25 (4.05)	0.19 (4.05)	0.42 (4.21)	0.25 (4.05)	0.33 (4.05)	0.33 (4.10)	0.33 (4.21)	0.25 (4.05)	0.25 (4.05)	0.28 (4.10)	8.17 (16.59)	5.58 (13.63)	5.42 (13.44)	6.39 (14.56)
6MAT	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	0.25 (4.05)	0.00 (4.05)	0.00 (4.05)	0.08 (4.05)	0.17 (4.05)	0.17 (4.05)	0.17 (4.05)	0.17 (4.05)	12.00 (20.26)	6.42 (14.65)	5.92 (14.07)	8.11 (16.33)
8MAT	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	0.33 (4.21)	0.25 (4.05)	0.33 (4.05)	0.31 (4.10)	19.17 (25.94)	10.08 (18.51)	9.42 (17.86)	12.89 (20.77)
10MAT	0.08 (4.05)	0.00 (4.05)	0.00 (4.05)	0.03 (4.05)	0.17 (4.05)	0.00 (4.05)	0.00 (4.05)	0.06 (4.05)	1.08 (5.92)	0.92 (5.43)	1.17 (6.12)	1.06 (5.82)	20.75 (27.08)	13.33 (21.40)	12.58 (20.77)	15.56 (23.09)
12MAT	0.33 (4.05)	0.00 (4.05)	0.00 (4.05)	0.11 (4.10)	0.25 (4.05)	0.08 (4.05)	0.00 (4.05)	0.11 (4.05)	3.75 (11.14)	1.50 (6.97)	2.00 (8.05)	2.42 (8.72)	26.00 (30.65)	16.08 (23.63)	16.25 (23.77)	19.44 (26.01)
Means	0.30 (4.31)	0.21 (4.34)	0.23 (4.05)		0.39 (4.42)	0.19 (4.18)	0.24 (4.28)		0.99 (5.60)	0.55 (4.75)	0.70 (5.04)		13.48 (20.6)	8.39 (16.2)	8.11 (16.0)	
CV (%)	7.80				8.45				8.62				4.22			
CD (P=0.05)	Bag=0.18 Storage period =0.27 Bag X Storage period =0.47				Bag=0.19 Storage period =0.29 Bag X Storage period =0.51				Bag=0.33 Storage period =0.51 Bag X Storage period =0.89				Bag=0.39 Storage period =0.60 Bag X Storage period =1.04			

*#MAT- Months After Treatment *Figures in parenthesis are angular transformed values*





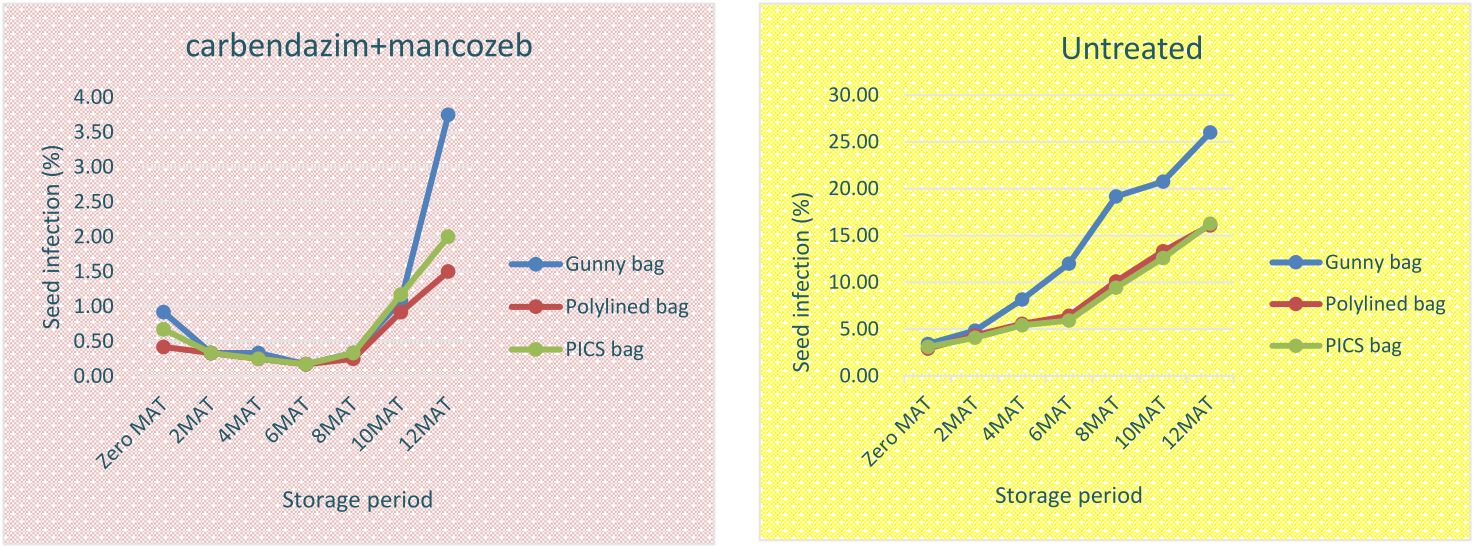


Fig.2. Impact of storage material on seed infection in treated and untreated seed of soybean

Discussion

In soybean, failure of seed germination is a major problem which is due to several factors. Of them the major ones are presence of micropores on seed coat, most of the biotic factors are seed borne diseases, the weather conditions especially during physiological maturity of seed and crop harvesting stage and finally harvesting methods. Practicing seed treatment is one of the best option for addressing the seed quality and healthy issues in soybean. The results of present study on influence of seed treatment with carboxin+thiram for highest per cent seed germination are in agreement with those reported by [5] [6] [7] [8] in rice, groundnut, soybean and groundnut, respectively. Further, the results of influence of storage material on germination are in accordance with [9] [10] [11] [12] in groundnut, tomato, hemp and soybean, respectively who stated that polyethylene bags gave the highest germination (%) and maintained seed viability for longer period compared to paper and cloth bags. While, the results of the investigations on seedling vigour in soybean are in congruence with [12] .

As a regular practice, soybean growers store the seed in gunny bags which have moisture previous nature and there by affects the viability through the invasion of storage mycoflora. Pre-storage seed treatment with chemical fungicides confer protection by acting as a protective agent against seed deterioration due to seed mycoflora as well as physiological ageing. Therefore, as a binding agent, chemical seed treatment maintain seed viability for a considerably longer period of time as it covers the minor cracks and aberrations on seed coat and thus aid in blocking the fungal invasion. Further, the chemical may also function as a physical barrier, which lessens the transpiration of inhibitors from seed coverings, thereby restricts the oxygen transport and helps in reducing the respiration of embryo and finally reducing the effect on seed ageing.

In the current investigation, combifungicides might have served as a seed coat barrier that prevented seed infection in addition to being toxic to fungus. Further, polylined gunny and PICS bags acted as moisture proof storage material which aid to maintain low seed moisture content. During the extended storage period, this has lead to lower seed metabolic activity, respiration rate and fungal infections than gunny bag. The results of present studies are in agreement with [13], [14] and [15]towards fungicide seed treatment and; [8] in groundnut for interaction effects of storage materials and fungicides. Further, the results of the study can be substantiate with the findings of [16]who reported that soybean germination was inhibited by 46% in comparison to the seeds treated with thiram and mancozeb which were completely free of fungal infections.

Future scope of study

The present study which has identified a low cost packaging material will contribute in maintaining the seed quality and health parameters of treated seed in soybean during storage under extended storage periods.

Conclusion

The present studies concluded that among the three storage materials evaluated for fungicide treated and untreated soybean seed up to 12 months storage period, polylined gunny bag was superior to maintain seed quality parameters. The interaction effect of influence of storage material, polylined gunny bag with fungicide, carboxin+thiram treated seed has maintained germination at minimum seed certification standards, highest seedling vigour with minimum seed infections and seed rots during extended storage period. Therefore, the polylined gunny bag which was found to be maintain the seed health and quality of soybean seeds may be used as an alternative storage material during storage for storage of soybean seeds.

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Conflict of interest

All the authors have declared and confirmed that they have no conflict of interest.

Ethical approval

The current study was the authors' original research project, which has not been presented, published, or submitted to any publications. The findings of the work do have undesirable effects on the environment, animals, and people.

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