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Effect of seed coating on seed quality and storability of rice (*Oryza sativa* L.)

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Abstract

Freshly harvested rice seeds (var. HPR 1068) were given nine coating treatments *viz.* polymer coating, flowable thiram, polymer + flowable thiram, vitavax 200, polymer + vitavax 200, imidacloprid, polymer + imidacloprid, polymer + flowable thiram + imidacloprid, polymer + vitavax 200 + imidacloprid and used along with control to study the effect of seed coating on seed quality and storability in HPR 1068 variety of rice at Seed Technology Laboratory, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur during 2015-16. The coated seeds were shade dried and stored in HDPE (high density polyethylene) inter woven non-laminated bags for 12 months. Irrespective of seed coating treatments, seed deteriorated and the vigour declined with increased fungal infection after twelve months of seed storage. Seed coated with polymer @ 3 ml per kg of seed and vitavax 200 @ 2 g per kg of seed (T_5) recorded the highest germination percentage (85.66 %), rate of germination (13.86), seedling length (14.30 cm), seedling dry weight (0.062 g) over the untreated control (T_0) and lowest electrical conductivity (0.223 m mho/cm/g) and seed infection (3.16 %) at the end of 12 months of storage. There was no insect infestation found during the storage period.

Key words: Seed coating, HPR 1068 variety of rice, seed quality, storability.

Rice (*Oryza sativa* L.) is a seed of the grass species and major dietary staple food for higher percentage of the world's population particularly in Asia, where more than 90 per cent of rice is grown. Rice is the predominant dietary energy source for 17 countries in Asia and the Pacific, 9 countries in North and South America and 8 countries in Africa. Rice provides 20% of the world's dietary energy supply. India is one of the world's largest producers of white rice and brown rice, accounting for 20% of all world rice production. In Himachal Pradesh, it occupies an area of 72.47 thousand hectares with a production of 125.23 thousand tonnes and productivity of 17.28 quintals/hectare (Anonymous, 2016). It is a good source of energy, regulate and improve bowel movements, stabilize blood sugar levels, slow down the ageing process, essential source of vitamin B1 to the human body, help in fighting several diseases, rich in selenium, high in manganese, rich in naturally-occurring oils, rich in anti-oxidants, high in fiber, source of a slow-release sugar and a perfect baby food.

In storage, the viability and vigour of the seeds not only vary from genera to genera and variety to variety but it is also regulated by many physiological factors like moisture content, atmospheric relative humidity, temperature, initial seed quality, physical and chemical composition of seed, gaseous exchange, storage structure, packaging materials, seed production location and techniques, etc (Doijode1990). Deterioration of seed during storage is inevitable and leads to different changes at various levels viz., impairment or shift in metabolic activity, compositional changes, decline or change in enzyme activities, phenotypic, cytological changes apart from quantitative losses. The rate of seed deterioration can be slowed down either by storing the seeds under controlled conditions or by imposing polymer film coating along with seed treatment chemicals. As the controlled condition involves huge cost, seed treatment remains the best alternative approach to maintain the seed quality. The quality of rice seed deteriorates mainly due to storage of untreated seed, storage conditions and the packaging materials used for storage of seed. Therefore, for effective rice cultivation, the availability of good quality seed remains one of the major constraints as the seeds are found to be sensitive to various insect-pest infestation and fungal infection. With this in view, the present study was carried out to investigate the utility of coating of seed with polymer alone, in combination with fungicides and insecticide for improving the storability and to know the effect of these treatments on seed quality in rice during storage.

Materials and Methods

An experiment was carried out during 2015-16 in the Seed Technology Laboratory of Department of Seed Science and Technology, CSKHPKV, Palampur. Well graded, freshly harvested seed produce of *kharif* 2015 of rice variety HPR 1068, procured from Rice and Wheat Research Centre Malan (Kangra) was dried to about 10 % moisture content and used in the present study. Ten treatments viz., were evaluated in completely randomized design (CRD) with three replications. The coated seeds after shade drying were packed in HDPE (high density polyethylene) inter woven non-laminated bags and stored in the month of December, 2015 for twelve months under ambient condition in Seed Technology Laboratory of Department of Seed Science and Technology, CSKHPKV, Palampur (Table 1). Evaluation of seed quality parameters, namely, germination (%), field emergence (%), seedling length (cm), seedling dry weight (g), rate of germination, electrical conductivity (m mho/cm/g), seedling vigour index, seed moisture content (%) and seed health status i.e. fungal infection (%) and insect infestation (%) was made initially and subsequently at bimonthly interval in order to identify the suitable polymer-chemical combination(s) for better storage of rice.

T_0	Control (untreated seeds)
T_1	Polymer coating (polykote @ 3 ml per kg of seed, diluted with 5 ml of water
T_2	Flowable thiram (Royal flow 40 SC) @ 2.4 ml per kg of seed
T_3	Polymer + flowable thiram (Royal flow 40 SC) @ 2.4 ml per kg of seed
T_4	Vitavax 200 (containing thiram 37.5% and carboxil 37.5%) @ 2 g per kg of seed
T_5	Polymer + vitavax 200 (containing thiram, 37.5% and carboxil, 37.5%) @ 2 g per kg of seed
T_6	Imidacloprid (Gaucho) @ 4 ml per kg of seed
T_7	Polymer + imidacloprid (Gaucho) @ 4 ml per kg of seed
T_8	Polymer + flowable thiram (Royal flow 40 SC) @ 2.4 ml per kg of seed + imidacloprid (Gaucho) @ 4 ml per kg of seed
T_9	Polymer + vitavax 200 (containing thiram, 37.5% and carboxil, 37.5%) @ 2 g per kg of seed + imidacloprid (Gaucho) @ 4 ml per kg of seed

Table 1. Ambient temperature and relative humidity during storage of HPR 1068 variety of rice (December 2015 to December 2016)

Months	Temperature (^{0}C)		RH (%)
	Mean Max.	Mean Min.	
December 2015	14.67	13.09	50.70
January 2016	13.16	11.98	45.00
February 2016	15.47	13.88	47.90
March 2016	18.03	16.35	47.03
April 2016	23.69	22.13	30.80
May 2016	26.41	24.76	37.00
June 2016	26.85	25.55	50.80
July 2016	25.52	24.34	74.95
August 2016	24.38	23.11	76.65
September 2016	23.94	22.94	72.93
October 2016	22.18	21.52	58.33
November 2016	20.10	18.29	38.11
December 2016	17.16	15.88	36.27

Source: Seed Technology Laboratory of Department of Seed Science and Technology, College of Agriculture, CSK HPKV, Palampur (H.P)

Table 2. Effect of seed coating treatments on germination (%) and field emergence (%) during storage of HPR 1068 variety of rice

Treatment	Months after storage													
	Germination (%)							Field emergence (%)						
	0	2	4	6	8	10	12	0	2	4	6	8	10	12
T_0	91.33	90.00	88.00	86.66	84.33	82.66	79.33	82.00	81.33	79.00	77.00	74.33	70.00	65.33
	(72.85)	(71.53)	(69.71)	(68.55)	(66.65)	(65.37)	(62.93)	(64.87)	(64.37)	(62.70)	(61.32)	(59.53)	(56.76)	(53.90)
T_1	92.00	91.00	89.00	87.00	85.00	83.00	80.00	83.00	82.00	80.33	78.00	75.00	71.00	66.00
	(73.56)	(72.53)	(70.60)	(68.84)	(67.18)	(65.62)	(63.41)	(65.62)	(64.87)	(63.65)	(62.00)	(59.97)	(57.39)	(54.31)
T_2	95.00	94.00	92.00	90.00	88.00	85.66	83.00	86.00	85.00	83.00	81.00	78.00	74.00	69.00
	(77.09)	(75.82)	(73.56)	(71.53)	(69.71)	(67.72)	(65.62)	(68.00)	(67.19)	(65.62)	(64.13)	(62.00)	(59.32)	(56.14)
T_3	97.00	96.33	94.00	92.33	90.00	88.00	85.33	88.33	87.66	85.66	83.33	80.66	76.33	71.33
	(80.08)	(78.95)	(75.82)	(73.90)	(71.55)	(69.71)	(67.45)	(70.00)	(69.41)	(67.72)	(65.88)	(63.89)	(60.86)	(57.60)
T_4	96.66	95.33	93.33	91.33	89.66	87.33	84.33	87.33	86.33	84.66	82.66	79.33	75.66	70.33
	(79.47)	(77.50)	(75.01)	(72.85)	(71.22)	(69.12)	(66.65)	(69.12)	(68.27)	(66.92)	(65.37)	(62.93)	(60.41)	(56.97)
T_5	97.66	96.66	94.33	92.66	90.66	88.33	85.66	89.33	88.33	86.66	84.00	81.66	77.33	72.00
	(81.22)	(79.47)	(76.20)	(74.26)	(72.18)	(70.00)	(67.72)	(70.91)	(70.00)	(68.55)	(66.40)	(64.62)	(61.54)	(58.02)
T_6	93.00	92.00	90.00	88.00	86.00	83.66	81.00	84.00	83.00	81.00	79.00	76.00	72.00	67.00
	(74.65)	(73.56)	(71.53)	(69.71)	(68.00)	(66.13)	(64.13)	(66.40)	(65.62)	(64.13)	(62.70)	(60.64)	(58.03)	(54.91)
T_7	93.33	92.33	90.00	88.66	86.33	84.00	81.33	84.00	83.33	81.00	79.33	76.00	72.33	67.00
	(75.01)	(73.90)	(71.55)	(70.30)	(68.27)	(66.40)	(64.37)	(66.39)	(65.88)	(64.13)	(62.93)	(60.64)	(58.24)	(54.91)
T_8	94.00	93.00	91.00	89.00	87.00	84.66	82.00	85.00	83.00	82.00	80.00	77.00	73.00	68.00
	(75.82)	(74.65)	(72.53)	(70.61)	(68.84)	(66.92)	(64.87)	(67.19)	(65.62)	(64.87)	(63.41)	(61.32)	(58.67)	(55.52)
T_9	96.00	95.00	93.00	91.00	89.00	87.00	84.00	87.00	86.00	84.00	81.66	79.00	75.00	70.00
	(78.43)	(77.09)	(74.65)	(72.51)	(70.61)	(68.83)	(66.40)	(68.84)	(68.00)	(66.40)	(64.62)	(62.70)	(59.97)	(56.76)
Mean	94.59	93.56	91.46	89.66	87.59	85.43	82.59	85.30	84.59	82.73	80.59	77.69	73.66	68.59
	(76.81)	(75.50)	(73.11)	(71.30)	(69.42)	(67.58)	(65.35)	(67.45)	(66.92)	(65.46)	(63.87)	(61.82)	(59.11)	(50.41)
SE(m±)	0.61	0.55	0.50	0.36	0.40	0.30	0.32	0.39	0.37	0.34	0.33	0.31	0.29	0.25
CD (P=0.05)	1.80	1.63	1.47	1.07	1.20	0.89	0.96	1.15	1.10	1.02	0.97	0.92	0.88	0.73

Figures in parenthesis indicates arcsine values; T_0 - control (untreated seeds), T_1 - polymer coating (polykote @ 3 ml/kg of seed, diluted with 5 ml of water), T_2 - flowable thiram (Royal Flow 40 SC) @ 2.4 ml/ kg of seed , T_3 - polymer + flowable thiram (Royal Flow 40 SC) @ 2.4 ml/ kg of seed , T_4 - vitavax 200 (containing thiram 37.5% and carboxil 37.5%) @ 2 g/kg of seed, T_5 - polymer + vitavax 200 (containing thiram 37.5% and carboxil 37.5%) @ 2 g/kg of seed, T_6 - imidacloprid (Gaucho) @ 4 ml/kg of seed, T_7 - polymer + imidacloprid (Gaucho) @ 4 ml/kg of seed, T_8 - polymer + flowable thiram (Royal Flow 40 SC) @ 2.4 ml/ kg of seed + imidachloprid (Gaucho) @ 4 ml/kg of seed and T_9 - polymer + vitavax 200 (containing thiram 37.5% and carboxil 37.5%) @ 2 g/kg of seed + imidacloprid (Gaucho) @ 4 ml/kg of seed thiram @ 2.4 ml/kg of seed (71.33 %) at the end of 12 months of storage. This could be due to decrease in germination percent, seedling vigour, seed ageing, seed deterioration and loss of seed viability over a period of storage. Higher field emergence was recorded in chemical treated seeds which may be due to protection of seeds from microorganisms and in turn help in establishment of seedling in the field condition. The results recorded for field emergence are similar to the findings in soybean (Hwang and Sung 1991; Chachalis and Smith 2001) and marigold (Kumar *et al.* 2014).

Irrespective of seed coating treatments, the seedling length (cm) decreased progressively with advancement in the storage period. Average seedling length recorded at the beginning and the end of storage was 19.68 cm and 11.59 cm, respectively (Table 3). Significantly higher seedling length was recorded in T_5 - polymer + vitavax 200 @ 2 g/kg of seed (14.30 cm) followed by T_3 - polymer + flowable thiram @ 2.4 ml/kg of seed (13.66 cm) at the end of 12 months of storage. It can be due to higher percentage of germination and better initial growth of seedlings in seed coated with polymer and fungicide, as it protect fungal invasion leading to better germination and subsequent higher seedling length. Similar results were reported in rice (Dadlani *et al.*, 1992), maize (Kaushik *et al.*, 2014) and in soybean (Thakur and Dhiman, 2016). Significantly higher seedling dry weight was recorded in T_5 - polymer + vitavax 200 @ 2 g/kg of seed (0.062 g) which was at par with T_3 - polymer + flowable thiram @ 2.4 ml/kg of seed (0.061 g) at the end of 12 months of storage. The seeds treated with polymer and fungicide showed higher seedling dry weight. It indicates that there is positive effect of seed coating polymer and fungicide which could be effective for better storage of seeds. These results are in conformity with findings in rice (Dadlani *et al.* 1992), pigeon pea (Patil *et al.* 2014) and soybean (Baig *et al.* 2012).

The rate of germination continued to decrease from initial to last month of the storage period. On an average the rate of germination in the beginning and end of the storage period was 16.71 and 11.32, respectively (Table 4). Significantly higher rate of germination was recorded in T_5 - polymer + vitavax 200 @ 2 g/kg of seed (13.86) followed by T_3 - polymer + flowable thiram @ 2.4 ml/kg of seed (13.53) at the end of 12 months of storage. Rate of germination decreased with the increasing storage period. Higher rate of germination was recorded for polymer and fungicides treated seeds. This may be due to protection of seeds from fungal infection. Similar results were reported in maize (Sherin and John 2003) and cotton (Kunkur 2005). Electrical conductivity increased with the advancing storage period. Significantly lower electrical conductivity was recorded in T_5 - polymer + vitavax 200 @ 2 g/kg of seed (0.223 m mho/cm/g) followed by T_3 - polymer + flowable thiram @ 2.4 ml/kg of seed (0.226 m mho/cm/g) at the end of 12 months of storage. The electrical conductivity of seed leachates is one of the biochemical characters assessed for seed deterioration. Increase in electrical conductivity may be attributed to higher incidence of fungi which leads to loss of membrane integrity. The polymer and fungicides coating holds the seeds intact and covers the cracks and aberrations of the seed coat and thus reduces the leaching of electrolytes. Similar results were reported in onion (Basavaraj *et al.* 2008) and soybean (Baig *et al.* 2012).

The fungal infection increased throughout the storage period, irrespective of seed coating treatments (Table 5). The storage fungi, infecting seeds were identified as *Fusarium* spp., and *Rhizophous* spp. Among these, *Fusarium* spp. was predominant. Significantly lower seed infection was recorded for seed coated with T_5 - polymer @ 3 ml per kg of seed and vitavax 200 @ 2 g per kg of seed (3.16 %) followed by T_3 - polymer + flowable thiram @ 2.4 ml/kg of seed (3.33 %) at the end of 12 months of storage. Seed microflora is mainly responsible for the degradation of protein and other food reserves resulting in reduction of vigour and germination. Seed treated with polymer and vitavax exerted a significant influence on total fungal colonies of paddy seeds when stored for a period of twelve months. Similar findings were reported in soybean (Ludwig *et al.*, 2011) and hybrid rice (Ambika *et al.*, 2014). No insect infestation was found in any of the treatment including untreated control till the end of storage period. Similar finding were reported in wheat (Sinha and Singh 1998), maize (Mohammad 2012) and hybrid rice (Ambika *et al.* 2014).

The moisture content (%) increased and decreased gradually during storage period as per fluctuations in the prevalent temperature and relative humidity. It started decreasing after second month of storage and decreased till fourth month as the ambient RH was less during that period, but thereafter seeds gained moisture and then again decreased with the decrease in RH. The moisture content of seed due to seed coating treatments recorded non-significant differences during the initial month of storage period, however, it varied significantly after second month of storage period.

Table 3. Effect of seed coating treatments on seedling length (cm) and seedling dry weight (g) during storage of HPR 1068 variety of rice

Treatment	Months after storage													
	Seedling length (cm)							Seedling dry weight (g)						
	0	2	4	6	8	10	12	0	2	4	6	8	10	12
T_0	18.36	16.10	15.46	14.20	13.16	11.26	9.16	0.094	0.089	0.080	0.072	0.068	0.060	0.052
T_1	18.56	16.33	15.66	14.76	13.60	11.56	9.86	0.095	0.091	0.081	0.074	0.069	0.061	0.053
T_2	19.23	18.40	17.26	16.36	15.60	13.60	11.60	0.100	0.095	0.086	0.080	0.074	0.067	0.058
T_3	21.53	20.95	19.40	18.20	17.66	15.53	13.66	0.103	0.099	0.089	0.082	0.078	0.070	0.061
T_4	20.86	19.13	18.46	17.50	16.53	15.56	12.76	0.102	0.098	0.088	0.081	0.076	0.069	0.060
T_5	22.20	21.76	20.86	19.06	18.56	16.33	14.30	0.104	0.100	0.090	0.083	0.079	0.071	0.062
T_6	18.66	17.26	16.53	15.33	14.56	12.26	10.56	0.097	0.092	0.083	0.076	0.071	0.063	0.054
T_7	18.95	17.30	16.66	15.30	14.66	12.40	10.66	0.098	0.092	0.084	0.077	0.072	0.064	0.055
T_8	19.20	18.36	17.16	16.06	15.36	13.36	11.06	0.099	0.095	0.085	0.078	0.073	0.065	0.056
T_9	19.33	18.46	18.40	17.40	16.20	14.30	12.30	0.101	0.097	0.087	0.081	0.076	0.068	0.059
Mean	19.68	18.40	17.58	16.41	15.58	13.61	11.59	0.099	0.094	0.085	0.078	0.073	0.065	0.057
SE(m±)	0.040	0.043	0.039	0.053	0.042	0.042	0.042	0.0005	0.0005	0.0005	0.0006	0.0006	0.0005	0.0006
CD (P=0.05)	0.121	0.128	0.116	0.158	0.124	0.124	0.124	0.0016	0.0017	0.0016	0.0017	0.0017	0.0016	0.0017

T_o - control (untreated seeds), T_1 - polymer coating (polykote @ 3 ml/kg of seed, diluted with 5 ml of water), T_2 - flowable thiram (Royal Flow 40 SC) @ 2.4 ml/ kg of seed , T_3 - polymer + flowable thiram (Royal Flow 40 SC) @ 2.4 ml/ kg of seed , T_4 - vitavax 200 (containing thiram 37.5% and carboxil 37.5%) @ 2 g/kg of seed, T_5 - polymer + vitavax 200 (containing thiram 37.5% and carboxil 37.5%) @ 2 g/kg of seed, T_6 - imidacloprid (Gaucho) @ 4 ml/kg of seed, T_7 - polymer + imidacloprid (Gaucho) @ 4 ml/kg of seed, T_8 - polymer + flowable thiram (Royal Flow 40 SC) @ 2.4 ml/ kg of seed + imidacloprid (Gaucho) @ 4 ml/kg of seed and T_9 - polymer + vitavax 200 (containing thiram 37.5% and carboxil 37.5%) @ 2 g/kg of seed + imidacloprid (Gaucho) @ 4 ml/kg of seed

Table 4. Effect of seed coating treatments on rate of germination and electrical conductivity (m mho/cm/g) during storage of HPR 1068 variety of rice

Treatment	Months after storage													
	Rate of germination							Electrical conductivity (m mho/cm/g)						
	0	2	4	6	8	10	12	0	2	4	6	8	10	12
T_0	15.13	14.00	13.16	12.23	11.43	10.26	9.40	0.146	0.158	0.169	0.202	0.225	0.237	0.244
T_1	15.20	14.26	13.46	12.56	11.76	10.53	9.60	0.144	0.157	0.168	0.201	0.225	0.234	0.242
T_2	16.86	15.46	14.70	14.40	13.50	12.66	11.53	0.138	0.147	0.160	0.192	0.220	0.226	0.230
T_3	18.56	17.40	16.63	16.50	15.43	14.36	13.53	0.134	0.145	0.153	0.189	0.213	0.219	0.226
T_4	17.76	16.60	15.83	15.73	14.66	13.50	12.90	0.136	0.146	0.156	0.190	0.216	0.221	0.230
T_5	18.83	17.56	16.80	16.60	15.70	14.83	13.86	0.133	0.141	0.150	0.187	0.211	0.217	0.223
T_6	15.33	14.40	13.56	12.70	11.90	10.43	9.70	0.143	0.157	0.165	0.198	0.224	0.232	0.240
T_7	15.46	14.63	13.86	12.90	12.00	10.73	9.90	0.142	0.153	0.164	0.196	0.224	0.231	0.237
T_8	16.50	15.26	14.70	13.63	12.60	10.50	10.46	0.140	0.150	0.162	0.194	0.222	0.229	0.234
T_9	17.53	16.23	15.36	15.40	14.33	13.10	12.36	0.137	0.146	0.157	0.191	0.218	0.224	0.228
Mean	16.71	15.58	14.80	14.26	13.33	12.09	11.32	0.139	0.151	0.160	0.194	0.219	0.227	0.233
SE(m±)	0.039	0.044	0.041	0.048	0.046	0.042	0.046	0.0005	0.0005	0.0005	0.0006	0.0006	0.0005	0.0006
CD (P=0.05)	0.11	0.13	0.12	0.14	0.13	0.12	0.13	0.0016	0.0017	0.0016	0.0017	0.0017	0.0016	0.0017

T_o - control (untreated seeds), T_1 - polymer coating (polykote @ 3 ml/kg of seed, diluted with 5 ml of water), T_2 - flowable thiram (Royal Flow 40 SC) @ 2.4 ml/ kg of seed , T_3 - polymer + flowable thiram (Royal Flow 40 SC) @ 2.4 ml/ kg of seed , T_4 - vitavax 200 (containing thiram 37.5% and carboxil 37.5%) @ 2 g/kg of seed, T_5 - polymer + vitavax 200 (containing thiram 37.5% and carboxil 37.5%) @ 2 g/kg of seed, T_6 - imidacloprid (Gaucho) @ 4 ml/kg of seed, T_7 - polymer + imidacloprid (Gaucho) @ 4 ml/kg of seed, T_8 - polymer + flowable thiram (Royal Flow 40 SC) @ 2.4 ml/ kg of seed + imidacloprid (Gaucho) @ 4 ml/kg of seed and T_9 - polymer + vitavax 200 (containing thiram 37.5% and carboxil 37.5%) @ 2 g/kg of seed + imidacloprid (Gaucho) @ 4 ml/kg of seed

Table 5. Effect of seed coating treatments on fungal infection (%) and insect infestation (%) during storage of HPR 1068 variety of rice

Treatment	Months after storage													
	Fungal infection (%)							Insect infestation (%)						
	0	2	4	6	8	10	12	0	2	4	6	8	10	12
T_0	2.00	2.33	3.00	3.66	4.33	5.33	6.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(1.73)	(1.82)	(2.00)	(2.15)	(2.30)	(2.51)	(2.67)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)
T_1	1.83	2.16	2.83	3.50	4.00	5.16	5.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(1.68)	(1.77)	(1.95)	(2.12)	(2.23)	(2.48)	(2.58)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)
T_2	1.16	1.66	2.16	2.83	3.33	3.83	4.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(1.46)	(1.63)	(1.77)	(1.95)	(2.08)	(2.19)	(2.27)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)
T_3	0.50	1.00	1.50	2.16	2.50	3.16	3.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(1.22)	(1.41)	(1.58)	(1.77)	(1.87)	(2.04)	(2.08)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)
T_4	0.66	1.16	1.83	2.50	2.83	3.33	3.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(1.28)	(1.46)	(1.68)	(1.87)	(1.95)	(2.08)	(2.12)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)
T_5	0.33	0.83	1.33	1.83	2.33	3.00	3.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(1.14)	(1.35)	(1.52)	(1.68)	(1.82)	(2.00)	(2.04)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)
T_6	1.66	2.33	2.66	3.33	3.83	4.66	5.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(1.63)	(1.82)	(1.91)	(2.08)	(2.19)	(2.37)	(2.51)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)
T_7	1.66	2.16	2.50	3.16	3.66	4.50	5.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(1.63)	(1.77)	(1.87)	(2.04)	(2.15)	(2.34)	(2.48)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)
T_8	1.50	1.83	2.33	3.00	3.50	4.16	4.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(1.58)	(1.68)	(1.82)	(2.00)	(2.12)	(2.27)	(2.37)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)
T_9	0.66	1.16	2.00	2.66	3.00	3.50	3.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(1.28)	(1.46)	(1.73)	(1.91)	(2.00)	(2.12)	(2.15)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)
Mean	1.19	1.66	2.21	2.56	3.13	4.06	4.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(1.46)	(1.61)	(1.78)	(1.95)	(2.07)	(2.24)	(2.32)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)
SE(m±)	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CD (P=0.05)	0.14	0.14	0.10	0.10	0.09	0.09	0.09	NS	NS	NS	NS	NS	NS	NS

Figures in parenthesis indicates arcsine values; T_o - control (untreated seeds), T_1 - polymer coating (polykote @ 3 ml/kg of seed, diluted with 5 ml of water), T_2 - flowable thiram (Royal Flow 40 SC) @ 2.4 ml/ kg of seed , T_3 - polymer + flowable thiram (Royal Flow 40 SC) @ 2.4 ml/ kg of seed , T_4 - vitavax 200 (containing thiram 37.5% and carboxil 37.5%) @ 2 g/kg of seed, T_5 - polymer + vitavax 200 (containing thiram 37.5% and carboxil 37.5%) @ 2 g/kg of seed, T_6 - imidacloprid (Gaucho) @ 4 ml/kg of seed, T_7 - polymer + imidacloprid (Gaucho) @ 4 ml/kg of seed, T_8 - polymer + flowable thiram (Royal Flow 40 SC) @ 2.4 ml/ kg of seed + imidacloprid (Gaucho) @ 4 ml/kg of seed and T_9 - polymer + vitavax 200 (containing thiram 37.5% and carboxil 37.5%) @ 2 g/kg of seed + imidacloprid (Gaucho) @ 4 ml/kg of seed

Among the different treatments, lowest moisture content was recorded in T_3 - polymer + flowable thiram @ 2.4 ml/kg of seed (10.46%) which was at par with T_9 - polymer + vitavax 200 @ 2 g/kg of seed + imidacloprid (Gaucho) @ 4 ml/kg of seed (10.50%), T_4 - vitavax 200 @ 2 g/kg of seed (10.50%) and T_2 - flowable Thiram @ 2.4 ml/kg of seed (10.50%) at the end of 12 months of storage. Similar results were reported in tomato (Harish *et al.*, 2014) and sunflower (Udabal *et al.* 2014).

Irrespective of seed coating treatments, the vigour of stored seed decreased gradually with advancement in the storage period. Highest seedling vigour index - I was recorded in T_5 - polymer + vitavax 200 @ 2 g/kg of seed (1220) followed by T_{3-} polymer + flowable thiram @ 2.4 ml/kg of seed (1171) at the end of 12 months of storage. The decrease in the vigour index may be due to decline in germination, decrease in seedling length and seedling dry weight. Higher vigour index in polymer coating along with fungicide is due to more germination, seedling length and lesser infection by storage fungi. Similar findings were reported in sorghum (Malarkodi and Dharmalingam 1999), maize (Vanangamudi *et al.* 2003) and sunflower (Udabal *et al.* 2014).

Conclusion

It can be concluded that rice seed coated with polymer @ 3 ml per kg of seed and vitavax 200 @ 2 g per kg of seed and packed in high density polyethylene (HDPE) inter woven non-laminated bag maintained the seed quality for more than 12 months of storage.

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