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Effect of Seed Treatment and Containers on Red Gram cv. BRG-5 Seed Quality during Storage

FATHIMA BANU SUTAR, PARASHIVAMURTHY, S. RAJENDRA PRASAD, V. PALANIMUTHU AND T. M. RAMANAPPA
Department of Seed Science and Technology, College of Agriculture, UAS, GKVK, Bengaluru
E-mail : parashiva2005@gmail.com

ABSTRACT

The storage experiment was carried to find out the 'Effect of different seed treatments and containers on seed quality parameters in red gram cv. BRG-5 seeds'. The seeds were treated with thiram @ 3 g, spinosad 45 SC @ 0.04 ml, powdered dry pepper 10 g, neem leaf powder 10 g and pongamia oil 5 ml / kg of seeds and were stored in cloth bag, biodegradable bag and super grain bag for a period of ten months. From the present investigation it could be concluded that seeds treated with thiram @ 3 g / kg of seeds and stored in super grain bag recorded significantly lower seed moisture (9.79 %), electrical conductivity (377 µS / cm), seed infection (23.11 %) and infestation (6.00 %), while maximum seed quality parameters *viz.,* germination (79.0 %), seedling vigour index-I (2464), seedling vigour index-II (3015), field emergence (68.00 %) and total dehydrogenase activity (1.71 $A_{480\ nm}$) at the end of ten months after storage period compared to other treatments.

Keywords : Seed treatments, Containers, Seed quality and storage

RED GRAM is mainly cultivated and consumed in developing countries of the world. In India, it is the second most important pulse crop after chickpea. It is a deep rooted and drought resistant crop. It is known by many vernacular names *viz.,* tur, arhar and pigeonpea.

It accounts for about 11.8 per cent of the total pulse area and 17.0 per cent of total pulse production of the country. India stands first in area and production of red gram in the world with an area of 5337.89 thousand hectares and production of 4873.24 thousand tonnes with 913 kg / ha productivity. In India, Maharashtra, Madhya Pradesh, Karnataka and Gujarat account for a major share in the production. In Karnataka, the five major red gram producing districts are Gulbarga, Bijapur, Bidar, Yadgir and Raichur (Tiwari and Shivhare, 2017).

There is a sizeable quantitative and qualitative loss of red gram seeds due to adverse effect of several biotic and abiotic stress factors during field and storage, about 7.5 per cent losses out of 9.5 per cent of total losses is in storage level. The maintenance of high quality in seed during storage is of great important. Therefore, an understanding of how best the seeds can be stored under ambient temperature and relative humidity at relatively low cost, with minimum deterioration in quality for periods extending over one or more seasons will be of immense use for seed industry and for farming community.

Hence, it is appropriate to give due emphasis to reduce qualitative as well as quantitative losses of red gram during storage. Several chemical insecticides, fungicides and plant products are known to influence the storability of many pulse seeds without impairing the seed quality traits. They exhibit profuse effects on bruchid infestation and seed quality parameters during storage.

During storage, viability and vigour are lost due to many biotic factors like storage pests and microflora. So, seed treatments with the fungicide and insecticide would reduce the quantitative and qualitative losses besides in maintaining the quality of seed for longer period. Hence, the study was takenup with the objective of assessing effect of different seed treatments and containers on seed quality parameters in red gram cv. BRG-5 seeds during storage.

Material and Methods

The study on effect of different seed treatments and containers on storability of red gram cv. BRG-5 seeds was studied at the STR, NSP, GKVK, Bengaluru under ambient conditions. After recording the initial seed quality parameters two kilogram red gram cultivar *viz.,* BRG-5 seeds were taken for each treatment. Seeds were treated with thiram @ 3 g, spinosad 45 SC @ 0.04 ml, powdered dry pepper 10 g, neem leaf powder 10 g/kg and pongamia oil 5 ml / kg of seeds. Then seeds were air dried under shade for 24h to bring back to its original moisture content. Then Seeds were packed in cloth bag, biodegradable bag and super grain bag and stored under room condition. After the treatment, samplings were done bimonthly to study the seed quality attributes upto 6 months of storage or till germination declines to less than 75 per cent as per Indian Minimum Seed Certification Standards (IMSCS). The seed quality parameters were evaluated as per ISTA (2011) procedures.

Results and Discussion

The initial seed quality parameters *viz*., seed moisture content (9.08 %), seed germination (97.00 %), seedling vigour index-I (3251), seedling vigour index-II (4078) electrical conductivity of seed leachates (121 µS/cm). Total dehydrogenase activity (3.08 A_{480} nm), field emergence (90.00 %), seed infection (0.0 %) and seed infestation (0.0 %) are presented in the respective tables.

Seed moisture content (%)

During second month of storage, there was non-significant difference with respect to seed treatments, containers and their interactions for seed moisture content. However, after tenth month of storage, significant difference with respect to seed moisture content was observed. The lowest (9.96 %) was recorded in thiram @ 3 g / kg of seeds (T_1) and the highest (10.19 %) was noticed in control (T_6). Among containers, significant difference was observed. The lowest (9.86 %) seed moisture content was recorded in super grain bag (C_3) and the highest (10.46 %) was in cloth bag (C_1). Significant difference was observed between seed treatments and containers interactions. T_1C_3 showed significantly lowest (9.79 %) seed moisture content and the highest (10.61 %) was in T_6C_1 (Table 1).

The effect of seed treatments on seed moisture content was significant at all seed treatments after six months of storage periods. Higher seed moisture content was recorded in control followed by neem leaf powder and powdered dry pepper but lower seed moisture percent was observed in seed treated with thiram in the storage condition. The beneficial effect of botanicals may be due to protection offered by treating material for direct contact of air with seed by maintaining cell wall integrity that markedly reduced the seed deterioration. This was responsible for maintenance of seed germination during storage (Girase *et al.,* 2006). Decrease in viability linked to moisture content of seed, which depends on the relative humidity of the storage environment. Seed moisture content of red gram fluctuated constantly during the length of this storage study.

Seed germination (%)

There was significant difference observed during second month of storage with respect to seed treatments in seed germination. The maximum (95.22%) seed germination was recorded in thiram @ 3 g / kg of seeds (T_1) and the minimum (90.78%) was in untreated control (T_6). And there was no significant difference in containers and interactions between seed treatments and containers. But the significant difference was observed in seed germination with respect to seed treatments after ten months of seed storage. The maximum (76.00 %) seed germination was recorded in thiram @ 3 g / kg of seeds (T_1) and the minimum (68.11 %) was noticed in untreated control (T_6).

Among containers, significant difference was observed. The highest (75.06 %) seed germination was recorded in super grain bag (C_3) followed by biodegradable bag (C_2) (73.72 %) and the lowest (70.67 %) was in cloth bag (C_1). There was significant difference in the interactions between seed treatments and containers observed. The highest (78.67 %) seed germination was recorded in T_1C_3 whereas; the lowest (60.67 %) was in T_6C_1 (Table 1).

TABLE 1

Effect of different seed treatments and containers on seed moisture content and seed germination per cent in red gram cv. BRG-5 during storage

Treatments	Months of storage from July 2017 to May 2018									
	Seed moisture content (%)					Seed germination (%)				
	2	4	6	8	10	2	4	6	8	10
Seed Treatment (T)	**Initial - 9.08 %**					**Initial - 97.00 %**				
T_1: Thiram @ 3 g/kg	9.11	9.40	9.29	9.60	9.96	95.22	92.11	82.89	80.89	76.00
T_2: Spinosad 45 SC @ 0.04 ml/kg	9.19	9.44	9.37	9.75	10.02	93.11	90.78	82.22	79.56	75.11
T_3: Powdered dry pepper 10 g/kg	9.24	9.54	9.47	9.90	10.10	93.56	90.00	79.67	79.11	73.11
T_4: Neem leaf powder 10 g/kg	9.24	9.56	9.51	9.92	10.13	92.22	90.56	81.11	79.11	74.22
T_5: Pongamia oil 5 ml/kg	9.23	9.50	9.44	9.82	10.07	91.56	90.00	78.78	77.33	72.33
T_6: Control	9.30	9.63	9.52	9.96	10.19	90.78	87.67	76.78	74.44	68.11
S.Em±	0.06	0.09	0.05	0.02	0.01	0.62	0.58	0.22	0.26	0.22
CD (P=0.05)	NS	NS	0.15	0.05	0.04	1.77	1.66	0.64	0.76	0.62
Containers (C)										
C_1: Cloth bag	9.28	9.67	9.73	10.17	10.46	91.89	88.78	78.50	75.83	70.67
C_2: Biodegradable bag	9.21	9.54	9.39	9.73	9.91	92.67	90.17	80.56	78.89	73.72
C_3: Super grain bag	9.17	9.32	9.18	9.57	9.86	93.67	91.61	81.67	80.50	75.06
S.Em±	0.04	0.06	0.04	0.01	0.01	NS	0.41	0.16	0.19	0.15
CD (P=0.05)	NS	0.19	0.11	0.03	0.03	1.25	1.17	0.45	0.54	0.44
Interaction (T X C)										
T_1C_1	9.20	9.55	9.47	9.87	10.27	94.33	90.33	80.67	78.33	73.67
T_1C_2	9.12	9.43	9.33	9.53	9.82	95.00	91.67	83.00	81.00	75.67
T_1C_3	9.02	9.22	9.07	9.41	9.79	96.33	94.33	85.00	83.33	78.67
T_2C_1	9.24	9.69	9.63	10.15	10.33	92.33	89.33	81.33	77.67	73.67
T_2C_2	9.18	9.37	9.35	9.59	9.86	93.00	90.67	82.33	79.67	75.33
T_2C_3	9.16	9.25	9.11	9.51	9.82	94.00	92.33	83.00	81.33	76.33
T_3C_1	9.28	9.67	9.81	10.22	10.51	92.67	89.00	78.67	77.67	71.67
T_3C_2	9.25	9.59	9.41	9.83	9.90	93.33	90.00	79.67	79.00	73.33
T_3C_3	9.21	9.35	9.20	9.65	9.88	94.67	91.00	80.67	80.67	74.33
T_4C_1	9.30	9.71	9.85	10.24	10.55	91.67	89.67	80.33	76.67	73.00
T_4C_2	9.22	9.61	9.44	9.84	9.95	92.33	90.33	81.33	79.67	74.33
T_4C_3	9.20	9.37	9.24	9.67	9.90	92.67	91.67	81.67	81.00	75.33
T_5C_1	9.29	9.66	9.74	10.23	10.49	90.33	89.33	77.33	75.67	71.33
T_5C_2	9.21	9.54	9.37	9.70	9.88	91.67	89.67	78.67	77.67	72.33
T_5C_3	9.20	9.32	9.19	9.52	9.84	92.67	91.00	80.33	78.67	73.33
T_6C_1	9.38	9.73	9.88	10.29	10.61	90.00	85.00	72.67	69.00	60.67
T_6C_2	9.27	9.72	9.42	9.91	10.04	90.67	88.67	78.33	76.33	71.33
T_6C_3	9.23	9.43	9.27	9.68	9.92	91.67	89.33	79.33	78.00	72.33
S.Em±	0.10	0.16	0.09	0.03	0.02	1.07	1.00	0.38	0.46	0.38
CD (P=0.05)	NS	NS	NS	0.08	0.07	NS	NS	1.10	1.31	1.08
CV (%)	1.75	2.97	2.97	2.92	2.88	2.42	2.60	3.35	3.93	4.94

Seed germination percentage was declined progressively with the advancement of storage period. Seed germination percentage was highest in thiram seed treatment; followed by spinosad seed treatment and the lowest was noticed in untreated control from 2, 4, 6, 8 and 10 moths of storage periods. Seed treatment with thiram and spinosad maintained seed germination percentage above IMSCS (75.00 %) at the end of the storage period. Previous studies suggested that the use of seed dressing chemicals maintained seed germination in treated seeds than control. Studies also reported that fungicides treatment increases seed germination percentage during storage. With respect to containers, seeds stored in super grain bags recorded the highest (75.06 %) seed germination and the lowest (70.67 %) was recorded in cloth bag after ten months of storage. This is mainly due to less insect pest activity in super grain bags which ultimately leads to decreased heat that might have resulted slower rate of deterioration as compared to other containers and thereby maintained higher seed quality as reported in rice by Wasala *et al.* (2016). The decline in seed germination percentage may be attributed to ageing effect leading to depletion of food reserves and decline in synthetic activity of embryo apart from death of seed because of fungal invasion, fluctuating temperature, relative humidity and container in storage also increased accumulation of total peroxide, malondialdehyde content and leakage of electrolytes due to ageing of seeds. These findings are in agreement with the results obtained by Shivayogi *et al.* (2009) in cotton.

Seedling vigour index-I and II

During the second month and ten months after storage, significant difference were observed in seedling vigour index-I and II with respect to seed treatments, containers and their interaction. Among the seed treatments the highest (3227, 3982, 2355 and 2874) seedling vigour index-I and II were noticed in thiram @ 3 g / kg of seeds (T_1) and the lowest (3004, 3692, 2018 and 2464) were in control (T_6). Among containers, the highest (3154, 3915, 2290 and 2808) seedling vigour index-I and II were noticed in super grain bag (C_1) and the lowest (3054, 3750, 2108 and 2573) were in cloth bag (C_1). Among interactions, the highest (3285, 4067, 2464 and 3015) seedling vigour index-I and II were recorded in T_1C_3 whereas; the lowest (2958, 3613, 1753 and 2176) was in T_6C_1 in second and end of storage period (Table 2).

The decline in seedling vigour indices may be attributed to decrease in germination per cent, seedling length and dry matter accumulation in seedling. These findings are in agreement with the results obtained by Shivayogi *et al.* (2009) in cotton. Fungicides seed treatment may be advantageous in lengthening seed storability as treated seed had higher seed germination and seedling vigour index than untreated seeds. Seed treatments were usually applied to protect the seed from seed borne disease (Bartlett *et al.,* 2012 and Munkvold, 2009). Seed deterioration can be reduced to acceptable levels by storing the seeds in triple layer Purdue Improved Cowpea Storage (PICS) bags in eight months retained higher germinability and seed integrity significantly better than seed stored in traditional gunny bags (Vales *et al.*, 2014).

Electrical conductivity of seed leachates (µS / cm)

Among the seed treatments, the electrical conductivity has shown significant difference during storage. However, the lowest (126, 133, 153, 237 and 384 µS / cm, respectively) electrical conductivity of seed leachates in 2, 4, 6, 8 and 10 months was recorded in thiram @ 3 g / kg of seeds (T_1) and the highest (136, 142, 164 and 413 µS / cm, respectively) in untreated control (T_6). The electrical conductivity differed significantly among containers in 2, 4, 6, 8 and 10 months. The electrical conductivity of seed leachates was lower (129, 135, 156, 241 and 392 µS / cm, respectively) in super grain bag (C_3) in 2, 4, 6, 8 and 10 months and highest (133, 140, 161, 249 and 406 µS / cm, respectively) was in cloth bag (C_3). In interaction between seed treatments and containers, the T_1C_3 (180, 230, 306 and 377 µS / cm, respectively) showed significantly lower electrical conductivity of seed leachates in 7, 8, 9 and 10 months and highest (203, 259, 346 and 423 µS / cm respectively) was in T_6C_1 (Table 3).

TABLE 2

Effect of different seed treatments and containers on seedling vigour index-I and II in red gram cv. BRG-5 during storage

Treatments	Months of storage from July 2017 to May 2018									
	Seedling vigour index-I					Seedling vigour index-II				
	2	4	6	8	10	2	4	6	8	10
Seed Treatment (T)			**Initial - 3251**					**Initial - 4078**		
T_1: Thiram @ 3 g/kg	3227	3157	2768	2644	2355	3982	3899	3385	3215	2874
T_2: Spinosad 45 SC @ 0.04 ml/kg	3126	3039	2709	2539	2275	3871	3787	3310	3111	2802
T_3: Powdered dry pepper 10 g/kg	3134	2983	2608	2520	2190	3870	3648	3150	3062	2686
T_4: Neem leaf powder 10 g/kg	3091	2999	2661	2547	2240	3832	3684	3233	3098	2763
T_5: Pongamia oil 5 ml/kg	3053	2975	2567	2441	2163	3749	3618	3059	2924	2619
T_6: Control	3004	2874	2477	2323	2018	3692	3492	2984	2823	2464
S.Em±	23.20	23.15	10.12	13.74	13.61	33.08	33.00	12.63	14.18	11.87
CD (P=0.05)	66.53	66.41	29.03	39.41	39.05	94.89	94.65	36.23	40.68	34.03
Containers (C)										
C_1: Cloth bag	3054	2949	2551	2396	2108	3750	3581	3065	2885	2573
C_2: Biodegradable bag	3109	3010	2643	2524	2222	3834	3686	3199	3065	2724
C_3: Super grain bag	3154	3054	2701	2588	2290	3915	3798	3297	3167	2808
S.Em±	16.40	16.37	7.16	9.72	9.63	23.39	23.33	8.93	10.03	8.39
CD (P=0.05)	47.04	46.96	20.53	27.87	27.61	67.10	66.93	25.62	28.77	24.07
Interaction (T X C)										
T_1C_1	3155	3102	2657	2533	2267	3896	3801	3229	3053	2749
T_1C_2	3240	3169	2782	2654	2334	3982	3895	3413	3239	2859
T_1C_3	3285	3200	2867	2746	2464	4067	4003	3514	3353	3015
T_2C_1	3082	3004	2666	2462	2194	3786	3716	3189	2962	2688
T_2C_2	3120	3035	2702	2552	2270	3870	3771	3321	3142	2824
T_2C_3	3176	3077	2760	2603	2360	3959	3873	3422	3228	2896
T_3C_1	3079	2941	2538	2458	2126	3789	3531	3057	2959	2595
T_3C_2	3131	2981	2612	2528	2197	3841	3633	3150	3064	2697
T_3C_3	3193	3027	2674	2573	2246	3979	3780	3243	3163	2767
T_4C_1	3056	2940	2614	2421	2193	3762	3566	3148	2931	2680
T_4C_2	3096	2997	2674	2571	2239	3845	3657	3240	3138	2772
T_4C_3	3122	3061	2694	2648	2288	3890	3831	3310	3226	2837
T_5C_1	2994	2941	2509	2376	2116	3653	3535	2961	2819	2549
T_5C_2	3062	2968	2563	2449	2160	3759	3601	3032	2915	2611
T_5C_3	3103	3015	2629	2497	2212	3836	3719	3183	3039	2697
T_6C_1	2958	2767	2349	2124	1753	3613	3340	2804	2588	2176
T_6C_2	3008	2911	2527	2387	2131	3705	3556	3037	2893	2581
T_6C_3	3045	2944	2584	2459	2170	3759	3581	3111	2990	2636
S.Em±	NS	NS	17.53	23.80	23.58	57.30	57.16	21.88	24.57	20.55
CD (P=0.05)	115.23	115.02	50.28	68.27	67.63	NS	163.94	62.75	70.46	58.95
CV (%)	3.23	3.76	4.61	5.51	6.59	3.72	4.86	5.49	5.98	6.58

There was an increase in electrical conductivity of seed leachates as the storage period advanced. It may be due to increased membrane permeability and decreased integrity of seed coat, membrane permeability and cellular membrane deterioration. Hence excess release of electrolytes caused higher electrical conductivity of seed leachates. Similar findings were also reported by Maheshbabu (2008) in soybean. Among the seed treatments, lower electrical conductivity of seed leachates were found in thiram compare to control which is due to fungicide seed treatment act as protective seed coat which helps in maintaining membrane integrity. Among the containers lower electrical conductivity of seed leachates were found in super grain bag. This might be due to air tight and penetration resistant property of this container which could have helped in maintaining seed quality and membrane integrity.

Total dehydrogenase activity (A_{480})

Seed treatment with Thiram @ 3g / kg (T_1) noticed higher (2.82 and 1.68 A_{480}) TDH and lower (2.63 and 1.56 A_{480}) were in control (T1) during second and end of the storage period, respectively.

During second and end of the storage period, seed stored in super grain bag recorded significantly highest (2.79 and 1.67 A_{480}) TDH and the lowest (2.69 and 1.57 A_{480}) were in cloth bag, respectively.

There were significant differences with respect to interaction between treatments and containers. However, maximum (2.93 and 1.71 A_{480}) TDH was recorded in T_1C_3 and the lowest (2.62 and 1.51 A_{480}) were noticed in T_6C_1 during second and end of the storage period, respectively (Table 3).

TDH activity has positive correlation with seed germination and negatively correlated with electrical conductivity of seed leachates. The dehydrogenase enzyme is essential for protein synthesis and energy production during germination. The decline in TDH activity lowers both energy (ATP) and supply of food reserves to the germinating seeds. Among the seed treatments, thiram recorded higher TDH activity value compare to control during storage period. Among containers, higher TDH activity value is higher in super grain bag.

Seed infection (%)

Among the seed treatments, the seed infection was shown significant difference during storage. The lowest (1.33, 2.67, 4.44, 7.56 and 12.44 %, respectively) seed infection in 2, 4, 6, 8 and 10 months was recorded in thiram @ 3 g / kg of seeds (T_1) and the highest (14.67, 20.89, 21.78, 32.00 and 45.78, respectively) was in control (T_6). The seed infection differed significantly among containers in 2, 4, 6, 8 and 10 months. The seed infection was lower (7.56, 10.00, 11.78, 17.33 and 23.11%, respectively) in super grain bag (C_3) in 2, 4, 6, 8 and 10 months and the highest (11.11, 15.33, 19.56, 28.89 and 42.22 %, respectively) was observed in cloth bag (C_3) (Table 4).

The seed infection (%) increased with increase in storage period irrespective of treatments. The seed borne pathogen was nil before the storage and at the end of ten months of storage, seed treated with thiram @ 3 g / kg of recorded minimum (12.44 %) infection. While, the maximum seed borne infection (45.78 %) was in control. Among containers, minimum (23.11 %) seed infection was observed in super grain bag compare to control (42.22 %). This might be due to the depletion of oxygen and increase in carbon dioxide thereby inactivating the harmful organism in air tight container.

In the present investigation, the fungi noticed in storage period were *Aspergillus niger, Aspergillus flavous* and *Mucor*. Storage fungi have been reported to invade and destroy the seeds of several species (Gupta *et al.,* 1993). These fungi can invade any kind of seeds and it leads to loss of viability, development of musty odour and discolouration of seeds under favourable conditions. The infection rate was differed with seed treatments, storage container and storage period. This might be due to fluctuations in the moisture during storage period and the occurrence of storage fungi coupled with higher moisture content in control leads to loss of seed quality parameters (Mukewar, 1994).

TABLE 3

Effect of different seed treatments and containers on electrical conductivity of seed leachates and total dehydrogenase activity in red gram cv. BRG-5 during storage

Treatments	Months of storage from July 2017 to May 2018									
	Electrical conductivity of seed leachates					Total dehydrogenase activity (A_{480nm}) (µS/cm)				
	2	4	6	8	10	2	4	6	8	10
Seed Treatment (T)	**Initial - 121 µS/cm**					**Initial - 3.08**				
T_1: Thiram @ 3 g/kg	126	133	153	237	384	2.82	2.65	2.54	2.06	1.68
T_2: Spinosad 45 SC @ 0.04 ml/kg	128	134	155	239	389	2.79	2.61	2.53	2.04	1.65
T_3: Powdered dry pepper 10 g/kg	132	138	160	245	400	2.71	2.58	2.47	1.98	1.61
T_4: Neem leaf powder 10 g/kg	130	136	158	242	394	2.75	2.60	2.50	2.02	1.63
T_5: Pongamia oil 5 ml/kg	134	140	162	249	406	2.67	2.55	2.45	1.95	1.58
T_6: Control	136	142	164	254	413	2.63	2.49	2.42	1.93	1.56
S.Em±	0.41	0.44	0.50	0.69	1.12	0.015	0.009	0.005	0.009	0.005
CD (P=0.05)	1.19	1.27	1.44	1.97	3.22	0.042	0.026	0.016	0.025	0.014
Containers (C)										
C_1: Cloth bag	133	140	161	249	406	2.69	2.51	2.42	1.93	1.57
C_2: Biodegradable bag	131	137	158	244	397	2.70	2.59	2.48	2.01	1.62
C_3: Super grain bag	129	135	156	241	392	2.79	2.65	2.56	2.06	1.67
S.Em±	0.29	0.31	0.35	0.48	0.80	0.010	0.006	0.004	0.006	0.004
CD (P=0.05)	0.84	0.90	1.02	1.39	2.28	0.030	0.018	0.011	0.018	0.010
Interaction (T X C)										
T_1C_1	128	135	156	242	394	2.75	2.59	2.48	1.99	1.64
T_1C_2	125	132	152	234	383	2.77	2.67	2.53	2.04	1.69
T_1C_3	125	130	151	230	377	2.93	2.69	2.62	2.16	1.71
T_2C_1	130	136	158	244	398	2.73	2.56	2.46	1.96	1.60
T_2C_2	127	134	154	237	387	2.74	2.61	2.52	2.06	1.64
T_2C_3	126	132	153	235	383	2.91	2.67	2.61	2.12	1.69
T_3C_1	133	140	162	249	405	2.68	2.51	2.42	1.92	1.55
T_3C_2	132	138	160	244	399	2.70	2.57	2.47	1.99	1.62
T_3C_3	130	137	158	243	396	2.74	2.65	2.53	2.02	1.66
T_4C_1	132	138	160	245	399	2.71	2.55	2.44	1.94	1.56
T_4C_2	130	136	157	241	393	2.72	2.58	2.49	2.03	1.64
T_4C_3	129	135	156	240	391	2.81	2.66	2.58	2.10	1.68
T_5C_1	136	143	165	255	415	2.63	2.48	2.39	1.90	1.53
T_5C_2	133	140	162	249	406	2.68	2.55	2.46	1.97	1.58
T_5C_3	131	138	159	244	398	2.69	2.63	2.52	1.98	1.64
T_6C_1	139	146	168	259	423	2.62	2.36	2.32	1.87	1.51
T_6C_2	136	142	165	255	415	2.63	2.53	2.43	1.95	1.53
T_6C_3	132	139	161	247	402	2.64	2.58	2.50	1.97	1.63
S.Em±	0.72	0.77	0.87	1.19	1.95	0.026	0.016	0.009	0.015	0.009
CD (P=0.05)	NS	NS	NS	3.41	5.59	0.073	0.045	0.027	0.043	0.025
CV (%)	2.97	2.91	2.96	2.98	2.97	3.412	3.184	3.029	3.886	3.812

TABLE 4

Effect of different seed treatments and containers on seed infection and seed infestation per cent in red gram cv. BRG-5 during storage

Treatments	Months of storage from July 2017 to May 2018 (in months)									
	Seed Infection (%)					Seed Infestation (%)				
	2	4	6	8	10	2	4	6	8	10
1	2	3	4	5	6	7	8	9	10	11
Seed Treatment (T)	**Initial - 0.0**					**Initial - 0.0**				
T_1: Thiram @ 3 g / kg	1.33	2.67	4.44	7.56	12.44	1.56	1.89	2.78	3.22	4.56
	(1.18)	(1.65)	(2.07)	(2.70)	(3.50)	(1.38)	(1.47)	(1.76)	(1.89)	(2.24)
T_2: Spinosad 45 SC @0.04 ml / kg	5.33	7.11	11.1	19.11	26.22	0.56	1.33	2.11	2.89	4.67
	(2.30)	(2.72)	(3.34)	(4.36)	(5.13)	(0.96)	(1.28)	(1.60)	(1.81)	(2.22)
T_3: Powdered dry pepper10 g / kg	11.56	12.44	17.78	28.44	40.00	1.89	2.56	3.33	5.22	8.11
	(3.45)	(3.50)	(4.25)	(5.35)	(6.33)	(1.50)	(1.70)	(1.94)	(2.35)	(2.88)
T_4: Neem leaf powder 10 g / kg	11.56	14.67	17.78	26.67	32.89	1.89	2.33	2.78	4.67	6.22
	(3.46)	(3.87)	(4.25)	(5.19)	(5.75)	(1.50)	(1.61)	(1.76)	(2.23)	(2.55)
T_5: Pongamia oil 5 ml / kg	11.11	15.56	20.44	28.44	44.00	0.67	1.00	2.11	3.44	4.89
	(3.39)	(3.98)	(4.54)	(5.35)	(6.64)	(1.03)	(1.06)	(1.59)	(1.95)	(2.29)
T_6: Control	14.67	20.89	21.78	32.00	45.78	2.56	3.44	4.78	7.89	11.00
	(3.88)	(4.60)	(4.69)	(5.69)	(6.71)	(1.70)	(1.96)	(2.26)	(2.85)	(3.35)
S.Em±	0.16	0.18	0.15	0.09	0.08	0.10	0.12	0.05	0.05	0.05
CD (P=0.05)	0.46	0.51	0.44	0.27	0.23	0.28	0.34	0.15	0.15	0.15
Containers (C)										
C_1: Cloth bag	11.11	15.33	19.56	28.89	42.22	2.44	3.22	4.44	6.61	8.94
	(3.28)	(3.85)	(4.39)	(5.35)	(6.43)	(1.68)	(1.85)	(2.20)	(2.63)	(3.03)
C_2: Biodegradable bag	9.11	11.33	15.33	24.89	35.33	1.44	2.00	2.83	4.61	6.94
	(2.93)	(3.28)	(3.87)	(4.94)	(5.88)	(1.34)	(1.53)	(1.81)	(2.22)	(2.68)
C_3: Super grain bag	7.56	10.00	11.78	17.33	23.11	0.67	1.06	1.67	2.44	3.83
	(2.61)	(3.03)	(3.31)	(4.03)	(4.72)	(1.01)	(1.17)	(1.45)	(1.69)	(2.06)
S.Em±	0.11	0.12	0.11	0.07	0.06	0.07	0.08	0.04	0.04	0.04
CD (P=0.05)	0.33	0.36	0.31	0.19	0.16	0.19	0.24	0.11	0.11	0.11
Interaction (T X C)										
T_1C_1	2.67	4.00	6.67	12.00	17.33	2.33	2.67	4.33	4.33	6.33
	(1.65)	(2.12)	(2.65)	(3.54)	(4.22)	(1.68)	(1.74)	(2.20)	(2.20)	(2.61)
T_1C_2	1.33	2.67	5.33	8.00	14.67	2.00	2.33	3.00	3.67	5.00
	(1.18)	(1.65)	(2.39)	(2.92)	(3.89)	(1.58)	(1.68)	(1.87)	(2.04)	(2.35)
T_1C_3	0.00	1.33	1.33	2.67	5.33	0.33	0.67	1.00	1.67	2.67
	(0.71)	(1.18)	(1.18)	(1.65)	(2.39)	(0.88)	(1.00)	(1.22)	(1.44)	(1.77)
T_2C_1	8.00	9.33	16.00	25.33	33.33	1.33	2.00	3.00	4.33	6.00
	(2.86)	(3.12)	(4.04)	(5.08)	(5.81)	(1.29)	(1.58)	(1.87)	(2.20)	(2.54)
T_2C_2	5.33	6.67	9.33	21.33	26.67	0.33	1.33	2.00	2.67	4.67
	(2.39)	(2.65)	(3.12)	(4.67)	(5.21)	(0.88)	(1.27)	(1.58)	(1.77)	(2.27)
T_2C_3	2.67	5.33	8.00	10.67	18.67	0.00	0.67	1.33	1.67	3.00
	(1.65)	(2.39)	(2.86)	(3.33)	(4.37)	(0.71)	(1.00)	(1.34)	(1.46)	(1.86)
T_3C_1	14.67	20.00	21.33	34.67	49.33	3.00	3.67	4.33	7.67	11.00
	(3.89)	(4.51)	(4.67)	(5.93)	(7.06)	(1.87)	(2.04)	(2.20)	(2.86)	(3.39)

1	2	3	4	5	6	7	8	9	10	11
T_3C_2	10.67	9.33	18.67	29.33	41.33	1.67	2.67	3.67	5.33	9.33
	(3.33)	(3.12)	(4.37)	(5.46)	(6.47)	(1.46)	(1.77)	(2.04)	(2.41)	(3.13)
T_3C_3	9.33	8.00	13.33	21.33	29.33	1.00	1.33	2.00	2.67	4.00
	(3.12)	(2.86)	(3.71)	(4.67)	(5.46)	(1.17)	(1.29)	(1.58)	(1.77)	(2.12)
T_4C_1	13.33	17.33	22.67	30.67	40.00	3.00	4.00	4.67	7.00	8.67
	(3.71)	(4.22)	(4.81)	(5.57)	(6.36)	(1.86)	(2.11)	(2.27)	(2.73)	(3.02)
T_4C_2	10.67	13.33	16.00	29.33	33.33	2.00	2.33	2.33	4.67	6.67
	(3.33)	(3.68)	(4.04)	(5.46)	(5.81)	(1.58)	(1.68)	(1.68)	(2.27)	(2.67)
T_4C_3	10.67	13.33	14.67	20.00	25.33	0.67	0.67	1.33	2.33	3.33
	(3.33)	(3.71)	(3.89)	(4.53)	(5.08)	(1.05)	(1.05)	(1.34)	(1.68)	(1.95)
T_5C_1	13.33	17.33	25.33	34.67	53.33	1.33	2.00	3.00	5.67	7.00
	(3.71)	(4.18)	(5.08)	(5.93)	(7.34)	(1.34)	(1.29)	(1.86)	(2.48)	(2.73)
T_5C_2	10.67	16.00	21.33	29.33	45.33	0.33	0.67	2.00	2.67	4.33
	(3.33)	(4.04)	(4.65)	(5.46)	(6.77)	(0.88)	(1.00)	(1.56)	(1.77)	(2.20)
T_5C_3	9.33	13.33	14.67	21.33	33.33	0.33	0.33	1.33	2.00	3.33
	(3.12)	(3.71)	(3.89)	(4.67)	(5.81)	(0.88)	(0.88)	(1.34)	(1.58)	(1.95)
T_6C_1	14.67	24.00	25.33	36.00	60.00	3.67	5.00	7.33	10.67	14.67
	(3.89)	(4.94)	(5.07)	(6.04)	(7.78)	(2.04)	(2.34)	(2.80)	(3.34)	(3.89)
T_6C_2	16.00	20.00	21.33	32.00	50.67	2.33	2.67	4.00	8.67	11.67
	(4.04)	(4.51)	(4.67)	(5.70)	(7.15)	(1.68)	(1.77)	(2.11)	(3.03)	(3.49)
T_6C_3	13.33	18.67	18.67	28.00	26.67	2.67	2.67	3.00	4.33	6.67
	(3.71)	(4.34)	(4.34)	(5.34)	(5.21)	(1.39)	(1.77)	(1.87)	(2.20)	(2.68)
S.Em±	0.28	0.31	0.27	0.16	0.14	0.17	0.20	0.09	0.09	0.09
CD (P=0.05)	NS	NS	NS	0.46	0.40	NS	NS	0.27	0.27	0.26
CV (%)	36.16	33.50	28.45	25.14	24.07	34.28	34.10	23.16	25.56	23.42

Seed infestation (%)

During the second month of storage, there was significant difference observed among seed treatments and containers for seed infestation. Among seed treatments, spinosad 45 SC @ 0.04 ml/kg of seeds (T_2) recorded the lowest (0.56 %) seed infestation where as control recorded the highest (2.56 %). Among containers, super grain bag (C_3) recorded the lowest (0.67%) seed infestation and the highest (2.44%) was in cloth bag (C_1). Among interactions no significant difference was observed, however, T_1C_3 and T_5C_3 recorded lowest (0.33 %) seed infestation whereas; T_6C_1 recorded the highest (3.67 %).

After tenth month of storage, significant difference was observed in seed infestation among the seed treatments, containers and their interactions. Among the seed treatments, thiram @ 3 g / kg (T_1) recorded the lowest (4.56 %) seed infestation which was on par with spinosad 45 SC @ 0.04 ml/kg of seeds (T_2) (4.67 %) where as the highest (11.00 %) was in control (T_6). Among containers, super grain bag (C_3) recorded the lowest (3.83 %) seed infestation and the highest (8.94 %) was in cloth bag (C_1). T_1C_3 recorded lowest (2.67 %) seed infestation, followed by T_2C_3 (3.00 %), T_5C_3 (3.33 %) where as T_6C_1 recorded the highest of (14.67 %) among interaction effects.

The seed infestation was enhanced with the advancement of storage period in all the treatment combinations. The initial seed infestation was nil and at the end of ten months of storage, the seeds treated with thiram @ 3 g / kg seeds, stored in super grain bag recorded lowest (2.67 %) seed infestation as compared to untreated seeds stored in cloth bag (14.67%). This might be due to unpleasant and repellant property of thiram and depletion of oxygen and increase in carbon dioxide thereby inactivating the harmful organism in an air tight container.

Thus, it could be concluded that the red gram seeds treated with thiram @ 3 g / kg of seeds and stored in super grain bag maintained seed quality parameters above IMSCS up to 10 MAS.

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