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Effect of Gamma Irradiation and Chemical Seed Treatments on Seed Longevity of Soybean and Green gram

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ABSTRACT: A study was conducted during 2016-17at the Department of Seed and Science and Technology, College of Agriculture, UAS, Raichur to know the effect of seed treatment and exposure to gamma irradiation on seed quality of soybean (*Glycine max*) and green gram (*Vigna radiata*). Among the different treatments imposed, significantly higher seed germination (70.3.0 and 77.3 %), germination rate index (4527 and 4631), peak value of germination (17.3 and 19.3), shoot length (11.55 and 15.9 cm), root length (14.48 and 18.00 cm), seedling vigour index (1828 and 2616), seedling dry weight (0.320 and 0.345 g), dehydrogenase enzyme activity (0.243 and 0.262 OD value) and alpha amylase enzyme activity (24.85 and 25.05 mm) with lowest abnormal seedling (16.0 and 10.5%), dead seed (13.8 and 12.3%) and mean germination time (2.39 and 2.23) were recorded even after nine months storage, respectively in soybean and green gramby treating the seeds with the combination of malathion + thiram each @ 2.0 g / kg of seed as compared to all other treatments and control. Whereas, seeds exposed to gamma irradiation showed a significant reduction in all the above parameters with an increase in gamma irradiation dosage and also with the advancement of storage period in both the crops.

Keywords: Soybean, Green gram, Gamma irradiation, Chemical seed treatment, Fumigation, Seed germination and longevity

Pulses are an integral part of an average Indian meal as they form the main source of protein since a large proportion of Indian population is vegetarian. In India, pulses are being cultivated over an area of 24.9 mha with an annual production of 16.3 mt with 656 kg per ha productivity [1]. However, the per capita availability of pulses in India is only 40 grams per person per day as against 140 grams per personper day as advocated by Indian Council of Medical Research [2].

Soybean [*Glycine max* (L.) Merill] is one of the most important protein rich oil seed crop used throughout the world as it possess largest component of edible oil (22.0%) and protein (42-45%). It is an important ingredient for more than 50 per cent of the world's high protein meal. It was introduced to India during 1880 and globally grown over an area of 91.40 mha with a production of 204.00 mt and the productivity of 2233 kg per ha. In India, it is grown on an area of 11.60 mha with a production of 14.22 mt and productivity of 1263 kg per ha which is much below world's average productivity. In Karnataka, it is being cultivated in 0.29 mha with a production of 0.27 mt and 952 kg per ha productivity [1].

Green gram (*Vigna radiate* L.), is another important pulse of south and south-east Asia, is the third most widely cultivated pulse after bengal gram and pigeonpea. In India, it is grown in an area of 3.82 mha with a production of 1.59 mt and 416 Kg per ha productivity accounting 65 per cent of world acreage and 54per cent world's production. In Karnataka, it is widely grown in *kharif* covering an area of 0.34 mha with a production of 0.43 mt and 126 kg per ha productivity [1].

Pulses and legumes are stored for nearly eight to nine months by the farmers and state agricultural universities, seed corporations and other government agencies for seed purpose in next season. During this period, post-harvest damages by insects have been recognized as an important bottle neck for pulse producers [3]. The larva feeds on the endosperm and germ of the seed and finally creates irregular holes with transparent thin outer covering [4]. In each stored seeds, the pest consumes approximately 5 to 7 per cent resulting up to 30-50 per cent seed damage [5, 6].

Considering the extent of losses and damage to pulse seeds, several research strategies are being adopted for management of these storage pests, of which use of fungicides, insecticides, fumigants and ionizing radiations are the options for providing protection to the seeds against insects and diseases. Seed treatment with fungicide is known to improve the germination of poor quality seed. A fungicide treatment also protects the seeds and young seedlings from many seed borne and soil borne pathogens [7].

The gamma rays are the physical mutagens which are non-particulate ionizing radiations, having high energy and penetrable capacity in biological tissues and make changes in base, disruption of hydrogen bonds between complementary stands of DNA. The key reason as to why irradiation has been adopted as a phytosanitary treatment of fresh commodities is that it is generally less damaging to fresh commodities than alternative temperature and fumigation treatments [8].

Hence, gamma irradiation is a technology with immense application both in agriculture and medical sector. In agriculture, it is being utilised in solving various problems such as reduction of post-harvest losses through suppressing sprouting and contamination, eradication or control of insect pests, reduction of food-borne diseases, extension of shelf life and breeding of high performance well adapted and disease resistant agricultural crop varieties. Gamma rays are known to influence the plant growth and development by inducing cytological, genetic, biochemical, physiological and morphogenetic changes in cells and tissues [9].

Further, in general, a common practice of treating the seeds with thiram and carboxin before storage is known to be effective against a wide range of seed storage pathogens [10-12] and thiram could delay the seed deterioration [13]. Looking into wide applicability of gamma irradiation and also the dose sensitivity for a particular crop and its application, in the days to come this technology may be used for stored pest management in the seed storage godown. But, what is its effect (negative or positive) on seed quality parameters need to be assessed particularly with respect to the pulses which are more sensitive to the gamma rays. Keeping in view the above facts, the present investigation was initiated.

MATERIALS AND METHODS

An experiment was conducted in the Department of Seed Science and Technology, College of Agriculture, University of Agricultural Sciences, Raichur during the year 2016-17 to study the effect of gamma irradiation and chemical seed treatments on seed quality of soybean and green gram. The experiment consisted of nine treatments. *Viz.*, T_1: Control, five gamma irradiation (T_2 to T_6) dosages T_2: 200 Gy, T_3: 400 Gy, T_4: 600 Gy, T_5: 800 Gy, T_6: 1000 Gy, three seed treatment chemicals, T_7: malathion @ 2 g per kg of seed, T_8: thiram @ 2 g per kg of seed and T_9: malathion+ thiram each @ 2 g per kg of seed. The experiment was conducted in a completely randomized design with four replications.

For imposition of gamma irradiation treatments, 3 kg seed was used for each treatment. Since, the capacity of gamma irradiation sample chamber was only 1.5 kg, the seed was divided into two parts and exposed to gamma irradiation. The seeds were put in the gamma irradiation chamber and the lid was closed. Then the required gamma irradiation dose was set as per the treatments. Later, the sample chamber (vertical drawer) moves inside cobalt-60 radiation isotope which emits gamma irradiation. The duration taken for gamma irradiation was automatically adjusted as per the dose set.

For imposing seed treatment chemicals, thiram (fungicide) and malathion (insecticide), the seeds were placed in a plastic tray and the required quantity of chemicals and their combinations were dusted after sprinkling a little quantity ofwater to the seeds and mixed thoroughly in order to have uniform seed coating. After imposition of treatments, the seeds were stored in cloth bag for nine months at room temperature. The observations on various seed quality parameters were recorded.

The germination test (Ger%) was conducted in four replicates of 100 seeds each following between paper methods in walk-in seed germinator maintained at 25 ± 2°C temperature at 90 per cent relative humidity for 8 days [14] in both the crops. Similarly, the abnormal seedlings (AbS) and dead seeds (DS) were recorded [14]. While, the mean germination time (MGT) was computed by adopting the formula suggested by Azimi and Hosseini [15]. The various seed quality parameters were recorded as per standard procedures *viz.*, the germination rate index (GRI) [16], peak value of germination (PVG) [17], shoot length (SL), root length (RL), seedling dry weight (SDW), seedling vigour index (SVI) [18], insect egg and seed damage [19], percent weight loss [20], dehydrogenase enzyme activity (DH) [21], alpha amylase enzyme activity [22] and electrical conductivity (EC) [23]. The experimental data thus obtained were subjected for statistical analysis as per Sundararaj *et al.* [24].

RESULTS AND DISCUSSION

Among the different treatments imposed, significantly higher seed germination (94.8 and 70.3 %) was recorded by the combination of malathion and thiram each @ 2 g per kg of seeds (T_9) compared to all other treatments and control T_1 (92.0 and 68.5%), respectively, at initial and nine months after storage in Soybean (Table 1a). Similarly, in green gram T_9, was effective in registering significantly higher seed germination (86.3 and 77.3%) compared to all other treatments and control-T_1 (85.5 and 73.8%), respectively at initial and nine months after storage (Table 2a).This may be due to better protection of seeds by both the combination of insecticide (malathion) and fungicide (thiram) when used at optimum dose. These results are in line with the earlier findings of Ravikumar *et al.* [25] who reported that soybean seeds treated with malathion (2 g/ kg of seeds) or in combination with fungicide (thiram @ 2 g/kg of seeds) prevented the insect infestation and thereby registered a higher seed germination.

While, exposing the seeds to gamma irradiation (T_2- T_6) showed a significant reduction in seed germination with an increasing gamma irradiation dosage. Among all the irradiation treatments, exposing the seeds to 1000 Gy (T_6) recorded the least seed germination (75.3 and 56.5%) compared to control (92.0 and 68.5%) in soybean (Table 1a). Similarly, in green gram T_6, registered 74.0 and 63.3 per cent seed germination compared to all other treatments and control (85.5 and 73.8 %) at initial and nine months after storage, respectively (Table 2a). This might be due to greater loss of leachates mainly because of enhanced membrane permeability [26].

From the present study, significantly lower abnormal seedlings (1.3 and 16.0%) and dead seeds (4.0 and 13.8%) were recorded by the combination of malathion and thiram each @ 2 g per kg of seed (T_9) compared to all other treatments and control (2.3 and 16.0%) and (5.8 and 15.5%) in Soybean (Table 1a) at initial and nine months after storage, respectively. Similarly, in green gram (Table 2a),T_9 was effective in registering significantly lower abnormal seedlings (2.3 and 10.5%) and dead seeds (11.5 and 12.3%) compared to all other treatments and control (3.3 and 11.8%) and (11.3 and 14.5%).

Further, a significant and drastic increase in the abnormal seedlings (%) and dead seeds (%) were noticed (Table 1a & 2a) with an increase in gamma radiation dosage (T_2 to T_6) in both the crops. This might be due to gamma irradiation induced oxidative stress with high production of reactive oxygen species (ROS) such as super oxide radical, hydroxyl radical and hydrogen peroxide which reacts rapidly with almost all the structural and functional organic molecules including proteins, lipids and nucleic acids causing disturbance in cellular metabolism [27].

Table 1a: Influence of gamma irradiation and seed treatment chemicals on seed quality parameters of soybean

Treatments	Ger% (%)		Ab S (%)		DS (%)		SL (cm)		RL (cm)		SDW (g)		SVI		MGT	
	Initial	9 MAS	Initial	9 MAS	Initial	9 MAS	Initial	9 MAS	Initial	9 MAS	Initial	9 MAS	Initial	9 MAS	Initial	9 MAS
T_1	92.0	68.5	2.3	16.0	5.8	15.5	14.50	11.73	17.48	12.30	0.395	0.303	2,941	1,645	1.51	2.59
T_2	85.0	65.5	7.3	18.0	7.8	16.5	13.48	9.53	16.28	11.85	0.388	0.298	2,530	1,400	1.40	2.64
T_3	84.3	62.8	7.0	19.5	8.8	17.8	11.75	8.98	15.63	11.63	0.383	0.288	2,305	1,290	1.62	2.75
T_4	82.0	61.3	8.8	20.0	9.3	18.8	10.68	8.00	14.55	11.48	0.373	0.278	2,069	1,191	1.62	2.89
T_5	77.8	57.8	13.5	21.0	8.8	21.3	10.13	6.53	14.00	10.53	0.338	0.27	1,876	985	1.64	3.10
T_6	75.3	56.5	14.8	22.3	10.0	21.3	9.50	5.95	13.38	9.63	0.303	0.238	1,723	880	1.67	3.30
T_7	93.3	68.8	2.8	16.3	4.0	15.0	14.38	11.23	17.68	13.53	0.410	0.308	2,989	1,703	1.36	2.56
T_8	93.8	69.5	2.8	15.3	3.5	15.3	14.58	11.43	17.98	14.08	0.418	0.313	3,050	1,768	1.34	2.46
T_9	94.8	70.3	1.3	16.0	4.0	13.8	14.73	11.55	18.50	14.48	0.420	0.320	3,149	1,828	1.31	2.39
Mean	86.4	64.5	6.7	18.3	6.9	17.2	12.60	9.40	16.20	12.20	0.380	0.290	2515	1410	1.50	2.74
SEm (±)	0.8	0.8	0.8	0.5	0.9	0.8	0.38	0.22	0.19	0.39	0.003	0.003	46	33	0.06	0.18
CD (p = 0.01)	2.3	2.4	2.2	1.3	2.6	2.2	1.11	0.65	0.56	1.14	0.010	0.008	136	96	0.18	0.55

Legends

T_1 - Control; T_2 - 200 Gy; T_3 - 400 Gy; T_4 - 600 Gy; T_5 _ 800 Gy; T_6 - 1000 Gy; T_7 - Melathion (2 g / kg of seed); T_8 - Thiram (2 g / kg of seed); T_9- Melathion+Thiram (each 2 g / kg of seed); MAS- Months after storage

Table 1b: Influence of gamma irradiation and seed treatment chemicals on seed quality parameters of soybean

Treatments	GRI		PVG		DH		α- amylse enzyme activity (mm)		EC (dSm⁻¹)	
	Initial	9 MAS	Initial	9 MAS	Initial	8 MAS	Initial	9 MAS	Initial	8 MAS
T_1	7643	4020	22.7	11.1	2.709	0.195	26.25	20.85	0.461	0.678
T_2	7475	4045	22.6	10.4	2.637	0.183	25.95	19.65	0.473	0.666
T_3	7291	3480	22.2	10.1	2.501	0.171	25.75	19.1	0.485	0.687
T_4	7061	3477	20.6	9.7	2.494	0.164	25.70	18.15	0.493	0.693
T_5	6794	3134	17.4	9.4	2.468	0.133	25.55	19.15	0.508	0.745
T_6	6626	3029	14.4	8.9	2.335	0.126	25.45	17.85	0.513	0.821
T_7	7767	4246	23.4	12.9	2.709	0.204	26.70	22.05	0.479	0.652
T_8	7955	4246	26.2	15.1	2.828	0.209	27.05	22.5	0.441	0.62
T_9	8138	4527	28.3	17.3	3.533	0.243	28.70	24.85	0.398	0.596
Mean	7417	3800	22.0	11.6	2.690	0.180	26.34	20.46	0.472	0.684
SEm (±)	34	11	0.3	0.1	0.187	0.009	0.10	0.06	0.002	0.025
CD (p = 0.01)	113	37	0.8	0.2	0.549	0.027	0.35	0.22	0.006	0.073

Legends
T_1 - Control, T_2 - 200 Gy, T_3 - 400 Gy, T_4 - 600 Gy, T_5 _ 800 Gy, T_6 - 1000 Gy, T_7 - Melathion (2 g / kg of seed), T_8 - Thiram (2 g / kg of seed), T_9- Melathion+Thiram (each 2 g / kg of seed)
MAS- Months after storage

Table 2a: Influence of gamma irradiation and seed treatment chemicals on seed quality parameters of green gram

Treatments	Ger% (%)		Ab S (%)		DS (%)		SL (cm)		RL (cm)		SDW (g)		SVI		MGT	
	Initial	9 MAS	Initial	9 MAS	Initial	9 MAS	Initial	9 MAS	Initial	9 MAS	Initial	9 MAS	Initial	9 MAS	Initial	9 MAS
T_1	85.5	73.8	3.3	11.8	11.3	14.5	17.65	14.95	21.30	15.70	0.403	0.280	3,330	2,258	1.86	2.61
T_2	86.0	75.0	3.5	12.0	10.5	13.0	18.05	14.70	21.85	16.98	0.403	0.290	3,432	2,375	1.86	2.58
T_3	82.0	67.0	7.0	16.8	11.0	16.3	16.23	12.98	20.18	14.73	0.393	0.273	2,986	1,857	1.88	2.62
T_4	79.8	64.5	9.5	17.3	10.8	18.3	15.23	11.08	19.18	13.78	0.37	0.270	2,744	1,601	1.89	2.69
T_5	75.0	64.0	11.8	18.8	13.3	17.3	13.45	9.18	17.43	12.03	0.34	0.260	2,318	1,356	1.92	2.73
T_6	74.0	63.3	13.3	19.0	12.8	17.8	12.40	7.55	16.38	10.63	0.315	0.258	2,132	1,150	2.08	2.82
T_7	84.8	73.5	5.0	13.3	10.3	13.3	17.93	13.80	22.33	17.28	0.408	0.333	3,409	2,283	1.82	2.36
T_8	85.0	73.3	3.0	14.5	12.0	12.3	17.70	13.95	22.53	17.73	0.415	0.338	3,420	2,320	1.81	2.34
T_9	86.3	77.3	2.3	10.5	11.5	12.3	18.40	15.90	22.63	18.00	0.418	0.345	3,536	2,616	1.80	2.23
Mean	85.5	70.2	6.5	14.9	11.5	15.0	16.30	12.70	20.40	15.20	0.385	0.294	3034	1979	1.88	2.55
SEm (±)	0.8	1.0	0.6	0.9	0.6	0.8	0.31	0.47	0.16	0.45	0.003	0.002	42	53	0.03	0.08
CD (p = 0.01)	2.2	2.9	1.9	2.6	1.8	2.3	0.91	1.38	0.46	1.33	0.008	0.006	125	157	0.09	0.27

Legends
T_1 - Control, T_2 - 200 Gy, T_3 - 400 Gy, T_4 - 600 Gy, T_5 _ 800 Gy, T_6 - 1000 Gy, T_7 - Melathion (2 g / kg of seed), T_8 - Thiram (2 g / kg of seed), T_9- Melathion+Thiram (each 2 g / kg of seed)
MAS- Months after storage

Among the different treatments, significantly higher shoot (14.73 and 11.55 cm) and root (18.50 and 14.48 cm) length were recorded inthe treatment combination of malathion and thiram each @ 2 g per kg of seed (T_9) compared to all other treatments and control (14.50 and 11.73 cm) and (17.48 and 12.30 cm) at initial and nine months after storage, respectively, in soybean (Table 1a). Similarly, in green gram (Table 2a), T_9 was able to record significantly higher shoot (18.40 and 15.90 cm) and root (22.63 and 18.00 cm) length compared to all other treatments and control (17.65 and 14.95 cm) and (21.30 and 15.7 cm) at initial and nine months after storage, respectively. The results are in line with the findings of Chaudhury *et al.* [28] who reported significantly higher root and shoot length by seed treatment with thiram and bavistin each at one gram per kg of seed. While, exposing the seeds to gamma irradiation (T_2 to T_6) showed a significant reduction in shoot and root length in rice with an increase in gamma radiation dosage. These results are in line with the findings of Uma and Salimath [29] who reported a significant reduction in root and shoot length of cowpea seeds with an increase in the irradiation dosage (10 Kr to 60 Kr).

Among the different treatments, significantly higher seedling dry weight (0.420 and 0.320 g) and seedling vigour index (3149 and 1828) were recorded by treatment combination of malathion and thiram each @ 2 g per kg of seed (T_9) compared to all other treatments and control (0.395 and 0.303 g) and (2941 and 1645) at initial and nine months after storage, respectively, in soybean (Table 1a). Similarly, in green gram (Table 2a), the treatment T_9 was able to register significantly higher seedling dry weight (0.418 and 0.345 g) and seedling vigour index (3536 and 2616) compared to all other treatments and control (0.403 and 0.280 g) and (3330 and 2258) at initial and nine months after storage, respectively. This might be due to longer shoot and root length recorded by T_9 in our study which had a direct correlation with seedling dry weight and seedling vigour index.The fungicide prevented the seed deterioration by reducing the fungal invasion and favoured the seed germination and other quality parameters [30]. Further, exposing the seeds to gamma irradiation (T_2 to T_6) showed a significant reduction in seedling dry weight and seedling vigour with an increase in gamma radiation dosage. This was due to shorter root and shoot length [29] registered in this experiment which could have resulted in a reduction in dry weight as well asseedling vigour index. Aldous and Stewart [31] reported thatdue to inhibition of mitosis and enzyme activities, it was more likely that reserve food was utilized less efficiently at higher dose of irradiation resulting in a significant reduction of seedling dry weight.

Among the treatments, significantly lower mean germination time (1.31 and 2.39) was noticed in the combination of malathion and thiram each @ 2 g per kg of seed (T_9) compared to all other treatments and control (1.51 and 2.59) at initial and nine months after storage, respectively, in soybean (Table 1a). Similarly, in green gram (Table 2a) T_9 was able to register lower mean germination time (1.80 and 2.23) compared to all other treatments and control (1.86 and 2.61) at initial and nine months after storage, respectively. Further, exposing the seeds to gamma irradiation (T_2 to T_6) showed a significant increase in mean germination time with an increase in gamma irradiation. This may be ascribed to histological, cytological changes, disruption and disorganization of seed layer and also generation of free radicals resulting in metabolic disorders in the germinating seeds [32] and inhibitory effect of gamma rays on seed germination [33].

The results of the present study, established that the combination of malathion and thiram each @ 2 g per kg of seed (T_9) was able to record significantly higher germination rate index (8138 and 4527) and peak value of germination (28.3 and 17.3) compared to all other treatments and control (7643 and 4020) and (22.7 and 11.1) in soybean (Table 1b) at initial and nine months after storage, respectively. Similarly, in green gram (Table 2b), (T_9) was able to record significantly higher germination rate index (8075 and 4631) and peak value of germination (25.5 and 19.3) compared to all other treatments and control (7341 and 4010) and (21.3 and 12.2) at initial and nine months after storage, respectively. Further, exposing the seeds to high dose of gamma

Table 2b: Influence of gamma irradiation and seed treatment chemicals on seed quality parameters of green gram

Treatments	GRI		PVG		DH		α- amylse enzyme activity (mm)		EC (dSm^{-1})		Insect egg (%)		Seed damage (%)		Weight loss (%)
	Initial	9 MAS	Initial	9 MAS	Initial	8 MAS	Initial	9 MAS	Initial	8 MAS	7 MAS	9 MAS	7 MAS	9 MAS	9 MAS
T_1	7341	4010	21.3	12.2	2.417	0.210	26.95	21.50	0.499	0.734	2.68	3.55	3.33	4.15	3.0
T_2	7459	4013	21.4	12.7	2.361	0.190	27.05	21.70	0.520	0.738	0.68	1.55	0.83	2.70	1.5
T_3	7033	3837	20.3	11.4	2.333	0.182	26.85	21.95	0.540	0.756	0.00	1.225	0.00	2.18	0.9
T_4	6933	3630	19.8	10.7	1.978	0.179	24.45	21.25	0.552	0.786	0.00	1.10	0.00	1.90	0.5
T_5	6434	3214	19.1	10.5	1.88	0.166	24.55	20.55	0.553	0.836	0.00	0.75	0.00	1.75	0.3
T_6	6417	3041	18.6	10.0	1.774	0.157	21.85	18.50	0.554	0.89	0.00	0.60	0.00	1.00	0.2
T_7	7645	4311	22.1	12.7	2.544	0.239	27.4	24.25	0.477	0.724	0.00	1.75	0.00	0.78	2.2
T_8	7842	4382	22.3	13.1	2.808	0.252	27.05	24.45	0.459	0.722	0.50	2.00	0.53	1.63	1.5
T_9	8075	4631	25.5	19.3	3.362	0.262	28.30	25.05	0.431	0.713	1.05	1.70	1.23	2.53	1.1
Mean	7242	3896	21.1	12.5	2.384	0.204	26.05	22.13	0.509	0.766	0.54	1.58	0.66	2.07	1.2
SEm (±)	167	6	0.1	0.1	0.176	0.006	0.19	0.07	0.002	0.012	0.26	0.06	0.30	0.25	0.3
CD (p = 0.01)	554	22	0.2	0.4	0.516	0.016	0.66	0.24	0.005	0.036	0.77	0.18	0.88	0.74	0.8

*Seven months after storage

Legends

T_1 - Control T_3 - 400 Gy T_5 _ 800 Gy T_7 - Melathion (2 g / kg of seed) T_9- Melathion+Thiram (each 2 g / kg of seed)

T_2 - 200 Gy T_4 - 600 Gy T_6 - 1000 Gy T_8 - Thiram (2 g / kg of seed) MAS- Months after storage irradiation (1000 Gy-T_6) registered the least germination rate index (6626 and 3029) and peak value of germination (14.4 and 8.9) compared to control (7643 and 4020) and (22.7 and 11.1) in soybean. Similarly, in green gram, T_6 registered the least germination rate index (6417 and 3041) and peak value of germination (18.6 and 10.0) compared to control (7341 and 4010) and (21.3 and 12.2). These varied physiological changes might be due to radiation induced plant sensitivity to gamma rays which in turn might have reduced the synthesis of endogenous growth regulators, especially cytokinins, [34] thereby reducing the seed quality parameters with corresponding decline in growth of the plants.

Significantly higher dehydrogenase enzyme activity (3.533 and 0.243 OD value) and alpha amylase enzyme activity (28.70 and 24.85 mm) were recorded by treatment combination of malathion and thiram each @ 2 g per kg of seed (T_9) compared to all other treatments and control (2.709 and 0.195 mm) and (26.25 and 20.85 mm) at initial and eight months after storage, respectively, in soybean (Table 1b). Similarly, in green gram (Table 2b) T_9 was able to give higher dehydrogenase enzyme activity (3.362 and 0.262 OD value) and alpha amylase enzyme activity (28.30 and 25.05 mm) compared to all other treatments and control (2.417 and 0.210 mm) and (26.95 and 21.50 mm) at initial and nine months after storage. Further, exposing the seeds to gamma irradiation (T_2 to T_6) showed a significant reduction in dehydrogenase and alpha amylase activity with an increase in gamma radiation dosage. This may be due to decline in the activity of amylases in seed which reduces the rate of starch hydrolysis and may eventually slowed down the germination process [35]. These results are in line with the findings of Ivan [36], who reported that irradiation of malt, caused a significant reduction in alpha and beta amylase activity.

Assessment of membrane integrity by measuring the electric conductivity of seed leachate helps to know the impact of the imposed treatment. In the present study, significantly lower electrical conductivity (0.398 and 0.596 dSm^{-1}) was recorded in the treatment combination of malathion and thiram each @ 2 g per kg of seed (T_9) compared to all other treatments and control (0.461 and 0.678 dSm^{-1}) at initial and eight months after storage, respectively, in soybean (Table 1b). Similarly, in green gram, T_9 recorded the lower electrical conductivity (0.431 and 0.713 dSm^{-1}) compared to all other treatments and control (0.499 and 0.734 dSm^{-1}) at initial and eight months after storage, respectively (Table 2b). Further, exposing the seeds to gamma irradiation (T_2 –T_6) showed an increase in electrical conductivity with increase in gamma irradiation dosage. This increase in electrical conductivity due to gamma irradiation is attributed to increased membrane permeability and enhanced leakage of leachates [26].

The insect egg and seed damage (%) were not at all noticed in soybean in any of the treatments at initial and even nine months after storage. Hence, the data for the same is not presented in the table 1b. However, in green gram (table 2b), they were noticed from seven months after storage in control-T_1 (2.68 and 3.33%), low dosage of gamma irradiation (T_2-200 Gy-0.68 and 0.83 %), thiram treatment (T_8-0.50 and .53%) and combination of thiram and malathion (T_9-1.05 and 1.23 %). Finally, at the end of nine months storage period, all the treatments except control (2.68 %) were able to maintain two and less than two per cent insect egg (%). Further, the seed damage at seven and nine months (3.33 & 4.15%) and weight loss (3.00 %) after nine months were significantly higher in control. Seed treatment with thiram, malathion and their combinations were also able to record lesser seed damage and weight loss percentage when compared to control. The results are in line with findings of Pramanik and Sardhar [37] who reported lower number of emerged adults, reduction in seed damage and weight loss in insecticide treated seeds of green gram and bengal gram. Further, exposing the seeds to gamma irradiation (T_2 to T_6) showed a significant reduction in insect egg (%), seed damage (%) with an increase in gamma radiation dosage even after nine months of storage. However, among all the treatments imposed the highest dosage of gamma irradiation (T6-100 Gy) recorded the least seed damage (0.00 and 1.0 %) and weight loss (0.2%) only. This might be due to the action of gamma irradiation as it acts as an effective disinfecting agent for seeds and thereby controlled the insects which lead to complete mortality of insects and also prevented hatching of eggs on seed leading to neither damage nor reduction in weight loss of the seed. The results are in line with the findings of Richard and Patrick [38] who reported 100 per cent mortality of *Sitophilus zeamais* and *Callosobruchus maculates* in the grains when they were exposed to gamma radiation at 300 Gy and 500 Gy. In the same line, Byun [39] observed complete mortality of egg and larval stages of rice weevil (*Sitophilus oryzae*) at 0.05 Krgamma irradiation.

CONCLUSION

As seed deterioration is unavoidable and irreversible process it cannot be stopped completely but the extent of deterioration can be slowed downed to certain extent. Similarly, in our study, irrespective of gamma irradiation dosage and seed treatment chemicals, the seed quality parameters declined progressively with an increase in storage period. However, seed treatment with malathion and thiram each at the rate of 2 g per kg of seed was found superior in maintaining the longevity of soybean and green gram seeds under ambient conditions in a better way compared to untreated control. Further, exposing the seeds to gamma irradiation even at low dosage (200 Gy) had inhibitory effect on seed germination of soybean. But in case of green gram, the low dosage had a stimulatory effect on seed germination. In addition, it was effective controlling the stored pestsbut not the higher dosages. Hence, this technology cannot be used for soybean seed due to its negative effect on the seed quality whereasin green gram the low dosage (200 Gy) can be used as it did not have an negative effect on seed quality parameters.

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