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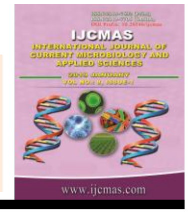

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Influence of Gamma Irradiation and Seed Treatment Chemicals on Seed Longevity of Bengal Gram (*Cicer arietinum* L.) and Black Gram (*Vigna mungo* L.)

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A B S T R A C T

A laboratory experiment was conducted in the Department of Seed Science and Technology, College of Agriculture, UAS, Raichur to study the influence of gamma irradiation and seed treatment chemicals on seed longevity of bengal gram (*Cicer arietinum L.*) and black gram (*Vigna mungo L.*). The experiment consisted of nine treatments with different dosage of gamma irradiation and seed treatment chemicals. Among the different treatments imposed, significantly higher seed germination (87.0 and 83.8 %), germination rate index (4684 and 3946), peak value of germination (23.5 and 20.0), seedling vigour index (2069 and 1755), dehydrogenase enzyme activity (1.816 and 1.576 OD value) and alpha amylase enzyme activity (23.5 and 18.8 mm) with lowest abnormal seedling (8.3 and 9.0 %) and mean germination time (2.10 and 2.34) were recorded even after nine months storage, respectively in bengal gram and black gram, respectively by treating the seeds with the combination of malathion + thiram each @ 2.0 g / kg of seed as compared to all other treatments and control. The above treatment was also effective in control of cent per cent insect eggs there by without any seed damage and consequently no weight loss compared to control with 23.00, 12.92 and 7.76 per cent insect egg, seed damage and weight loss, respectively in bengal gram. But in case of black gram the seed infestation did not take place in any of the treatments including control. Further, exposing the seeds to the gamma irradiation (T_2 to T_6) showed a significant reduction in all above seed quality parameters with an increase in gamma irradiation dosage. While, the seed quality parameters such as, abnormal seedlings, dead seeds, mean germination time and electrical conductivity increased with the increase in dosage of gamma irradiation. However, among all the gamma irradiation treatments imposed, the highest dosage of gamma irradiation (T6-100 Gy) recorded the least seed damage (1.46 %) and weight loss (0.02%) only.

Introduction

Pulses are an integral part of an average Indian meal as a main source of protein wherein, a large proportion of population is vegetarian. Among the pulses, chickpea (*Cicer arietinum* L.) is popularly cultivated in sub tropical and semi arid to warm temperature region under receding soil moisture. It is one of the earliest food legumes cultivated by man which plays an important role in human diet. India is the third largest producer of chickpea accounting for 68 per cent of worlds production with a cultivated area of 8.39 mha and production of 7.05 mt, with an average productivity of 840 kg per ha (Anonymous, 2016). Another important pulse crop, black gram (*Vigna mungo* L.) or urd is reported to be originated from India which also happens to be the largest producer and consumer of black gram in the world. In India, black gram contributes about 13 per cent of total pulse area and 10 per cent of total production covering an area of 3.62 mha with a production of 1.94 mt and a productivity of 537 kg per ha (Anonymous, 2016).

Among the various pests of pulses, the pulse beetle is a major pest since they infest the grains or seeds both in field as well as store houses where they multiply rapidly and cause heavy losses (Aslam, 2004). Considering the extent of losses and damage to pulse produce, several research strategies are being adopted for management of these stored pests and disease of which, use of fungicides, insecticides, fumigants and ionizing radiations provide protection to the seeds. Seed treatment with fungicides is known to improve the germination of seeds by protecting the seeds and young seedlings from many seed borne and soil borne pathogens (Taylor *et al.,* 1998). Among the fungicides, thiram acts as a protective agent against seed deterioration by prevention of fungal invasion and physiological ageing as a result of which the seed viability can be maintained for comparatively longer period of time (Savitri *et al.,* 1998).

Ionizing radiations such as ultraviolet rays, X-rays and gamma rays has the potential to protect seeds from insect infestation and microbial contamination through sterilization. However, in recent years gamma radiation has become the most potent and viable solution for control of these insects with high efficiency and with little side effects. This process consists of disinfecting the seeds with a determined dose of radiation which inhibits the reproduction and even causes complete death of the infesting insects (Richard and Patrick, 2014). These 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 (Borzouei *et al.,* 2010).

Gamma radiation can be used for alteration of physiological characters (Kiong *et al.,* 2008). The biological effect of gamma-rays is based on the interaction with atoms or molecules in the cell, particularly water, to produce free radicals (Kovacs and Keresztes, 2002). These radicals can damage or modify important components of plant cells and have been reported to affect the morphology, anatomy, biochemistry and physiology of plants depending on the radiation dose (Ashraf *et al.,* 2003). The effects include changes in the plant cellular structure and metabolism *e.g.,* dilation of thylakoid membranes, alteration in photosynthesis, modulation of anti-oxidative system and accumulation of phenolic compounds (Kovacs and Keresztes, 2002; Kim *et al.,* 2004; and Ashraf, 2009). Further, several workers have also reported the stimulatory effect of these gamma irradiation on plant growth at low dosage (Woodstock and Justice, 1967). While, irradiation of seeds at higher doses disturbs the synthesis of protein (Xiuzher, 1994), hormone balance (Rabie *et al.*, 1996), leaf gas exchange (Stoeva and Bineva, 2001), water exchange and enzyme activity (Stoeva *et al.*, 2001). These morphological, structural and functional changes depend on the strength and duration of gamma-irradiation stress and also the crop species on which the treatments are imposed.

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 carried out with an objective to study the "Influence of gamma irradiation and seed treatment chemicals on seed longevity of bengal gram (*Cicer arietinum* L.) and black gram (*Vigna mungo* L.)".

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 2015-16 to study the Influence of gamma irradiation and seed treatment chemicals on seed longevity of bengal gram (*Cicer arietinum* L.) and black gram (*Vigna mungo* L.)". The experiment consisted of nine treatments. *Viz.*, T_1: Control, five dosages of gamma irradiation (T_2 to T_6) 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: Melathion at 2 g per kg of seed, T_8: Thiram at 2 g per kg of seed and T_9: Melathion + Thiram each at 2 g per kg of seed. The experiment was conducted in a completely randomized design in four replications. For imposition of gamma irradiation treatments, 3 kg seed was used for each treatment. Since, the capacity of sample chamber was only 1.5 kg, the seed was divided into two parts and exposed twice. Once after filling the seeds in the container the lid was closed.

Then the required gamma irradiation 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 will be automatically adjusted as per the dose set.

While, for imposition of seed treatment chemicals, thiram (fungicide) and malathion (insecticide), the seeds were placed in a plastic tray and the required quantity of thiram, malathion and their combinations were dusted after sprinkling a little quantity water to the seeds and mixed thoroughly in order to have uniform seed coating. The seeds after treatment imposition were stored in cloth bag for nine months at room temperature. The monthly and bimonthly observations on various parameters were recorded and the mean value of crops presented in table 1 and 2.

The germination (germn) test was conducted in four replicates of 100 seeds each following between paper method in walk-in a seed germinator maintained at 25 ± 2 °C temperature and 90 per cent RH for 8 days (ISTA, 2013). Similarly, the abnormal seedlings (Ab S) and dead seeds (DS) were recorded as per ISTA (ISTA, 2013). While, the mean germination time (MGT) was computed by adopting the formula suggested by (Azimi *et al.*, 2013). Whereas, the germination rate index (GRI) was determined as per the procedure prescribed by Mudaris (1998), peak value of germination (PVG) by (Gairola *et al.*, 2011), shoot length (SL), root length (RL), seedling dry weight (SDW), seedling vigour index (SVI) by Abdul-Baki and Anderson (1973), insect egg and seed damage by (Tamiru *et al.*, 2016), percent weight loss by Harris and Lindblad (1978), dehydrogenase enzyme acticity (DH) by Kittock and Law (1968)., alpha amylase enzyme activity by Simpson and Naylor (1962) and electrical conductivity (EC) by (Milosevic *et al.,* 2010) were recorded. The experimental data thus obtained were statically analysed by the procedure prescribed by (Sundararaj *et al.,* 1972).

Results and Discussion

Among the different treatments imposed, significantly higher seed germination (93.5 and 91.0 %) was recorded by T_9 (combination of melathion and thiram each @ 2 g/ kg of seed) compared to all other treatments and control (90.5 and 85.3 %) in bengal gram and black gram at initial months after storage, respectively (Table 1a and 2a). While, the seed germination decreased (87.0 and 83.8 %) in T_9 after nine months after storage period in bengal gram and black gram, respectively. This may be due to better protection of seeds by both the combination of insecticide (melathion) and fungicide (thiram) when used at optimum dose. These results are in line with the earlier findings of Ravikumar *et al.*, (1987) who reported that soybean seeds treated with melathion (2 g/ kg of seed) or in combination with fungicide (thiram @ 2 g/ kg of seed) prevented the insect infestation and there by registered higher seed germination. Similarly, Anahousur and Bidari (1973) reported higher seed germination in soybean by treating the seeds with thiram (2 g / kg of seeds) even six months after storage.

Among the gamma irradiation treatments (T_2 to T_6), T_6 (1000 Gy) recorded the lowest seed germination (79.0 and 75 %) in bengal gram and black gram, respectively at initial month after storage indicating the inhibitory effect when used at higher dosage. While, decrease in seed germination (69.5 and 66.0 %) at nine months after storage in Bengal gram and black gram, respectively (Table 1a and 2a). While, T_2 (200 Gy) registered slightly higher seed germination (94.0 and 89.5 %) compared to control (90.5 and 85.3 %) in bengal gram and black gram at initial month after storage. While over the storage period decrease in seed germination (83.5 and 79.0 %) in T_2 after nine months after storage in bengal gram and black gram, respectively. This stimulatory effect on seed germination at low dosage of gamma irradiation might be due to better oxygen uptake and dehydrogenase enzyme activity there by providing energy to the germinating embryo and overall increasing the capacity of metabolic activities as per (Krishnaswamy and Seshu, 1989). This may also be due to activation of RNA (Kuzin *et al.,* 1975) or protein (Kuzin *et al.,* 1976) synthesis which might have occurred during early stage of germination after irradiation of seeds. Similarly, Selvaraju (2001) observed that the low dose (1 kr) of gamma irradiation improved the seed germination in three rice varieties when compared to untreated control. However, with an increase in the gamma irradiation dosage from 200 Gy (T_2) to 1000 Gy (T_6) the seed germination reduced drastically. The inhibitory effect at higher dosage could be as a result of greater loss of leachates due to enhanced membrane permeability (Krishnaswamy and Seshu., 1989). Hence, leaching of electrolytes was more in seeds exposed to higher dose of gamma irradiation (T_6-1000 Gy) than low dosage (T_2-200 Gy) which reduced germinability accompanied with the reduction in the activities of dehydrogenase and alpha amylase enzymes. It could also be due to accumulation of non-volatile growth inhibitors in irradiated seeds (Rajarajeshwari, 2011). Similarly, Uma and Salimath (2001) reported a significant reduction in the seed germination potential of cow pea seeds with an increase in irradiation dosage (10 Kr to 60 Kr). Likewise, Narayan *et al.*, (2014) noticed decrease in the seed germination with an increase in gamma irradiation dosage from 200 to 800 Gy and they also reported that the regeneration potential of callus derived from primary leaves of treated seeds improved at low dosage (200 to 400 Gy). In the same line, Ariramana *et al.*, (2014) in pigeon pea, Monica and Seetharaman (2014) in *Lablab purpureus* and Dhulgande *et al.*, (2015) in pea reported inhibition of seed germination and seedling growth at higher doses or concentrations of mutagens. While, Muhammad Amjad and Muhammad Akbar (2002) reported higher electrical conductivity of onion seeds exposed to gamma irradiation (10, 20, 40, 80 and 100 Krad) than that of un irradiated seeds.

From the present study, significantly lower abnormal seedlings (1.5 and 2.5 %) and dead seeds (0.8 and 1.5 %) were noticed in T_9 (combination of melathion and thiram @ 2 g/ kg of seeds) compared to all other treatments and control (2.5 and 3.8 %) and (1.0 and 6.0 %) in bengal gram and black gram (Table 1a and 2a) at initial months after storage. However with the advancement of storage period there was increase in abnormal seedlings (8.3 and 9.0 %) and dead seeds (4.5 and 9.8 %) in T_9 compare to control (9.0 and 9.8 %) and (6.0 and 12.0 %) at nine months after storage period in bengal gram and black gram, respectively. Further, the abnormal seedlings (%) and dead seeds (%) increased alarmingly with the increase in gamma irradiation dosage (T_2 to T_6). Further, T_6 (1000 Gy) recorded the highest abnormal seedlings (14.8 and 16.3 %) and dead seeds (3.0 and 8.0 %) compared to control (2.5 and 3.8 %) and (1.0 and 6.0 %) in bengal gram and black gram respectively, at initial month after storage. While, over the storage period drastic increase in abnormal seedlings (22.0 and 23.0 %) and dead seeds (9.0 and 14.5 %) in T_6 compared to control (9.0 and 9.8 %) and (6.0 and 12.0 %) in bengal gram and black gram at nine month after storage, respectively was noticed. This might be due to gamma irradiation induced oxidative stress with over production of reactive oxygen species (ROS) such as super oxide radical, hydroxyl radical and hydrogen peroxide which reacts rapidly with almost all structural and functional organic molecules including proteins, lipids and nucleic acids causing disturbance in cellular metabolism (Salter and Hewitt., 1992). Similarly, Muhammad Amjad and Muhammad Akbar (2002) also noticed increase in abnormal seedlings with an increase in irradiation dose.

Among the different treatments, significantly higher shoot (9.9 and 10.2 cm) and root (16.7 and 13.5 cm) length were recorded by T_9 (melathion + thiram @ 2 g/ kg of seeds) compared to all other treatments and control (8.2 and 8.9 cm) and (16.4 and 12.7 cm) in bengal gram and black gram (Table 1a and 2a) at initial month after storage, respectively. While, over the storage period decrease in shoot (8.8 and 9.0 cm) and root length (15.0 and 11.9 cm) in T_9 compared to control (6.9 and 7.7 cm) and (14.5 and 11.1 cm) in bengal gram and black gram at nine months after storage, respectively. This might be due to the influence of fungicides which might have increased the phenol production and total sugars (Sindhan *et al.,* 1996). The results are in line with the findings of Choudury *et al.*, (2011) who reported significantly higher root and shoot length due to seed treatment with thiram and bavistin each at one gram per kg of seeds. Similarly, Ravikumar *et al.*, (1987) reported that soybean seeds treated with melathion (10 g/ kg of seeds) or in combination with thiram (2 g/ kg of seeds) prevented insect infestation and recorded higher shoot length. Among the gamma irradiation treatments, 1000 Gy (T_6) recorded the lower shoot length (5.1 and 5.9 cm) and root length (11.0 and 8.6 cm) compared to lower dosage T_2 (8.2 and 9.0 cm) and (15.9 and 12.1 cm) and control (8.2 and 8.9 cm) and (16.4 and 12.7 cm) in bengal gram and black gram respectively, at initial month after storage for shoot and root length. While, with the advancement of storage period decrease in shoot (4.0 and 4.8 cm) and root length (10.0 and 7.4 cm) in T_6 compared to control (6.9 and 7.7 cm) and (14.5 and 11.1 cm) in bengal gram and black gram, respectively at nine months after storage period was noticed. This decrease in shoot and root lengths at higher dose was probably due to reduced mitotic activity of the meristematic tissues (Shakoor *et al.*, 1978 and Khalil *et al.*, 1986). Reduction in seedling growth at higher dosage has been attributed to the changes in the level of auxin and ascorbic acid contents and also due to physiological and biochemical disturbances (Gunekal and Sparrow, 1954), changes in the enzyme activity (Alduous and Stewart, 1952), chromosomal breakage and mitotic inhibition (Sparrow and vans, 1961) and inhibition of DNA synthesis (Mikaelson, 1968). These results are in line with the findings of Uma and Salimath (2001) who reported a significant reduction in root and shoot length of cow pea seeds with an increase in the irradiation dosage (10 Kr to 60 Kr). Similarly, Aparna *et al.*, (2013) reported a significant reduction in root and shoot length of groundnut seeds at higher dosage of gamma irradiation compared to un irradiated control.

Among the different treatments significantly higher seedling dry weight (2.913 and 1.098 g) was recorded by T_9 (combination of melathion and thiram @ 2 g/ kg of seeds) compared to all other treatments and control (2.603 and 1.030 g) in bengal gram and black gram at initial month after storage respectively (Table 1a and 2a). While, over the storage period decrease in seedling dry weight (2.748 and 0.933 g) in T_9 compared to control (2.438 and 0.870 g) in bengal gram and black gram at nine months after storage, respectively was noticed. Similarly, T_9 was also able to record significantly higher seedling vigour index (2485 and 2154) compared to all other treatments and control (2226 and 1841) in bengal gram and black gram at initial month after storage. This might be due to longer shoot and root length recorded in our study which had a direct correlation with seedling dry weight and seedling vigour index. The fungicide protected the seed deterioration by reducing the fungal invasion and favoured the seed germination and other quality parameters (Sundaresh *et al.*, 1987). These results are in line with the findings of Basavaraj *et al.*, (2008) who reported that onion seeds coated with polymer (@ 12 ml) + thiram (@ 2 g / kg of seeds) recorded higher seedling dry weight and seedling vigour index. Among the gamma irradiation treatments (Table 1a and 2a), 1000 Gy (T_6) recorded the lower seedling dry weight (2.388 and 0.773 g) and seedling vigour index (1332 and 1023) compared to the lower dosage, T_2 (2.735 and 1.073 g) and (2265 and 1892) and control (2.603 and 1.030 g) and (2226 and 1841) in bengal gram and black gram respectively, at initial months after storage for seedling dry weight and seedling vigour index. While, with the advancement of storage period reduced the seedling dry weight (2.318 and 0.605) and seedling vigour index (1029 and 754) in T_9 compared to lower dosage T_2 (2.425 and 0.865) and (1763 and 1448) and control (2.438 and 0.870) and (1770 and 1478) in bengal gram and black gram at nine months after storage, respectively for seedling dry weight and seedling vigour index. This reduction in seedling dry weight and seedling vigour index at higher dosage might be due to shorter root and shoot length registered in our study which had a direct correlation with dry weight and seedling vigour index. Due to inhibition of mitosis and enzyme activities it is more likely that the reserve food was utilized less efficiently at higher dose of irradiation which might have resulted in reduction of seedling fresh and dry weight (Alduous and Stewert, 1952). The other causes for reduction in dry matter may be inhibition of cell elongation. The results are in line with the findings of Veeresh *et al.,* (1995) who recorded an increase in shoot fresh weight of winged bean at lower dose, however decreased at higher dose. Similarly, Aparna *et al.,* (2013) in groundnut and Radha and Uma (2015) in finger millet reported reduction in seedling vigour index at higher dosage.

Similarly, T_9 also recorded significantly lower mean germination time (1.19 and 1.31) compared to all other treatments and control (1.34 and 1.51) in bengal gram and black gram at initial month after storage, respectively (Table 1a and 2a). While, over the storage period increase in mean germination time (2.10 and 2.34) in T_9 compared to control (2.37 and 2.40) in bengal gram and black gram at nine months after storage, respectively was observed. While, the gamma irradiation treatments delayed the mean germination time with an increase in dosage and T_6 (1000 Gy) recorded the higher mean germination time (1.64 and 1.67) in bengal gram and black gram respectively, at initial month after storage. While, advancement of storage period increased the mean germination time (2.57 and 2.59) in T_6 compared to control (2.37 and 2.40) in bengal gram and black gram at nine months after storage, respectively was observed. 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 (Lokesha *et al.,* 1992)and inhibitory effect of gamma rays on seed germination (Majeed *et al.,* 2010). These results are also in line with the findings of Majeed *et al.,* (2010) who found that the mean germination time of *Lepidum sativam* was significantly delayed at higher dose of gamma rays. From the present study, it was observed that, T_9 (combination of melathion and thiram each @ 2 g/ kg of seeds) recorded significantly higher germination rate index (7701 and 7198) compared to all other treatments and control (6809 and 5950) in bengal gram and black gram at initial month after storage, respectively. While, the germination rate index decreased (4684 and 3946) in T_9 compared to control (4219 and 3658) in bengal gram and black gram at nine months after storage, respectively (Table 1b and 2b).

Similarly, the peak value of germination was also significantly higher in T_9 (44.0 and 24.5) compared to all other treatments and control (35.0 and 21.8) in bengal gram and black gram at initial month after storage, respectively (Table 1b and 2b). While, the peak value of germination in T_9 decreased (23.5 and 20.0) compared to control (18.0 and 16.5) in bengal gram and black gram at nine months after storage, respectively. Among the gamma irradiation treatments, 1000 Gy (T_6) recorded the least germination rate index (6071 and 5151) and peak value of germination (27.5 and 15.3) compared to the lower dosage T_2 (7029 and 6020) and (36.5 and 22.8) and control (6809 and 5950) and (35.0 and 21.8) in bengal gram and black gram respectively, at initial month after storage for germination rate index and peak value of germination. While, the germination rate index decreased (2784 and 3067) and peak value of germination (13.5 and 9.5) in T_6 compared to lower dosage T_2 (4245 and 3779) and (19.0 and 17.0) and control (4219 and 3658) and (18.0 and 16.5) in bengal gram and black gram at nine months after storage, respectively. These physiological changes due to radiation increases plant sensitivity to gamma rays which in turn reduce the synthesis of endogenous growth regulators, especially cytokinins (Kiong *et al.,* 2008) there by reduced the germination parameters with corresponding decline in growth of the plants.

Table.1a Influence of gamma irradiation and seed treatment chemicals on seed quality parameters of bengal gram

Treatments	Germn (%)		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	90.5	83.0	2.5	9.0	1.0	6.0	8.2	6.9	16.4	14.5	2.603	2.438	2226	1770	1.34	2.37
T_2	94.0	83.5	3.3	10.0	1.3	6.3	8.2	6.8	15.9	14.3	2.735	2.425	2265	1763	1.33	2.22
T_3	87.5	80.0	3.5	11.0	1.8	6.8	8.0	6.8	14.4	12.5	2.425	2.265	1959	1537	1.37	2.40
T_4	85.0	77.0	6.0	13.5	2.0	7.3	7.1	5.9	13.7	11.9	2.410	2.250	1766	1364	1.39	2.44
T_5	82.0	74.3	11.3	18.0	2.5	8.0	6.6	5.4	13.4	11.5	2.423	2.343	1641	1251	1.59	2.48
T_6	79.0	69.5	14.8	22.0	3.0	9.0	5.1	4.0	11.0	10.0	2.388	2.318	1332	1029	1.64	2.57
T_7	92.5	85.5	2.0	9.0	1.3	5.3	8.5	7.4	14.1	12.5	2.772	2.460	2091	1704	1.32	2.26
T_8	93.0	86.0	1.8	8.5	1.0	5.0	9.2	8.1	16.2	14.9	2.810	2.468	2366	1975	1.25	2.14
T_9	93.5	87.0	1.5	8.3	0.8	4.5	9.9	8.8	16.7	15.0	2.913	2.748	2485	2069	1.19	2.10
Mean	88.6	80.6	5.2	12.1	1.6	6.4	7.9	6.7	14.6	13.0	2.609	2.413	2015	1607	1.38	2.33
S.Em±	0.8	2.0	1.4	1.4	0.8	0.8	0.5	0.5	1.0	0.9	0.065	0.077	123	97	0.07	0.04
C.D. at 1%	2.3	5.8	4.0	4.0	2.4	2.3	1.3	1.4	3.0	2.8	0.194	0.231	368	291	0.21	0.13

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 bengal gram, cont..

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	9 MAS	Initial	9 MAS	Initial	8 MAS	6 MAS	9 MAS	6 MAS	9 MAS	9 MAS
T_1	6809	4219	35.0	18.0	2.035	1.489	22.9	20.3	0.603	0.651	10.0	23.0	4.17	12.92	7.76
T_2	7029	4245	36.5	19.0	2.161	1.570	23.9	20.4	0.607	0.665	7.0	15.0	2.30	4.79	1.22
T_3	6730	4062	32.5	17.0	1.992	1.321	22.7	18.2	0.645	0.673	0.0	12.0	0.00	4.38	0.38
T_4	6383	3684	31.0	16.0	1.941	1.319	22.3	17.7	0.656	0.695	0.0	10.0	0.00	2.92	0.36
T_5	6100	3680	30.0	15.0	1.931	1.289	22.0	17.4	0.659	0.705	0.0	7.0	0.00	2.09	0.06
T_6	6071	2784	27.5	13.5	1.622	1.136	21.0	16.9	0.749	0.795	0.0	5.0	0.00	1.46	0.02
T_7	7383	4380	39.5	21.5	2.430	1.742	25.5	21.4	0.584	0.621	0.0	0.0	0.00	0.00	0.00
T_8	7581	4545	42.5	23.0	2.499	1.775	25.9	22.5	0.566	0.608	0.0	0.0	0.00	0.00	0.00
T_9	7701	4684	44.0	23.5	2.520	1.816	26.5	23.5	0.551	0.598	0.0	0.0	0.00	0.00	0.00
Mean	6865	4031	35.4	18.5	2.126	1.495	23.6	19.8	0.624	0.668	1.9	8.0	0.72	3.17	1.09
S.Em±	304	240	2.2	2.3	0.285	0.106	1.2	1.0	0.004	0.004	0.9	1.9	0.07	0.02	0.06
C.D. at 1%	912	719	6.6	6.9	0.855	0.318	3.6	3.0	0.012	0.011	2.7	5.7	0.22	0.06	0.19

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

Table.2a Influence of gamma irradiation and seed treatment chemicals on seed quality parameters of black gram

Treatments	Germn (%)		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	85.3	78.5	3.8	9.8	6.0	12.0	8.9	7.7	12.7	11.1	1.030	0.870	1841	1478	1.51	2.40
T_2	89.5	79.0	4.0	11.0	6.5	12.5	9.0	7.5	12.1	10.9	1.073	0.865	1892	1448	1.40	2.40
T_3	84.0	75.8	4.8	11.5	6.8	13.3	8.5	7.3	11.1	9.6	0.948	0.793	1647	1282	1.58	2.46
T_4	83.0	75.5	7.3	14.0	7.0	13.5	8.3	7.1	10.0	8.7	0.923	0.763	1519	1193	1.61	2.47
T_5	80.0	72.0	12.8	20.0	7.3	14.0	7.3	6.0	9.6	8.2	0.848	0.693	1349	1021	1.65	2.49
T_6	75.0	66.0	16.3	23.0	8.0	14.5	5.9	4.8	8.6	7.4	0.773	0.605	1023	754	1.67	2.59
T_7	90.3	82.5	3.0	10.0	3.0	11.8	9.3	8.2	12.7	11.6	1.063	0.900	1983	1634	1.36	2.38
T_8	90.8	83.3	2.8	9.5	1.8	10.0	9.9	8.8	13.2	11.7	1.090	0.918	2093	1702	1.34	2.37
T_9	91.0	83.8	2.5	9.0	1.5	9.8	10.2	9.0	13.5	11.9	1.098	0.933	2154	1755	1.31	2.34
Mean	85.4	77.4	6.3	13.1	5.3	12.4	8.6	7.4	11.5	10.1	0.983	0.816	1722	1363	1.49	2.43
S.Em±	1.2	2.0	1.0	1.4	0.9	0.9	0.4	0.5	1.0	0.7	0.033	0.059	101	64	0.06	0.092
C.D. at 1%	3.4	5.7	3.0	4.2	2.7	2.7	1.3	1.3	2.8	2.1	0.099	0.171	303	191	0.18	0.276

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.2b Influence of gamma irradiation and seed treatment chemicals on seed quality parameters of black gram, cont......

Treatments	**GRI**		**PVG**		**DH**		**α- amylse enzyme activity (mm) ***		**EC (dSm^{-1}) ***	
	Initial	9 MAS	Initial	9 MAS	Initial	9 MAS	Initial	9 MAS	Initial	8 MAS
T_1	5950	3658	21.8	16.5	1.419	1.323	22.5	17.0	0.532	0.581
T_2	6020	3779	22.8	17.0	1.448	1.330	23.3	17.4	0.538	0.586
T_3	5921	3588	20.3	13.5	1.393	1.104	21.0	15.9	0.563	0.608
T_4	5885	3288	17.8	11.0	1.382	1.060	20.9	14.6	0.585	0.626
T_5	5368	3205	15.5	10.0	1.340	1.031	20.0	13.3	0.593	0.647
T_6	5151	3067	15.3	9.5	1.328	1.029	19.1	11.8	0.595	0.655
T_7	6053	3813	23.0	17.0	1.506	1.340	25.0	17.7	0.52	0.559
T_8	6550	3896	23.3	18.0	1.579	1.399	25.6	17.9	0.508	0.546
T_9	7198	3946	24.5	20.0	1.720	1.576	26.0	18.8	0.481	0.532
Mean	6011	3582	20.4	14.7	1.457	1.244	22.6	16.0	0.546	0.593
S.Em±	238	288	1.4	3.0	0.218	0.129	1.4	0.9	0.003	0.003
C.D. at 1%	714	864	4.4	9.0	0.654	0.387	4.2	2.9	0.009	0.007

*Eight months after storage

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

These results are in line with the earlier findings of Cheema and Atta (2003) who reported decreased in peak value of germination with an increase in gamma irradiation dose. Similarly, Aparna *et al.,* (2013) reported decrease in speed of germination, mean daily germination, peak and germination value significantly with an increase in radiation dose.

Significantly higher dehydrogenase enzyme activity (2.520 and 1.720) was recorded by T_9 (combination of melathion and thiram @ 2 g / kg of seeds) compared to all other treatments and control (2.035 and 1.419) in bengal gram and black gram at initial month after storage respectively (Table 1b and 2b). While, the dehydrogenase enzyme activity decreased (1.816 and 1.576) in T_9 compared to control (1.489 and 1.323) in bengal and black gram at eight months after storage, respectively. Similarly, the alpha amylase enzyme activity was also higher in T_9 (26.5 and 26.0 mm) compared to all other treatments and control (22.9 and 22.5 mm) in bengal gram and black gram at initial month after storage respectively. While the alpha amylase enzyme activity decreased (23.5 and 18.8 mm) in T_9 compared to control (20.3 and 17.0 mm) in bengal gram and black gram at eight months after storage, respectively. Among the gamma irradiation treatments, 1000 Gy (T_6) recorded the lowest dehydrogenase (1.622 and 1.328) and alpha amylase (21.0 and 19.1 mm) enzyme activities compared to the lower dosage, T_2 (2.161 and 1.448) and (23.9 and 23.3 mm) and control (2.035 and 1.419) and (22.9 and 22.5 mm) in bengal gram and black gram respectively, at initial months after storage. While, the dehydrogenase (1.136 and 1.029) and alpha amylase (16.9 and 11.8 mm) enzyme activities decreased in T_6 compared to lower dosage T_2 (1.570 and 1.330) and (20.4 and 17.4 mm) and control (1.489 and 1.323) and (20.3 and 17.0 mm) in bengal gram and black gram. This might be due to decline in the activity of amylases in seed which reduces the rate of starch hydrolysis and thus might have slowed down the germination process (Koksel *et al.,* 1998). These results are in line with the findings of Ivan *et al.,* (2012) who reported that irradiation of malt caused a significant reduction in alpha and beta amylase activity. Similarly, Delia *et al.,* (2013) noticed that the biochemical differences based on photosynthetic pigment content revealed an inverse relationship to the dosage of exposure.

The insect egg and seed damage (%) were not at all noticed in black gram in any of the treatments even at even nine months after storage. Hence, the data for the same is not presented in the Table 2b. However, in bengal gram (Table 1b), they were noticed from six months after storage in control-T_1 (10.0 %) and low dosage of gamma irradiation (T_2-200 Gy-7.0 %). Finally, at the end of nine months storage period, treating the seeds with melathion-T_7, Thiram-T_8 and combination of melathion and thiram-T_9 were effective in control of cent per cent insect eggs there by without any seed damage and consequently no weight loss compared to control with 23.00, 12.92 and 7.76 per cent insect egg, seed damage and weight loss, respectively. This might be due to treating the seeds with insecticides and fungicides might have inhibited hatching of eggs resulting no emergence of adults and thereby absence of pinholes on seeds. The results are in line with findings of Pramanik and Sardhar (2006) who reported lower number of emerged adults, reduction in seed damage and weight loss in insecticide treated seeds of green gram and bengal gram. Similarly, Radhakrishnan *et al.,* (1983) reported 90 per cent pulse bruchid mortality with dust formulation of five per cent melathion.

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 in Bengal gram and hence, the highest dosage of gamma irradiation (T6-100 Gy) recorded the least seed damage (1.46 %) and weight loss (0.02%) only. This might be due to disinfecting action of gamma irradiation on seeds and thereby might have controlled the insects which lead to complete mortality of insects and also prevent hatching of eggs on seed surface leading to neither damage nor reduction in weight loss of the seed. The results are in line with the findings of Richard and Patrick (2014) who reported 100 per cent mortality of *Sitophilus zeamais* and *Callosobruchus maculatus* when exposed to gamma radiation at 300 Gy and 500 Gy. In the same line, Byun *et al.,* (1988) evaluated the effect of gamma irradiation for controlling infestation of rice weevil (*Sitophilus oryzae*) and observed complete mortality of egg and larval stages at 0.05 kGy. While, Kareem and Baki (2013) observed severe reduction in fecundity and fertility of pest in rice in 25 days old larvae treated with a gamma dose of 80 Gy.

In conclusion, seed treatment with the combination of melathion and thiram each at the rate of 2 g per kg of seed was found effective in maintaining the longevity of bengal gram and black gram seeds under ambient storage conditions. Among the different dosage of gamma irradiation, the lower dosage (200 Gy) significantly improved the seed quality both in bengal gram and black gram during storage.

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