Effect of solarization against bruchid infestation and seed quality in Greengram(*Vigna radiata* L. Wildzek) during storage

Abstract: Among the storage insect pests the Pulse beetle, *Callosobruchus chinensis* is predominant storage pest of green gram which infests during pre and post-harvest stages. The ovipositional potential, adult emergence, seed damage decreased at above 35ºC. After exposing to solar heat, it is better to store the seeds in moisture vapour proof containers like polythene bags having 700 gauge to maintain the quality of seeds during storage. To know the effect of solarization cum packaging in a clear polyethylene (700 gauge) packets on the storability of seeds and bruchid management in greengram. A laboratory study was conducted during June 2018 to April 2019 at the Seed Research and Technology Centre, PJTSAU. The experiment was conducted with eight treatments with three replications. The data on seed germination percentage, seed moisture content, adult emergence and insect infestation were recorded at every three months upto nine months of storage and statistically analyzed by using completely randomized block design (CRD). Solarization of fresh seeds in clear polyethylene (700 gauge) packet for 4 h for 6 days was able to maintain per cent insect infestation (0.49%) below permissible limit and maintained germination percentage (90.67) >IMSCS upto six months of storage as compared with 4.22 per cent seed damage and 83.33 per cent germination in untreated control (Fresh seeds). Seeds packed in a clear polyethylene (700 gauge) packet serves as a moisture vapour proof containers and able to reduce moisture by 22.16 per cent over the untreated control.

Keywords: Solarization treatment, polythene (700 gauge) packaging material, Bruchid management, Seed Quality

1. INTRODUCTION: "In India, greengram is third important pulse crop cultivated an area 4.5 million hectares with total production of 2.5 million tones with a productivity of 548 kg ha^{-1}. The greengram is cultivated in different districts of Telangana *viz.*, Mahabubabad, Sangareddy, Suryapet, Khammam, Vikarabad and Kamareddy. In storage, major constraint is seeds are easily prone to be infested with *C. chinensis* (L.). This insect was first recorded on mungbean in 1957. Later, it was observed infesting cowpea in Pakistan" [1].

"Unlike other storage pests, its infestation starts in the field itself. The female beetle lays eggs on matured green gram pods. The eggs after hatching enters into the seed and remain inside the developing seed" [2]. When such seeds are harvested and stored, grubs continue to feed. Adults emerges out making a circular hole on seed. As the Larval development occurs within the seed it causes significant losses in seed weight and viability. It is a challenging task for its management as it is very difficult to observe the damage until the adult emerges by breaking the seed coat. It causes 33 per cent infestation to legume seeds. [3] reported "seed weight loss 55-60 per cent and 45.50- 66.30 per cent losses in protein content due to bruchid infestation in storage. Pesticide application is the most potent and convenient method of pest control but despite of many advantages, the long and indiscriminate use of pesticides have resulted many environmental and health hazards. Solar heating for the management of bruchid is less hazardous and safe method to control bruchids". "Eggs deposited on the surface of the seeds exposed to high temperature and low humidity will desiccate and fail to hatch. Therefore, bruchids living within seed are also managed with elevated temperature. Farmers in many parts of the tropics are already using solar heat to kill any larvae inside the seeds and also it is used to drive insects from infested seeds. The effectiveness of the technique will enhance if solarization of seed followed by packing and storing seed in a clear polyethylene bags of 700 gauge. Solar disinfestations technology is an effective, low cost, non- toxic pest control process, which does not alter seed quality and other desirable properties of the seed" [4].

1. MATERIALS AND METHODS

A laboratory experiment was conducted to know the effect of solarization against bruchid infestation in freshly harvested greengram seeds cv. of MGG 295. This was procured from Agricultural research station, Warangal. Seeds were cleaned and disinfested. One kilogram of freshly harvested certified seed with very high percentage of germination and low moisture content (< 10 %) was taken for each treatment. For artificial inoculation pulse seed, the seeds were inoculated with bruchids (5 pairs / kg seed) and kept under ambient condition in the room for two weeks. Later adult insects were removed from seeds. Solarization was done at noon and same schedule was maintained in every treatment. During solarization, 5 cm thickness of seed layer inside seed packet was kept. The temperature outside/inside of packets were recorded each day before and after the solarization. After treatment, the seeds were kept under ambient condition. This experiment was carried out with eight treatments, replicated thrice and data on insect infestation, seed germination and moisture content of seed were recorded at every three months interval upto nine of storage.

Treatments:

T1: Solarization of fresh seeds in clear polyethylene (700gauge) packet for 3h for 2 days

T2: Solarization of fresh seeds in clear polyethylene (700 gauge) packet for 3h for 4 days

T3: Solarization of fresh seeds in clear polyethylene (700 gauge) packet for 3h for 6 days

T4: Solarization of inoculated-seeds in clear polyethylene (700 gauge) packet for 3h for 2 days

T5: Solarization of inoculated-seeds in clear polyethylene (700 gauge) packet for 3h for 4 days

T6: Solarization of inoculated-seeds in clear polyethylene (700 gauge) packet for 3h for 6 days

T7: Control (fresh seed)
T8: Control (inoculated seed)

2.1 Seed damage (per cent)

The seed damage was calculated by taking a random sample of 100 seeds and counting the number of seeds with bored holes by pulse beetle and converted to percentage.

$$\text{Percentage seed damage} = \frac{\text{Number of damaged seeds}}{\text{Total number of seeds}} \times 100$$

2.2 Adult emergence (Number)

The number of adults emerged per kg seeds was counted at three months interval upto nine months of storage.

2.3 Per cent seed germination at different periods

Germination of the seeds was determined by paper towel method by maintaining three replications of each treatment. 100 seeds were kept in moist paper towel and allowed to germinate in walk in germinator for seven days and the percentage of germination was calculated by using the formula

$$\text{Seed germination percentage} = \frac{\text{Number of germinated seeds}}{\text{Total Number of seeds}}$$

2.4 Seed moisture content at different periods

Moisture content of the seed was estimated by using Dickyjohn moisture meter

1.5 Statistical Analysis

The data recorded was subjected to statistical analysis by adopting the Fishers method of analysis of variance (ANOVA) as described by [5]. The experimental data were subjected to square root and angular transformation values where ever necessary and analyzed by using Completely Randamized Design in OPSTAT software. Critical difference (CD) and standard error of mean SEm values were calculated by the F test was found significant at 5% level.

3. RESULTS AND DISCUSSION

3.1 Seed damage (%) : At three months of storage, solarization of fresh seed for 3 hours for

2, 4 and 6 days and solarization of inoculated seed for 3 hours for 4 and 6 days maintained insect damage below permissible limit (<1.00%). At six months of the storage none of the solarization treatments restricted insect damage below permissible limit except solarization of fresh seed for 3 hours for 6 days in which insect damage (0.49%) was recorded. Maximum insect damage 8.17% was observed in untreated inoculated seeds. At nine months of storage, though none of the treatments restricted insect damage below permissible limit but lowest per cent insect damage (2.87%) was observed in solarization of fresh seed for 3 hours for 6 days. Per cent reduction in insect damage over the control recorded was 73.74%. While, in case of solarization of inoculated seed for 3 hours for 6 days, the per cent reduction of insect damage over the untreated control was 26.19%. As the storage duration increased per cent insect damage increased from two months to nine months in all the treatments due to increase in insect population. "Minimum seed infestation was found in solarization of fresh seeds in clear polyethylene (700 gauge) packet for 3h for 6 days after nine months of storage. Bruchid-infested seeds exposed to sunlight at 40 to 50^0 C reduces the seed infestation" [6]. [7] reported that "when seeds are kept under sun radiations it significantly inhibits the development of *Callosobruchus maculatus"*. These results were in accordence with [8]and[9] .

3.2 Adult emergence: The lowest average insect population (1.00) was observed in solarization of fresh seed for 3 hours for 6 days at three months of storage as compared with the highest population build up in untreated inoculated seed (10.00). While insect population in the rest of the treatments ranged from 2.33-8.33. Similar trend was observed at six and nine months of storage. The results revealed that solar heating inhibits egg hatching which in turn reduces the insect population buildup. The present results are in accordance to [10] [11]who reported that "Solar heating of seeds was effective in eliminating eggs of bruchids and then protecting seeds from bruchid damage in pigeon pea seeds". Sun exposure of bruchid infested seeds at 40 to 50^0 C, which reduces the developmental stages of bruchids [6].) observed no emergence of progenies in neem seed oil treated seeds with 4 hours exposure to sun radiations [11] in cowpea seeds. "Exposure of cowpea seeds to 50^0 C for 2 hours leads to complete disinfection of bruchids" [12]. [13] also reported that "the developmental stage at 42^0 C get seized in bruchids. These recorded results were in accordance with" [9].

3.3 Seed germination percentage

At three months of storage, The highest germination (97.33) was observed in Solarization of fresh seeds in clear polythene (700 gauge) packet for 3 h for 6 days. However, it was on par with Solarization of inoculated seeds in clear polythene (700 gauge) packet for 3 h for 6 days (95.33). Similar trend was observed at six months and nine months of storage, Solarization of fresh seeds in clear polythene (700 gauge) packet for 3 h for 6 days maintained significantly highest germination 90.67 and 84.00 per cent, respectively.

While, untreated control recorded lowest germination percentage 81.33 and 72.00 at six and nine months of storage, respectively. “The germination percentage upto three months gradually reduced with increase in storage period. This shows natural ageing of greengram seeds and level of bruchid infestation. There is drastic decrease in seed germination after six months of treatment imposition, which is due to insect infestation. The seed germinability of seed is reduced as pulse beetle bores into the seed and consume of seed reserve. These holes are also responsible for the entering of harmful microorganisms and interfere with the water intake, which retards the seed germination” [13] . The results of this study were in line with the findings of [14] in horse gram seeds, [9]and [8] in cowpea.

3.4 Seed moisture: Minimum seed moisture 9.93, 9.83 and 10.57 per cent were observed in T_3 (solarization of fresh seeds in clear polyethylene (700 gauge packet for 3h for 6 days at three, six and nine months of storage, respectively. While, maximum seed moisture 12.67, 13.67 and 15.40 were recorded in untreated control (inoculated seed) at three, six and nine months of storage respectively. Packaging material made with 700 gauge polyethylene will serve as moisture vapour proof containers and further sealing it create hermetic conditions thereby insect is killed due to hyper-carbic and hypoxic conditions and seeds will retain its natural properties and thus increases shelf life. The present results are in consonance with [15] who investigated the effects of low input drying procedures on seed quality of maize, cowpea, and bambara groundnut by using four drying regimes (sun, shade, silica gel and conventional drying room). They reported that seeds stored with silica gel showed the lowest moisture content in all three species *viz.*, maize (7%), cowpea (3%) and bambara groundnut (8%) followed by sun drying which reduced the initial seed moisture content from 10% to 7.8%, 5.1%, and 8.4% in maize, cowpea and bambara grountnut, respectively.

4. CONCLUSION

Solar disinfestation is a cost effective, nontoxic technology for bruchid management in greengram. As the seed is hygroscopic in nature, seed quality is affected by fluctuation in moisture content, relative humidity and temperature. Packaging material made with700 gauge polyethylene will serve as moisture vapour proof containers and further sealing it create hermetic conditions thereby insect is killed due to hypercarbic and hypoxic conditions. Seeds will retain its natural properties and thus increases shelf life. From the present study, it is concluded that the treatment with solarization of fresh seeds in clear polyethylene (700 gauge) packet for 4 h for 6 days was able to maintain per cent insect infestation (**0.49**%) below permissible limit and maintained germination percentage (**90.67**)>IMSCS upto six months of storage as compared with 4.22 per cent seed damage and 83.33 per cent germination in untreated control (Fresh seeds).

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Table 1. Effect of solarization on adult emergence and seed damage (per cent) in greengram

S.No	Treatments	Storage duration					
		Adult emergence			Seed Damage (%)		
		3 M	6 M	9 M	3 M	6 M	9 M
T_1	Solarization of fresh seeds in clear polythene (700 guage) packet for 3 h for 2 days.	2.33^{b} (1.82)	10.09^{b} (3.31)	23.67^{b} (4.96)	0.83^{d} (5.23)	3.34^{c} (10.50)	7.54^{c} (15.93)
T_2	Solarization of fresh seeds in clear polythene (700 guage) packet for 3 h for 4 days.	1.00^{a} (1.38)	5.30^{a} (2.51)	15.00^{a} (3.99)	0.47^{b} (3.87)	2.23^{b} (8.57)	3.91^{b} (11.38)
T_3	Solarization of fresh seeds in clear polythene (700 guage) packet for 3 h for 6 days.	1.00^{a} (1.38)	3.00^{a} (1.98)	12.33^{a} (3.65)	0.13^{a} (2.06)	0.49^{a} (3.87)	2.87^{a} (9.67)
T_4	Solarization of inoculated seeds in clear polythene (700 guage) packet for 3 h for 2 days.	7.33^{c} (2.87)	53.3^{d} (7.34)	189.33^{f} (13.79)	1.34^{e} (6.60)	5.41^{e} (13.4)	13.37^{e} (21.43)
T_5	Solarization of inoculated seeds in clear polythene (700 guage) packet for 3 h for 4 days.	8.33^{c} (3.04)	34.3^{c} (5.94)	116.00^{e} (10.81)	0.78^{cd} (5.07)	4.41^{d} (12.1)	11.70^{d} (19.99)
T_6	Solarization of inoculated seeds in clear polythene (700 guage) packet for 3 h for 6 days.	6.67^{c} (2.75)	31.0^{c} (5.65)	64.00^{d} (7.99)	0.55^{bc} (4.22)	2.12^{b} (8.37)	10.79^{d} (19.16)
T_7	Control (Fresh seed)	3.00^{b} (2.00)	13.3^{b} (3.78)	35.33^{c} (6.02)	1.14^{e} (6.17)	4.22^{ed} (11.86)	10.93^{d} (19.29)
T_8	Control (Inoculated seed)	10.00^{d} (3.31)	75.0^{e} (8.71)	254.00^{g} (15.96)	4.23^{f} (11.87)	8.17^{e} (16.02)	14.62^{e} (22.47)
	SE (m)±	0.137	0.194	0.273	0.317	0.377	0.405
	CD (p=0.05)	0.415	0.586	0.825	0.96	1.14	1.223

Figures in the parentheses are square root and angular transformed values for adult emergence and seed damage, respectively

Table 2. Effect of solarization on per cent seed germination and seed moisture

S.No	Treatment	Storage duration					
		Germination percentage			Seed Moisture content (%)		
		3 M	6 M	9 M	3 M	6 M	9 M
T_1	Solarization of fresh seeds in clear polythene (700 gauge) packet for 3 h for 2 days	93.00[bc] (74.65)	86.00[b] (68.05)	80.00[b] (63.42)	10.6 [cd] (18.99)	10.5[ab] (18.90)	12.50[bc] (20.69)
T_2	Solarization of fresh seeds in clear polythene (700 gauge) packet for 3 h for 4 days	95.67[a] (78.30)	86.67[b] (68.57)	81.67[a] (64.64)	10.47[c] (18.87)	10.33[a] (18.7)	12.43[b] (20.63)
T_3	Solarization of fresh seeds in clear polythene (700 gauge) packet for 3 h for 6 days	97.33[a] (80.70)	90.67[a] (72.20)	84.00[a] (66.50)	9.93[a] (18.36)	9.83[a] (18.27)	10.57[a] (18.95)
T_4	Solarization of inoculated-seeds in clear polythene (700 gauge) packet for 3 h for 2 days	91.67 [c] (73.22)	85.67[b] (67.73)	77.33[b] (61.63)	11.43[e] (19.75)	12.40[c] (20.61)	14.67[d] (22.50)
T_5	Solarization of inoculated-seeds in clear polythene(700 gauge) packet for 3 h for 4 days	92.33[c] (73.90)	86.67 [b] (68.56)	81.00[ab] (64.13)	10.9[d] (19.27)	10.43[a] (18.84)	12.67[b] (20.84)
T_6	Solarization of inoculated-seeds in clear polyethylene (700 gauge) packet for 3 h for 6 days	95.33[b] (77.55)	87.67[b] (69.43)	82.00[a] (64.80)	10.07[ab] (18.49)	10.20[a] (18.61)	13.43[c] (21.49)
T_7	Control (Fresh seed)	90.33[c] (71.88)	83.33[c] (65.89)	81.00ab (64.13)	11.93[f] (20.20)	12.63[c] (20.81)	14.73[d] (22.55)
T_8	Control (inoculated seed)	83.00[d] (65.67)	81.33[c] (64.38)	72.00[c] (58.03)	12.67[g] (20.84)	13. 67[d] (21.69)	15.40[d] (23.09)
	SE (m)±	1.076	0.704	1.15	0.123	0.277	0.239
	CD (P=0.05)	3.25	2.138	3.48	0.372	0.84	0.72

Figures in the parentheses are angular transformed values

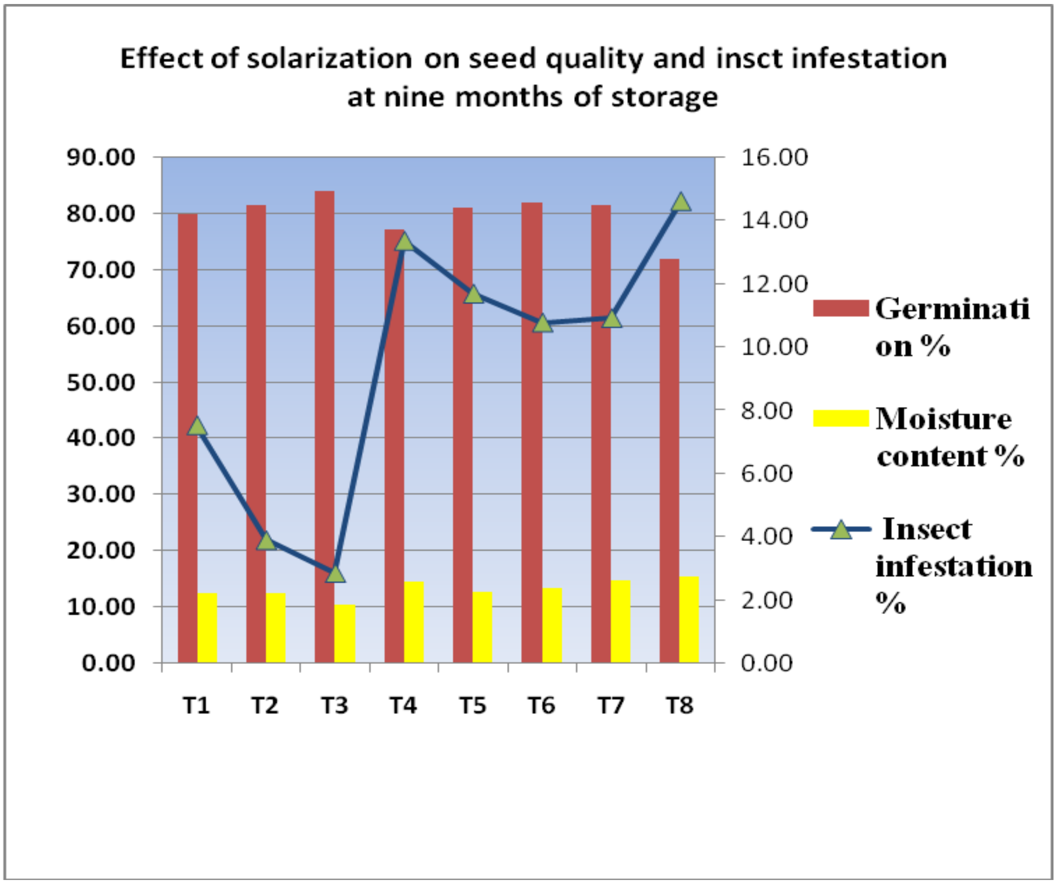

Fig 1: Effect of solarization on seed quality and insct infestation at nine months of storage