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Solar heating of seeds, a low cost method to control bruchid (*Callosobruchus* spp.) attack during storage of chick pea

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Abstract
Chick pea (*Cicer arietinum* L.) and other legume crops growing in the tropics and subtropics are important host of Bruchids (*Callosobruchus* spp.), which can cause significant economic losses. During summer bright days, solarizing chick pea seeds in a clear polythene (700 gauge) packet for 6 days (4 hours each day) will prevent damage from the pulse beetle and preserve seed germination (above 85.00% IMSCS level) for up to 9 months of storage. Solar heating is a secure and reasonably priced approach for deinfesting chick pea seeds that farmers in semi-arid tropical and humid tropical climates may want to take into consideration.

Keywords: Solarization, chick pea, pulse beetle, seed damage, adult population, seed germination, transparent polythene bag-700 gauge

Introduction
According to and Srivastava and Pant (1989) [12], Ramzan *et al.* (1990) [11], bruchids (*Callosobruchus* spp.) are significant grain legume storage pests that are known to inflict significant economic losses, particularly in pulses farmed in tropical and subtropical regions. As a result of having to dispose of their produce right once after harvest, even though the market price may not be very lucrative at the time, farmers frequently avoid growing legumes. Seeds with bruchid damage do not germinate effectively, which has an impact on plant stand and ultimately yield. This is especially true for short-season legumes where there is a significant amount of time between harvest and the following sowing season. For instance, the time between harvest and sowing the following season's crop of chick peas might range from six to nine months, as opposed to two months for cultivars of long-duration pigeon pea. Therefore, a practical and affordable approach for bruchid protection of farm-stored seeds must be developed. Farmers are using a variety of chemical and non-chemical techniques to shield seeds from bruchid attack. Despite being efficient, chemical treatments like fumigation or the mixing of insecticides like Malathion are dangerous. Inert dusts, hermetic storage in metal bins or polyethylene-lined earthen structures, turning, and treatment with neem and castor oils are the main farm-level strategies typically utilized for bruchids, however their use is restricted and transient (Yadav, 1997) [13]. One of the usual procedures used in the semi-arid tropics is sun-drying in an open yard. A substantial danger of post-treatment infection also exists when the seeds are dispersed in the open. The warmth from the sun's rays may be significantly increased if seeds are stored under polyethylene, such as in small transparent polyethylene bags, as in the case of soil solarization (Chauhan *et al*., 1988) [2].
In cowpea (Murdock and Shade, 1991) [7] and beans (Chinwada and Giga, 1996) [4], solar heating can lessen bruchid damage, but there is no information on how high temperatures in polyethylene bags influence seed viability, particularly in the case of chick pea. It is unknown if this strategy would successfully suppress bruchids in chick pea without adversely affecting seed viability because the relative susceptibility of legumes to temperature and moisture content varies. This study examines how the temperature fluctuations in small polyethylene bags exposed to sunlight in the semi-arid tropics affect bruchid survival, infestation, and chick pea seed germination when the bags are later stored.

Materials and Methods

The experiment on solarization of chick pea seeds was taken at Seed Technology Research Unit, Pearl Millet Research Station, Junagadh Agricultural University, Jamnagar-Gujarat during 2020-21 and 2021-22 continuous for two years by taking eight treatments with three replications. The designed used was completely randomized design for the study. The Chick pea seed of variety GJG 3 was procured from Mega Seed Department, Junagadh Agricultural University, Junagadh during both the years. One kg of freshly harvested seed of chick pea with very high percentage of germination (> 85.00%, IMSCS level) and low moisture content (<10%) was taken for each treatment. Its germination, insect damage (%) was also recorded as per standard procedure at the initiation of experiment. Initial culture of Pulse beetle population was maintained from an already infested chick pea seeds at Seed Entomology Laboratory of STR, Pearl Millet Research Station, JAU, Jamnagar and allowed to massively reproduce in the laboratory at ambient temperature and relative humidity on fresh and uninfested chick pea var. GJG 3. For inoculation of chick pea seed, 5 pairs of pulse beetles per kg seed were taken and were kept under ambient condition in the laboratory for 2 weeks in plastic containers of 2.0 kg capacity covered with muslin cloth fastened with rubber rings. Then after 2 weeks adult pulse beetles were removed from seed lot before transferring them in the transparent polythene packets of 700 gauges. Solarization was done around noon (11.00 to 15.00 hrs) and same schedule was maintained in every treatment. The solarization was done for four hours every day for two days, four days and six days for both inoculated with pulse beetles and non-inoculated seed lot. Two controls were also taken as treatment *i.e.* one inoculated with pulse beetle and another without inoculation as untreated control. During solarization, the thickness of seed layer inside seed packet was kept at 5.0 cm. The seed packets were closed tightly before solarization. After solarization treatment, the seed packets were kept under ambient conditions ensuring prevention of cross infestation. The observations on temperature before and after solarization, outside and inside the packet and maximum temperature inside the packet were recorded (Table-4). The periodical observations on seed damage, adult population and germination were recorded at 3 months interval up to total period of 12 months. The two years data were pooled and analyzed statistically. The treatments details are as under.

1. Solarization of fresh seeds in transparent polythene (700 gauge) packet for4 hrs for 2 days
2. Solarization of fresh seeds in transparent polythene (700 gauge) packet for4 hrs for 4 days
3. Solarization of fresh seeds in transparent polythene (700 gauge) packet for4 hrs for 6 days
4. Solarization of inoculated seeds with pulse beetle in transparent polythene (700 gauge) packet for4 hrs for 2 days
5. Solarization of inoculated seeds with pulse beetle in transparent polythene (700 gauge) packet for4 hrs for 4 days
6. Solarization of inoculated seeds with pulse beetle in transparent polyethylene (700 gauge) packet for4 hrs for 6 days
7. Control (Fresh seed)
8. Control (Inoculated seed with pulse beetle)

Results and Discussion

a) **Seed damage:** The information in table 1 showed that, after a three-month storage period, the results were significant in 2020–2021 and 2021–2022 and that, with the exception of T7 and T8, all treatments were found to be damage-free. With the exception of T7 (1.17%) and T8 (2.50%), all of the treatments were determined to be damage-free in the case of pooled data, and the results were significant. Again, the results were significant at 6 months of storage (Table 1), and all treatments were determined to be free of harm, with the exception of T7 and T8, for both the years 2020–21 and 2021–22. Only T7 (2.00%) and T8 (5.17%) of the pooled 6-month samples recorded harm excluding other treatments. T3 (0.00%) and T6 (0.00%) were determined to be free from damage and to be much better than the other treatments at 9 months of storage (Table-1) during 2020–21. In contrast, no treatment was determined to be harm-free in 2021–22; T3 had the least damage (1.00%). It was comparable to T2 (2.33%) and T6 (1.33%), though. T3 (0.50%) recorded the least percent damage when pooled at 9 months, and it was at par with T6 (0.67%). T3 and T6 had the lowest pulse beetle damage at 12 months of storage (Table-1), which was 1.00% during 2020–21. The least amount of pulse beetle damage was observed in T3 (3.33%) during 2021–22. It was comparable to T2 (6.67%) and T6 (4.67%), though. T3 (2.17%) had the lowest percent harm in the case of pooled data over the previous two years' worth of 12 months. It was, however, on par with T6 (2.84%).

b) **Pulse beetle population:** With the exception of T7 (2.00 adults/100 g seeds) and T8 (10.00 adults/100 g seeds) during 2020–21, all treatments were devoid of adult population after 3 months of storage (Table-2). All of the treatments except T7 (1.33 adults/100 g seeds) and T8 (6.00 adults/100 g seeds) showed no adult emergence in 2021–22. Similar to the pooled data from the two years, all treatments except T7 and T8 recorded adult populations of 1.67 and 8.00 per 100 g of seeds, respectively. Only T7 (7.67 adults/100 g seeds) and T8 (36.00 adults/100 g seeds) were observed to have adult populations during the 6-month storage period (Table-2) during 2020–21. Only T7 (9.00 adults per 100 g of seeds) and T8 (16.33 adults per 100 g of seeds) reported adult populations during 2021–22. The treatments that reported adult populations in the case of pooled were T7 (8.34 adults/100 g seeds) and T8 (26.17 adults/100 g seeds). T3 & T6 were shown to be significantly better than the other treatments at 9 months of storage (Table-2). The lowest adult population was seen in T3 (1.33 adults/100g seeds) during 2021–2022. It was comparable to T6 (2.33 adults/100 g seeds), though during 2021-22. T3 (0.67 adults/100 g seeds) had the lowest adults/100 g seeds in the case of pooled data. It was, however, comparable to T6 (1.17 adults/100 g seeds). The ratios were 32.84 and 86.67 adults per 100 grams of seeds in T7 and T8, respectively. The lowest adult population was found in T3 at the 12-month storage period (Table-2), in the year 2020–21 (4.00 adults/100 g seeds). It was comparable to T6 however (5.00 adults/100 g seeds). T7 had 110.67 adults per 100 grams of seeds, while T8 had 196.67 adults per 100 grams of seeds. The pulse beetle adult population in T3 was noticeably at its lowest during the year 2021–2022, with only 8.33 adults per 100 g of seeds. In T7 and T8, the ratio of adults to seeds was 125.00 and 211.67, respectively. According to pooled data, T3 (6.17 adults/100 g seeds) had the lowest adult population of the pulse beetle. T7 had 117.84 adults per 100 g of seeds, while T8 had 204.17 adults per 100 g of seeds.

c) **Germination:** In 2020–21, the germination percentage was not significant after three months of storage (Table-3). While in 2021–22, the results were determined to be significant, and T3 had the highest germination rate (96.00%). It was comparable to T1 (95.33), T2 (95.33%), T4, (95.67%), and T6, (95.67%), though. The seed that was inoculated with pulse beetles and designated T8 as the control had the lowest germination rate (93.67%). In the case of pooled, T3 (95.34%) had the highest germination percentage. It was comparable to T1 (94.50), T2 (94.83%), T4 (94.50%), T5 (94.67%), and T6 (95.33%), but not quite. T8 (93.33%), the control (seed injected with a pulse beetle), had the lowest germination rate, followed by T7 (94.17%). The results were significant during 6 months of storage (Table-3) throughout 2020–21, and T6 had the greatest germination rate of 93.00%. It was comparable to T2 (92.33%), T3 (92.33%), and T5 (92.33%), though. In contrast, it was 90.67% in the T7-Control group (fresh seed) and 88.67% in the T8-Control group (seed that had been inoculated with pulse beetle). The results were determined to be significant between 2021 and 2022, and T3 had the highest germination rate (93.33%). It was comparable to the other treatments, with the exception of T7 (90.67%) and T8 (90.00%). In the instance of pooled, T6 had the highest germination rate (93.17%). It was comparable to T2 (92.50%), T3 (92.83%), and T5 (92.67%), though. While it was lower in T7 (90.67%) and T8 (89.34%). The highest germination rate was seen in T3 (89.67%) at the end of a 9 month storage period (Table-3), during 2020–21. It was comparable to T2 (88.33%) and T6 (89.00%). The maximum germination rate was seen in T3 during 2021–2022 (92.00%). It was, however, at par with T6 (91.33%). In the case of pooled, T3 (90.84%) had the highest germination percentage. It was, however, on level with T6 (90.17%). In 2020–21, throughout the 12-month storage period (Table-3), T3 once more had the greatest germination rate (87.33%). It was only at par with T6 (86.33%), though. Significantly, T3 (89.00%) had the greatest germination percentage during 2021–2022. When pooled, T3 substantially had the highest germination rate (88.17%). In contrast, it was 67.17% in the T7-Control group (fresh seed) and 55.34% in the T8-Control group (seed that had been inoculated with pulse beetle). The temperature recorded during 2020 ranged from 47 to 52 degrees. Whereas, during 2021 it ranged from 51 to 56 degrees inside the seed packet after solarization.

When exposed to solar heat, *C. chinenesis* experienced extremely high adult death rates on cowpea seeds, according to Pareek and Kumawat (2013) [8]. In the study of Alice *et al.* (2013) [1], it was determined that exposing *C. maculatus* adults to sun heat for 2, 4, and 6 hours at a temperature of 50 EC reduced oviposition in *Vigna subterranea*. According to Mounica and Natarajan (2016) [6], solarizing bruchid-infested seeds reduced oviposition as time spent in the sun increased. With increased exposure, the number of eggs laid in the heat-treated cowpea as compared to the control significantly decreased. According to Prasanthi *et al.* (2017) [9], solar heating can lessen the harm caused by *Callosobruchus spp.* in cowpea. According to Ragaa *et al.* (2017) [10], using heat to protect grain effectively is still one of the best options because it is simple, quick, and gives residue-free disinfestations of grain. The outcomes further corroborate Alice *et al.*'s (2013) [1] findings that black gram seeds were adequately protected against *C. maculatus* infestation by sun drying, and that by lengthening the exposure duration to sunlight, the quantity of bruchid adults significantly decreased. In their 2004 study, Maina and Lale found that as exposure time increased, the amount of damage to cowpea seeds exposed to solar heat decreased significantly. Even after 41 weeks of storage, seeds that had received solar heat treatment remained unharmed by bruchids. According to Chauhan and Ghaffar (2002) [3], the rate of germination was reduced to 42% in the control treatment, which contained up to 91% bruchid-damaged seeds.

Table 1: Effect of solarization on damage to chick pea seeds by pulse beetle during storage

No.	Treatments	3 Months			6 Months			9 Months			12 Months		
		2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
1	T_1	2.87 (0.00)	2.87 (0.00)	2.87 (0.00)	2.87 (0.00)	2.87 (0.00)	2.87 (0.00)	10.50 (3.33)	12.46 (4.67)	11.48 (4.00)	14.15 (6.00)	18.05 (9.67)	16.10 (7.84)
2	T_2	2.87 (0.00)	2.87 (0.00)	2.87 (0.00)	2.87 (0.00)	2.87 (0.00)	2.87 (0.00)	9.36 (2.67)	8.74 (2.33)	9.05 (2.50)	13.34 (5.33)	14.95 (6.67)	14.15 (6.00)
3	T_3	2.87 (0.00)	2.87 (0.00)	2.87 (0.00)	2.87 (0.00)	2.87 (0.00)	2.87 (0.00)	2.87 (0.00)	5.74 (1.00)	4.30 (0.50)	5.74 (1.00)	10.50 (3.33)	8.12 (2.17)
4	T_4	2.87 (0.00)	2.87 (0.00)	2.87 (0.00)	2.87 (0.00)	2.87 (0.00)	2.87 (0.00)	11.94 (4.33)	13.34 (5.33)	12.64 (4.83)	15.70 (7.33)	22.24 (14.33)	18.97 (10.83)
5	T_5	2.87 (0.00)	2.87 (0.00)	2.87 (0.00)	2.87 (0.00)	2.87 (0.00)	2.87 (0.00)	11.02 (3.67)	11.02 (3.67)	11.02 (3.67)	14.53 (6.33)	17.08 (8.67)	15.81 (7.50)
6	T_6	2.87 (0.00)	2.87 (0.00)	2.87 (0.00)	2.87 (0.00)	2.87 (0.00)	2.87 (0.00)	2.87 (0.00)	6.54 (1.33)	4.70 (0.67)	5.74 (1.00)	12.46 (4.67)	9.10 (2.84)
7	T_7	4.78 (0.67)	7.33 (1.67)	6.06 (1.17)	6.54 (1.33)	9.36 (2.67)	7.95 (2.00)	15.32 (7.00)	17.69 (9.33)	16.50 (8.17)	23.50 (16.00)	27.78 (22.00)	25.64 (19.00)
8	T_8	7.95 (2.00)	9.88 (3.00)	8.91 (2.50)	12.88 (5.00)	13.16 (5.33)	13.02 (5.17)	23.01 (15.33)	22.27 (14.67)	22.64 (15.00)	29.22 (24.00)	33.04 (30.00)	31.13 (27.00)
T	S.Em +/-	0.55	0.45	0.35	0.39	0.62	0.36	0.67	1.16	0.67	1.09	1.64	0.98

	C.D. at 5%	1.65	1.34	1.02	1.17	1.85	1.05	2.02	3.47	1.93	3.27	4.91	2.83
Y	S.Em +/-	-	-	0.18	-	-	0.18	-	-	0.33	-	-	0.49
	C.D. at 5%	-	-	0.51	-	-	NS	-	-	0.96	-	-	1.42
YXT	S.Em +/-	-	-	0.50	-	-	0.52	-	-	0.95	-	-	1.39
	C.D. at 5%	-	-	NS	-	-	NS	-	-	NS	-	-	NS
	C.V.%	-	-	21.60	-	-	18.72	-	-	14.20	-	-	13.86

N.B.: Figures in parenthesis are original values, while outsides are arcsine transformed values.

Table 2: Effect of solarization on adult population of pulse beetle, *Callosobruchus* spp. in chick pea seeds by pulse beetle during storage.

No.	Treatments	3 Months			6 Months			9 Months			12 Months		
		2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
1	T_1	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	3.07 (9.00)	3.44 (11.33)	3.26 (10.17)	5.95 (35.00)	6.23 (38.33)	6.09 (36.67)
2	T_2	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	2.77 (7.33)	2.72 (7.00)	2.75 (7.17)	4.79 (23.00)	4.97 (24.33)	4.88 (23.67)
3	T_3	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	1.34 (1.33)	1.03 (0.67)	2.11 (4.00)	2.96 (8.33)	2.54 (6.17)
4	T_4	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	3.34 (10.67)	4.37 (18.67)	3.85 (14.67)	5.64 (31.33)	6.36 (40.00)	6.00 (35.67)
5	T_5	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	3.08 (9.00)	3.96 (15.33)	3.52 (12.17)	5.51 (30.00)	5.81 (33.33)	5.66 (31.67)
6	T_6	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	1.68 (2.33)	1.19 (1.17)	2.34 (5.00)	4.26 (17.67)	3.30 (11.33)
7	T_7	1.56 (2.00)	1.34 (1.33)	1.45 (1.67)	2.83 (7.67)	3.06 (9.00)	2.95 (8.34)	5.57 (30.67)	5.95 (35.00)	5.46 (32.84)	10.51 (110.67)	11.20 (125.00)	10.85 (117.84)
8	T_8	3.23 (10.00)	2.53 (6.00)	2.88 (8.00)	6.03 (36.00)	4.09 (16.33)	5.06 (26.17)	8.95 (80.00)	9.67 (93.33)	9.31 (86.67)	14.00 (196.67)	14.55 (211.67)	14.28 (204.17)
T	S.Em +/-	0.09	0.09	0.12	0.13	0.12	0.35	0.22	0.24	0.16	0.41	0.24	0.24
	C.D. at 5%	0.27	0.27	0.42	0.39	0.35	1.17	0.65	0.71	0.46	1.22	0.73	0.686
Y	S.Em +/-	--	--	0.06	--	--	0.18	--	--	0.08	--	--	0.12
	C.D. at 5%	--	--	NS	--	--	NS	--	--	0.23	--	--	0.34
YXT	S.Em +/-	--	--	0.09	--	--	0.12	--	--	0.23	--	--	0.34
	C.D. at 5%	--	--	0.26	--	--	0.36	--	--	NS	--	--	NS
	C.V.%	--	--	14.78	--	--	14.02	--	--	10.29	--	--	8.68

N.B.: Figures in parenthesis are original values, while outsides are square root transformed values.

Table 3: Effect of solarization on germination of chick pea seeds during storage

No.	Treatments	3 Months			6 Months			9 Months			12 Months		
		2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
1	T_1	75.43 (93.67)	77.58 (95.33)	76.51 (94.50)	73.57 (92.00)	73.93 (92.33)	73.75 (92.17)	69.45 (87.67)	70.33 (88.67)	69.89 (88.17)	64.90 (82.00)	64.16 (81.00)	64.53 (81.50)
2	T_2	76.24 (94.3)	77.54 (95.33)	76.89 (94.83)	73.93 (92.33)	74.30 (92.67)	74.11 (92.50)	70.03 (88.33)	72.22 (90.67)	71.12 (89.50)	65.40 (82.67)	67.22 (85.00)	66.31 (83.84)
3	T_3	76.66 (94.67)	78.52 (96.00)	77.59 (95.34)	73.93 (92.33)	75.07 (93.33)	74.50 (92.83)	71.25 (89.67)	73.59 (92.00)	72.42 (90.84)	69.15 (87.33)	70.64 (89.00)	69.90 (88.17)
4	T_4	75.47 (93.67)	77.54 (95.33)	76.50 (94.50)	73.57 (92.00)	73.93 (92.33)	73.75 (92.17)	67.76 (85.67)	68.59 (86.67)	68.17 (86.17)	63.69 (80.33)	64.16 (81.00)	63.92 (80.67)
5	T_5	75.43 (93.67)	78.00 (95.67)	76.72 (94.67)	73.93 (92.33)	74.68 (93.00)	74.31 (92.67)	68.59 (86.67)	68.88 (87.00)	68.73 (86.84)	64.16 (81.00)	64.91 (82.00)	64.54 (81.50)
6	T_6	77.08 (95.00)	78.00 (95.67)	77.54 (95.33)	74.68 (93.00)	75.05 (93.33)	74.86 (93.17)	70.63 (89.00)	72.88 (91.33)	71.76 (90.17)	68.31 (86.33)	67.48 (85.33)	67.90 (85.83)
7	T_7	75.43 (93.67)	76.66 (94.67)	76.05 (94.17)	72.22 (90.67)	72.22 (90.67)	72.22 (90.67)	64.90 (82.00)	65.66 (83.00)	65.28 (82.50)	54.54 (66.33)	55.56 (68.00)	55.05 (67.17)
8	T_8	74.68 (93.00)	75.43 (93.67)	75.06 (93.33)	70.33 (88.67)	71.58 (90.00)	70.96 (89.34)	61.37 (77.00)	63.44 (80.00)	62.40 (78.50)	47.10 (53.67)	49.03 (57.00)	48.07 (55.34)
T	S.Em +/-	0.48	0.58	0.38	0.36	0.49	0.30	0.49	0.41	0.32	0.44	0.63c	0.38
	C.D. at 5%	NS	1.73	1.09	1.07	1.48	0.88	1.47	1.24	0.93	1.32	1.87	1.10
Y	S.Em +/-	-	-	0.19	-	-	0.15	-	-	0.16	-	-	0.19
	C.D. at 5%	-	-	0.54	-	-	0.44	-	-	0.46	-	-	0.55
YXT	S.Em +/-	-	-	0.53	-	-	0.43	-	-	0.45	-	-	0.54
	C.D. at 5%	-	-	NS	-	-	NS	-	-	NS	-	-	NS
	C.V.%	-	-	1.21	-	-	1.01	-	-	1.15	-	-	1.50

N.B.: Figures in parenthesis are original values, while outsides are arcsine transformed values.

Table 4: Temperature recorded during both the years in the experiment.

		Outside temperature ºC		Inside temperature ºC	
Day		Before solarization	After solarization	Before solarization	After solarization
01 (19.05.20)	:	36.0	40.0	33.0	47.0
02 (20.05.20)	:	36.0	41.0	33.0	50.0
03 (21.05.20)	:	37.0	41.0	33.0	51.0
04 (22.05.20)	:	37.0	41.0	32.0	52.0
05 (23.05.20)	:	36.0	41.0	33.0	50.0
06 (24.05.20)	:	37.0	41.0	33.0	52.0
Day					
01 (22.06.21)	:	35.0	42.0	30.0	54.0
02 (23.06.21)	:	36.0	42.0	32.0	56.0
03 (24.06.21)	:	34.0	38.0	30.0	51.0
04 (25.06.21)	:	33.0	39.0	30.0	53.0
05 (26.06.21)	:	35.0	40.0	30.0	56.0
06 (27.06.21)	:	34.0	38.0	31.0	54.0

Conclusion

Solarizing chick pea seeds, during summer bright days, in a clear polythene (700 gauge) packet for 6 days (4 hours each day) will prevent damage from the pulse beetle and preserve seed germination (above 85.00% IMSCS level) for up to 9 months of storage. This is a low cost and eco-friendly technology for protecting chick pea seeds from the pulse beetle.

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