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# Effect of solarisation against bruchids and on seed quality in green gram during storage

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**Abstract**
The present experiment was carried out to study the effect of solarisation on seed storability in green gram against bruchids (*Callosobruchus maculatus*) infestation. Eight treatments were maintained as a set of 4 treatments of inoculated with bruchids and another set of 4 treatments without bruchids & the experiment will replicate thrice and all were exposed to solarisation of various durations except control. Results revealed that, seeds exposed to four hours for three days and significantly differed in all seed quality parameters *viz*., number of eggs (192.33), number of adults (37.00), seed germination (79.67%), root length (7.22 cm), shoot length (17.73 cm), mean seedling length (24.95 cm), mean seedling dry weight (178 mg), seedling vigour index-I (1988) and seedling vigour index-II (1421) till nine months of storage compared to control (237.33, 62.67, 63.00%, 5.10 cm, 13.73 cm, 18.83 cm, 142 mg, 1375 and 1034, respectively).

**Keywords:** Solarisation, bruchids, gram, *Callosobruchus maculatus*

## Introduction

Cereals and legumes generally known as major constitutes for the most vital diet component for the majority of people in the world providing the calories and proteins consumed by the resource-poor and provide the rural folks with employment and sustainable source of income. There is a need to meet average demand by storing excess supply during the harvesting season for gradual release to the market during the off season period. For regular availability of agricultural outputs or stabilizing the economy of any country, it is required that quality seed to the farmers for sowing. In order to satisfy the demand for a plentiful supply, seeds must be stored throughout the year.

Pulses are poor storer and became infested by bruchids (*Callosobruchus maculatus*) starts in the field and continues in storage. Bruchid is minor pests in the field, which assume a major pest during seed storage. Under traditional storage conditions, 100 per cent infestation of seeds damaged by the bruchids within 3 to 5 months of storage (Adebayo and Anjorin, 2018). The pulse beetle *Callosobruchus maculatus* is a major pest of economically important leguminous grains, such as cow pea, lentil, green gram, and black gram (Park, 2003) and in storage; it is damaged to a great extent. The pest being an internal feeder laid eggs on the seed surface in the field as well as during threshing which hatch during storage. To manage this storage pest, pesticides have positive effect on the pests, they continued to remain hazardous to man and the environment. With the objective of finding alternative to pesticide that are environmentally friendly and does not pose dangers to man. However, the problems of many synthetic insecticides which include high persistence, poor knowledge of application by resource-poor farmers, high cost, genetic resistance and hazards to environment and human health have necessitated the search for relatively cheap, environmentally safe and sustainable control measures. As part of the quest for an alternative to chemical insecticides, research efforts are currently being focused on eco-friendly control measures such as, irradiation, heat treatment, bio pesticides, integrated pest management, use of insect hormones.

Solarisation is one of the alternatives, less hazardous and safe method to control *C. maculatus*. Eggs deposited on the surface of the seeds exposed to high temperature and low humidity will desiccate as a result deformed. Therefore, bruchids living within seed are excellent targets for management using elevated temperature. The effectiveness of the technique depends upon spreading the seeds in thin layer and exposing them to the sun for a long period. Solar disinfestations technology is an effective, low cost, non-toxic pest control process, which does not alter desirable properties of seeds.

With the above facts we conducted a research with effect of solarisation (exposing seeds to solarisation for different periods) against bruchids and on seed quality during seed storage. Recorded the number of eggs, number of adults, germination (%), root and shoot length (cm), mean seedling length (cm), mean seedling dry weight (mg), seedling vigor index-I and seedling vigor index-II until the seeds get down their minimum standards as per IMSCS.

## Materials and Methodology

The experiment will set up to study the management of pulse beetle through solar radiation in stored green gram seeds (Variety: KKM-3). Eight treatments will be maintained as a set of 4 treatments of inoculated with bruchids and another set of 4 treatments without bruchids & the experiment will replicate thrice. The observations will be recorded during storage till seed maintains MSCS level. One kg of freshly harvested certified seed with very high percentage of germination and low moisture content (<10%) will be taken for each treatment. Solarisation should be done around noon and same schedule should be maintained in every treatment. The temperature outside/inside of packets should be recorded each day before and after the solarisation. After treatment, the seed packets should be kept under ambient ensuring prevention of cross infestation. The temperatures were recorded using thermometer when seeds kept for solarisation and they are present below.

| | | 10:00 AM | 2:00 PM |
|---|---|---|---|
| Day-1 | Outside the packet | 35 $^0$C | 36 $^0$C |
| | Inside the packet | 30 $^0$C | 35 $^0$C |
| | In between seed | 35 $^0$C | 40 $^0$C |
| Day-2 | Outside the packet | 32 $^0$C | 34 $^0$C |
| | Inside the packet | 30 $^0$C | 37 $^0$C |
| | In between seed | 32 $^0$C | 45 $^0$C |
| Day-3 | Outside the packet | 35 $^0$C | 40 $^0$C |
| | Inside the packet | 30 $^0$C | 42 $^0$C |
| | In between seed | 36 $^0$C | 46 $^0$C |

**Treatments: Eight**

$T_1$: Exposure period 4h for one day (Inoculated with bruchids)
$T_2$: Exposure period 4h for two days (Inoculated with bruchids)
$T_3$: Exposure period 4h for three days (Inoculated with bruchids)
$T_4$: Exposure period 4h for one day
$T_5$; Exposure period 4h for two days
$T_6$; Exposure period 4h for three days
$T_7$: Control (Inoculated with bruchids)
$T_8$: Control

## Results and Discussion

The present experiment results were presenting here on effect of solarisation on various seed quality parameters *viz.*, number of eggs, number of adults, germination (%), root and shoot length (cm), mean seedling length (cm), mean seedling dry weight (mg), seedling vigor index-I and seedling vigor index-II until the seeds get down their minimum standards as per IMSCS.

### No. of eggs

The significant difference was observed in all treatments in showing the number of eggs till the nine months period (Table.1). Among the treatments studied $T_6$ (exposure period 4h for three days) recorded least number of eggs (0.00 to 192.33) during nine months of storage. The treatments $T_4$ and $T_5$ (exposure period 4h for one and two days) are on par with each other in showing the number of eggs (0.00 to 202.67 and 0.00 to 197.67 respectively) during storage period. The treatments of inoculated seeds $T_1$ and $T_2$ (exposure period 4h for one and two days) are also on par with each other in showing the number of eggs (0.00 to 222.00 and 0.00 to 206.00 respectively) during storage period and recorded more number of eggs than the seeds which were un inoculated or fresh seeds (Lal and Vidal, 2003) [8]. Treatments of both the control ($T_7$ and $T_8$) also recorded highest number of eggs compared to solarisation exposed seeds. Among two control treatments inoculated seed shown the highest number of eggs (0.00 to 237.33) compared to un inoculated seeds (0.00 to 229.33) during nine months of storage (Fig. 1). Eggs are deposited on surface of seed direct contact with solar radiation leads to disruption of the normal functioning of the reproductive physiology of bruchids played an important role since egg-laying was depressed in few treatments where the female mortality was low. Although high temperatures are known to depress egg production their precise effect on the reproductive system of these bruchids in green gram. Similar results were observed in Doumma (2007) in cowpea, Singh (2009) in green gram, Alice and Sreekant (2017) in vigna species and Emmanuel and Hassan (2019).

### No. of adults

The significant difference was observed in all treatments in showing the number of adults till the nine months period. Among the treatments studied $T_6$ (exposure period 4h for three days) recorded least number of adults (0.00 to 37.00) during nine months of storage (Table.1). The treatments $T_4$ and $T_5$ (exposure period 4h for one and two days) are on par with each other in showing the number of adults (0.00 to 42.67 and 0.00 to 40.00 respectively) during storage period (Fig. 2). The treatments of inoculated seeds $T_1$ and $T_2$ (exposure period 4h for one and two days) are shown the number of adults (0.00 to 50.00 and 0.00 to 47.00 respectively) during storage period and recorded more number of adults than the seeds which were un inoculated or fresh seeds. Treatments of both the control ($T_7$ and $T_8$) also recorded highest number of adults compared to solarisation exposed seeds. Among two control treatments inoculated seed shown the highest number of adults (1.33 to 62.67) compared to un-inoculated seeds (1.33 to 54.00) during nine months of storage. According to Lal and Vidal (2003) [8] a significantly reduction in oviposition, adult progeny development and/or survival has been observed. There is a precise mechanisms causing death at high temperatures, but changes in lipids, particularly increased fluidity of phospholipid membranes in the nervous system, metabolic rate imbalances, perturbation of ionic activities, as well as desiccation have been proposed as possible mechanisms of death due to high temperatures known to cause inability to move and finally death in adult insects (Chapman, 1982) [2]. It has also been reported that insects die at low humidities from the effects of desiccation and in many cases low humidities make insects more susceptible to heat (Fields, 1992) [6]. Similar results were observed in Lale and Ajayi (2001) [9] in ground nut, Doumma (2007) in cowpea, Emmanuel and Hassan (2019), Alice and Sreekant (2017) in vigna species, Singh (2009) in green gram, Mali and Satya (2018) [10] in green gram.

### Germination (%)

The significant difference was observed in all treatments in showing the germination (%) till the nine months period. Among the treatments studied $T_6$ (exposure period 4h for three days) recorded highest germination (95.00 to 79.67%) during nine months of storage. The treatments $T_4$ and $T_5$ (exposure period 4h for one and two days) are on par with each other in showing the germination (95.00 to 77.67% and 95.00 to 78.33% respectively) during storage period (Table.2). The treatments of inoculated seeds $T_1$ and $T_2$ (exposure period 4h for one and two days) are shown the germination (95.00 to 67.00% and 95.00 to 65.00 respectively) during storage period and recorded lowest germination (%) than the seeds which were un-inoculated or fresh seeds. Treatments of both the control ($T_7$ and $T_8$) also recorded lowest germination (%) compared to solarisation exposed seeds. Among two control treatments inoculated seed shown the lowest germination (95.00 to 63.00%) compared to un inoculated seeds (95.00 to 70.67%) during nine months of storage. Adverse effects on seed germination, root, shoot length and other quality paramnetrs could also be due to increasing temperatures. Also after exposing seeds exposed with low period of solar radiation which will not show any effects on egg survival. Hence, the eggs will hatch and damage the seeds, leading to reduce the seed quality parameters by making holes and consumption of seed reserve (plate 1 and 2). These holes are responsible for the entering of a harmful micro-organisms and also interfere with the water intake which retards the seed germination (Sonali *et al.*, 2018) [17] and pertaining results of this study are confirmative with Deshpande *et al.* (2011) [3] in cowpea, Muyinza *et al.* (2012) [12], Narayanswamy *et al.* (2014) [13] in soybean, Raghavendra and Loganathan (2017) [16], Manisha *et al.* (2017) [11] and Divya *et al.* (2018) [4] in horse gram.

**Root length (cm)**

The significant difference was observed in all treatments in showing the root length (cm) till the nine months period. Among the treatments studied $T_6$ (exposure period 4h for three days) recorded highest root length (12.50 to 7.22 cm) during nine months of storage. The treatments $T_4$ and $T_5$ (exposure period 4h for one and two days) are on par with each other in showing the root length (12.50 to 6.34 cm and 12.50 to 6.70 respectively) during storage period. The treatments of inoculated seeds $T_1$ and $T_2$ (exposure period 4h for one and two days) are shown the root length (12.50 to 5.97 cm and 12.50 to 6.52 cm respectively) during storage period and recorded lowest root length (cm) than the seeds which were un inoculated or fresh seeds. Treatments of both the control ($T_7$ and $T_8$) also recorded lowest root length (cm) compared to solarisation exposed seeds. Among two control treatments inoculated seed shown the lowest root length (12.50 to 5.10 cm) compared to un inoculated seeds (12.50 to 5.52 cm) during nine months of storage. Eggs will hatch and damage the seeds by making holes and consumption of seed reserve also interfere with the water intake which retards the growth. Similar results were observed in, Hartaman *et al.* (2002) [7] in azuki bean, Narayanaswamy *et al.* (2014) [13] in soybean.

**Shoot length**

The significant difference was observed in all treatments in showing the shoot length (cm) till the nine months period. Among the treatments studied $T_6$ (exposure period 4h for three days) recorded highest shoot length (26.50 to 17.73 cm) during nine months of storage. The treatments $T_4$ and $T_5$ (exposure period 4h for one and two days) are showing the shoot length (26.50 to 16.64 and 26.50 to 17.38 cm respectively) during storage period. The treatments of inoculated seeds $T_1$ and $T_2$ (exposure period 4h for one and two days) are shown the shoot length (26.50 to 15.73 cm and 26.50 to 16.23 cm respectively) during storage period and recorded lowest shoot length (cm) than the seeds which were un inoculated or fresh seeds. Treatments of both the control ($T_7$ and $T_8$) also recorded lowest shoot length (cm) compared to solarisation exposed seeds. Among two control treatments inoculated seed shown the lowest shoot length (26.50 to 13.73 cm) compared to un inoculated seeds (26.50 to 14.80 cm) during nine months of storage. Eggs will hatch and damage the seeds by making holes and consumption of seed reserve also interfere with the water intake which retards the growth. Similar results were observed in Ellanda *et al.* (2017) and Narayanaswamy *et al.* (2014) [13] in soybean.

**Mean seedling length (cm)**

The significant difference was observed in all treatments in showing the mean seedling length (cm) till the nine months period. Among the treatments studied $T_6$ (exposure period 4h for three days) recorded highest mean seedling length (39.00 to 24.95 cm) during nine months of storage. The treatments $T_4$ and $T_5$ (exposure period 4h for one and two days) are showing the mean seedling length (39.00 to 22.98 cm and 39.00 to 24.08 cm respectively) during storage period. The treatments of inoculated seeds $T_1$ and $T_2$ (exposure period 4h for one and two days) are shown the seedling length (39.00 to 21.70 cm and 39.00 to 22.75 cm respectively) during storage period and recorded lowest mean seedling length (cm) than the seeds which were un inoculated or fresh seeds (Table.2). Treatments of both the control ($T_7$ and $T_8$) also recorded lowest mean seedling length (cm) compared to solarisation exposed seeds. Among two control treatments inoculated seed shown the lowest mean seedling length (39.00 to 18.83 cm) compared to un inoculated seeds (39.00 to 20.32 cm) during nine months of storage. Eggs will hatch and damage the seeds by making holes and consumption of seed reserve also interfere with the water intake which retards the growth. Similar results were observed in, Hartaman *et al.* (2002) [7] in azuki bean, Narayanaswamy *et al.* (2014) [13] in soybean.

**Mean seedling dry weight (mg)**

The significant difference was observed in all treatments in showing the mean seedling dry weight (mg) till the nine months period. Among the treatments studied $T_6$ (exposure period 4h for three days) recorded highest mean seedling dry weight (310 to 178 mg) during nine months of storage. The treatments $T_4$ and $T_5$ (exposure period 4h for one and two days) are showing the mean seedling dry weight (310 to 160 and 310 to 173 mg respectively) during storage period. The treatments of inoculated seeds $T_1$ and $T_2$ (exposure period 4h for one and two days) are shown the seedling dry weight (310 to 153 mg and 310 to 163 mg respectively) during storage period and recorded lowest mean seedling dry weight (mg) than the seeds which were un inoculated or fresh seeds. Treatments of both the control ($T_7$ and $T_8$) also recorded lowest mean seedling dry weight (mg) compared to solarisation exposed seeds. Among two control treatments inoculated seed shown the lowest mean seedling dry weight (310 to 142 mg) compared to un inoculated seeds (310 to150 mg) during nine months of storage. This shows the level of seed deterioration due to the natural ageing of seeds and level of bruchid infestation. These finding results are also collaborating with, Raghavendra and Loganathan (2017) [16] and Narayanaswamy *et al.* (2014) [13] in soybean.

**Seedling vigour index-I**

The significant difference was observed in all treatments in showing the seedling vigour index-I till the nine months period. Among the treatments studied $T_6$ (exposure period 4h for three days) recorded highest seedling vigour index-I (3705 to 1988) during nine months of storage. The treatments $T_4$ and $T_5$ (exposure period 4h for one and two days) are showing the seedling vigour index-I (3705 to 1784 and 3705 to 1886 respectively) during storage period (Table.3). The treatments of inoculated seeds $T_1$ and $T_2$ (exposure period 4h for one and two days) are shown the seedling vigour index-I (3705 to 1642 and 3705 to 1737 respectively) during storage period and recorded lowest seedling vigour index-I than the seeds which were un inoculated or fresh seeds. Treatments of both the control ($T_7$ and $T_8$) also recorded lowest seedling vigour index-I compared to solarisation exposed seeds. Among two control treatments inoculated seed shown the lowest seedling vigour index-I (3705 to 1375) compared to un inoculated seeds (3705 to 1497) during nine months of storage. During ageing increase infestation leads to reduce the seedling length and germination leads to reduction vigour with ageing. Similar results were observed in, Hartaman *et al.* (2002) [7] in azuki bean, Patro *et al.* (2007) [15] in pulses and Deshpande *et al.* (2011) [3] in cowpea, Narayanaswamy *et al.* (2014) [13] in soybean, Raghavendra and Loganathan (2017) [16] in pigeon pea and Ellanda *et al.* (2017).

**Seedling vigour index-II**

The significant difference was observed in all treatments in showing the seedling vigour index-II till the nine months period. Among the treatments studied $T_6$ (exposure period 4h for three days) recorded highest seedling vigour index-II (2945 to 1421) during nine months of storage. The treatments $T_4$ and $T_5$ (exposure period 4h for one and two days) are showing the seedling vigour index-II (2945 to 1243 and 2945 to 1358 respectively) during storage period. The treatments of inoculated seeds $T_1$ and $T_2$ (exposure period 4h for one and two days) are shown the seedling vigour index-II (2945 to 1148 and 2945 to 1247 respectively) during storage period (Table.3) and recorded lowest seedling vigour index-I than the seeds which were un inoculated or fresh seeds. Treatments of both the control ($T_7$ and $T_8$) also recorded lowest seedling vigour index-II compared to solarisation exposed seeds. Among two control treatments inoculated seed shown the lowest seedling vigour index-II (2945 to 1034) compared to un inoculated seeds (2945 to 1106) during nine months of storage. During ageing increase infestation leads to reduce the seedling dry weight and germination leads to reduction vigour with ageing. Similar results were observed in, Hartaman *et al.* (2002) [7] in azuki bean, Patro *et al.* (2007) [15] in pulses and Deshpande *et al.* (2011) [3] in cowpea, Narayanaswamy *et al.* (2014) [13] in soybean, Raghavendra and Loganathan (2017) [16] in pigeon pea and Ellanda *et al.* (2017).

**Table 1:** Effect of solarisation on number of eggs and number of adults in green gram

| Number of eggs | | | Number of adults | |
|---|---|---|---|---|
| **Treatment** | **0 MAS** | **9 MAS** | **0 MAS** | **9 MAS** |
| $T_1$ | 0.00 | 222.00 | 0.00 | 50.00 |
| $T_2$ | 0.00 | 216.00 | 0.00 | 47.00 |
| $T_3$ | 0.00 | 209.33 | 0.00 | 45.00 |
| $T_4$ | 0.00 | 202.67 | 0.00 | 42.67 |
| $T_5$ | 0.00 | 197.67 | 0.00 | 40.00 |
| $T_6$ | 0.00 | 192.33 | 0.00 | 37.00 |
| $T_7$ | 0.00 | 237.33 | 0.00 | 62.67 |
| $T_8$ | 0.00 | 229.33 | 0.00 | 54.00 |
| Mean | 0.00 | 213.33 | 0.00 | 47.29 |
| S.Em+ | 0.00 | 1.66 | 0.00 | 0.67 |
| CD (P=0.05) | 0.00 | 4.97 | 0.00 | 2.00 |
| CV (%) | 0.00 | 1.35 | 0.00 | 2.44 |

$T_1$: Exposure period 4h for one day (Inoculated with bruchids)
$T_2$: Exposure period 4h for two days (Inoculated with bruchids)
$T_3$: Exposure period 4h for three days (Inoculated with bruchids)
$T_4$: Exposure period 4h for one day
$T_5$; Exposure period 4h for two days
$T_6$; Exposure period 4h for three days
$T_7$: Control (Inoculated with bruchids)
$T_8$: Control

**Table 2:** Effect of solarisation on seed germination and seedling length in green gram

| Seed germination (%) | | | Seedling length (cm) | |
|---|---|---|---|---|
| **Treatment** | **0 MAS** | **9 MAS** | **0 MAS** | **9 MAS** |
| $T_1$ | 95.00 | 67.00 | 39.00 | 21.70 |
| $T_2$ | 95.00 | 65.00 | 39.00 | 22.75 |
| $T_3$ | 95.00 | 66.33 | 39.00 | 23.60 |
| $T_4$ | 95.00 | 77.67 | 39.00 | 22.98 |
| $T_5$ | 95.00 | 78.33 | 39.00 | 24.08 |
| $T_6$ | 95.00 | 79.67 | 39.00 | 24.95 |
| $T_7$ | 95.00 | 63.00 | 39.00 | 18.83 |
| $T_8$ | 95.00 | 70.67 | 39.00 | 20.32 |
| Mean | 95.00 | 70.96 | 39.00 | 22.40 |

| | | | | |
|---|---|---|---|---|
| S.Em+ | 0.00 | 1.60 | 0.00 | 0.26 |
| CD (P=0.05) | 0.00 | 4.81 | 0.00 | 0.79 |
| CV (%) | 0.00 | 3.91 | 0.00 | 2.03 |

$T_1$: Exposure period 4h for one day (Inoculated with bruchids)
$T_2$: Exposure period 4h for two days (Inoculated with bruchids)
$T_3$: Exposure period 4h for three days (Inoculated with bruchids)
$T_4$: Exposure period 4h for one day
$T_5$; Exposure period 4h for two days
$T_6$; Exposure period 4h for three days
$T_7$: Control (Inoculated with bruchids)
$T_8$: Control

**Table 3:** Effect of solarisation on seedling vigour index-I and II in green gram

| Seedling vigour index-I | | | Seedling vigour index-II | |
|---|---|---|---|---|
| **Treatment** | **0 MAS** | **9 MAS** | **0 MAS** | **9 MAS** |
| $T_1$ | 3705 | 1642 | 2945 | 1148 |
| $T_2$ | 3705 | 1737 | 2945 | 1247 |
| $T_3$ | 3705 | 1849 | 2945 | 1305 |
| $T_4$ | 3705 | 1784 | 2945 | 1243 |
| $T_5$ | 3705 | 1886 | 2945 | 1358 |
| $T_6$ | 3705 | 1988 | 2945 | 1421 |
| $T_7$ | 3705 | 1375 | 2945 | 1034 |
| $T_8$ | 3705 | 1497 | 2945 | 1106 |
| Mean | 3705.0 | 1719.8 | 2945.0 | 1232.7 |
| S.Em+ | 0.00 | 29.75 | 0.00 | 32.67 |
| CD (P=0.05) | 0.00 | 89.20 | 0.00 | 97.95 |
| CV (%) | 0.00 | 3.00 | 0.00 | 4.59 |

$T_1$: Exposure period 4h for one day (Inoculated with bruchids)
$T_2$: Exposure period 4h for two days (Inoculated with bruchids)
$T_3$: Exposure period 4h for three days (Inoculated with bruchids)
$T_4$: Exposure period 4h for one day
$T_5$; Exposure period 4h for two days
$T_6$; Exposure period 4h for three days
$T_7$: Control (Inoculated with bruchids)
$T_8$: Control

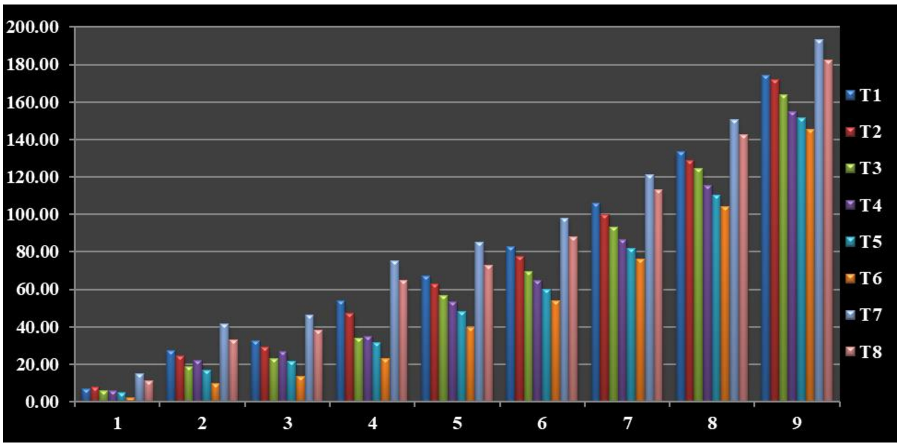


**Fig 1:** Effect of solarisation on number of eggs during storage

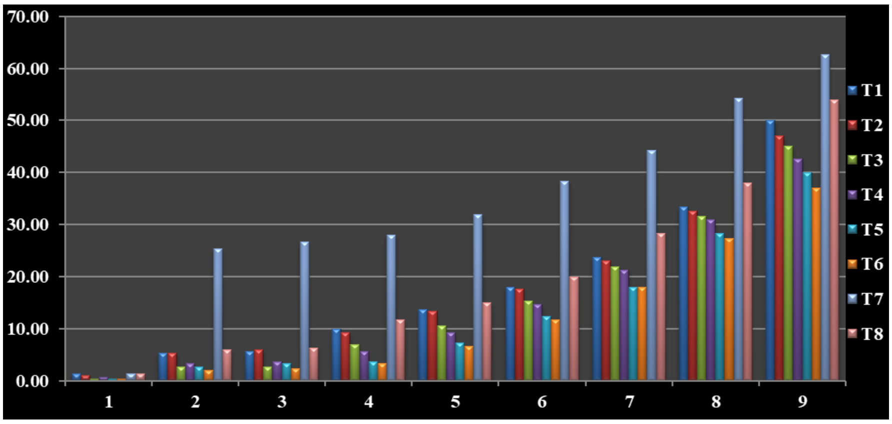

**Fig 2:** Effect of solarisation on number of adults during storage

$T_1$: Exposure period 4h for one day (Inoculated with bruchids)
$T_2$: Exposure period 4h for two days (Inoculated with bruchids)
$T_3$: Exposure period 4h for three days (Inoculated with bruchids)
$T_4$: Exposure period 4h for one day
$T_5$; Exposure period 4h for two days
$T_6$; Exposure period 4h for three days
$T_7$: Control (Inoculated with bruchids)
$T_8$: Control

**Plate 1:** Seeds showing number of adults in exposed period of four hours to solarisation at ninth month of storage in green gram

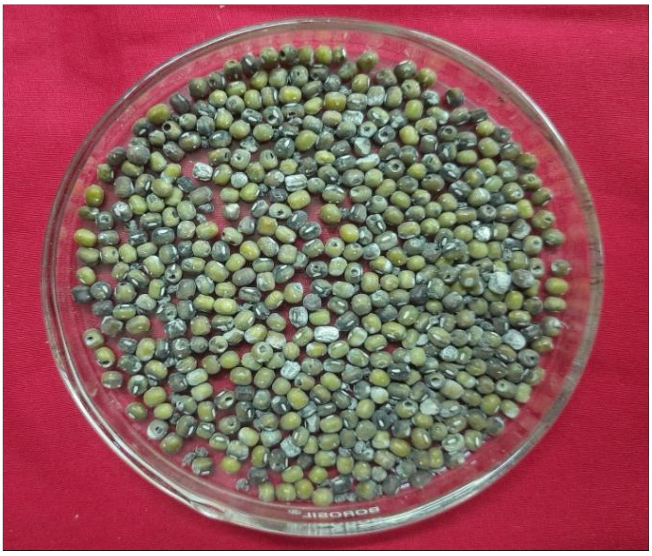

**Plate 2:** Seeds showing number of adults in control (seeds not exposed to solarisation) at ninth month of storage in green gram

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