The Pharma Innovation Journal 2023; 12(1): 924-929

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(1): 924-929

www.thepharmajournal.com
Received: 01-11-2022
Accepted: 05-12-2022

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Effect of different layers of cereals on infestation and development of pulse beetle (*C. maculatus*) infesting kabuli gram

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Abstract
The present investigation were carried out at laboratory of the Department of Agricultural Entomology, College of Agriculture, Dapoli, Dist. Ratnagiri 415 712 (Maharashtra). To protect the kabuli gram grains from bruchid infestation either 4 cm or 6 cm layers of five different cereals *viz.*, red rice, nachani, wheat, bajara and maize were put above the kabuli gram and 5 pairs of adults *C. maculatus* were released in each treatment. The bruchid was not able to cause any damage to all the five cereal grains. Treatments comprised of either 4 cm or 6 cm layer of nachani, red rice and bajara were found effective in protecting kabuli gram grains from bruchid infestation. These treatments recorded least adult survival duration, no probing movement, no egg laying on kabuli gram grains, no damaged grains, no adult emergence and no weight loss.

Keywords: Layers, cereals, pulse beetle, *C. maculatus*, kabuli gram

1. Introduction
Pulses are the second most significant group of crops. Pulses are excellent source of protein (20-40%), carbohydrate (50-60%) and solidly strong source of thiamine, niacin, calcium and iron. It is the crucial source of protein in the vegetarian diet of Indians. The pulses protein is rich in lysine and has low sulphate containing amino acid. India is the largest producer (25% of global production), consumer (27% of world consumption) and importer (14%) of pulses in the world. Pulses account for around 20 percent of the land planted under food grains and contributes around 7-10 percent of the total food grains production in the country (Anonymous, 2019) [1].

It is predicted that India's population would reach 1.68 billion by 2030 from the present level of 1.39 billion. Accordingly, the projected pulse for the year 2030 is 32 million tons with anticipated required growth rate of 4.2 percent (Anonymous, 2021) [2]. India has to produce not only enough pulses but also remain competitive to protect the indigenous pulse production. With a proportion of almost 40 percent in the total production, gram is the most important pulse, followed by tur at 15 to 20 percent and urid and moong at about 8 to 10 percent. Gram is widely appreciated healthy food. It is protein rich supplement to pulses-based diets, especially to the poor in developing countries, where peoples are vegetarians and cannot afford animal protein. Grains of Kabuli gram are bigger in size than desi gram and contain more fat (5.1%) and carbohydrates (24.4%) and have more caloric value (365 k Cal/100 gm). However, protein (24.4%) and ash (2.8%) contain of Kabuli gram little bit less while crude fiber contain is significantly less (3.9%) than desi gram (Khan *et al.* 1995) [9].

2. Materials and Methods
The present laboratory studies entitled "Effect of different layer of cereals on infestation and development of pulse beetle, *Callosobruchus maculatus* (Fab.) (Coleoptera: Chrysomelidae)" were undertaken at Laboratory of Department of Agricultural Entomology, College of Agriculture Dapoli, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli Dist. – Ratnagiri during 2021-2022. The present investigation was carried out with laboratory maintained culture of *C. maculatus*.

2.1 Maintenance of culture of *C. maculatus*
Initial culture of *Callosobruchus maculatus* (Fab.) were obtained from the pulses which were

already infested by the bruchids from local market and kept in glass jar. The taxonomic key given by Haines (1988) [6] was used for the identification and isolation of a desired species of pulse beetle *i.e., Callosobruchus maculatus*. Healthy and uninfested grains of Kabuli gram was purchased from market and kept uniformly in glass jar. Five pairs of adult *C. maculatus* isolated from original culture were released into glass jar of healthy grains. A piece of muslin cloth was placed firmly with rubber band on mouth of glass jar to prevent escape of adults. The newly emerged adults were transferred into similar sized glass jar containing uninfested and healthy Kabuli gram grains in order to maintain the culture of test insect throughout the study. The freshly emerged adults of uniform age were used for further studies (Plate 1).

2.2.1 Details of the Experiment

A statistically designed laboratory experiment was laid out during year 2021-22 to study effect of different layer of cereals on infestation and development of pulse beetle (*C. maculatus*) infesting Kabuli gram. For these 33 plastic jars of 10 X 7 cm size were used. Each jar was marked at an equal distance of 2 cm from the bottom. At the bottom of the jars, grains of Kabuli gram were filled either up to 2 cm layer or 4 cm layer and above the layer of Kabuli gram, layers of different cereals *viz.*, red rice, wheat, nachani, bajara and maize were filled either up to 6 cm or 4 cm respectively, according to the treatments. In the control treatment only Kabuli gram grains were filled up to 8 cm layer. Upper 2 cm layer at the neck region of each jar were kept empty. Five pairs of adult pulse beetle *C. maculatus* were separated out from the laboratory culture maintained in separate plastic jars and released at the top of each jar. They were allowed to mate freely and lay eggs in the jar until all beetles were died.

The details of laboratory experiment conducted are given below

Design of experiment	Completely Randomized Design (CRD)
Location	Department of Agricultural Entomology, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. Maharashtra.
Year of study	2021-22
Name of test insect	Pulse beetle, *Callosobruchus maculatus*
Number of replications	Three
Number of treatments	Eleven

Treatment details

Sr.no	Treatments	Storage type
T1	Kabuli gram 2 cm layer + Red rice 6 cm layer	Layer storage
T2	Kabuli gram 4 cm layer + Red rice 4 cm layer	Layer storage
T3	Kabuli gram 2 cm layer + Nachani 6 cm layer	Layer storage
T4	Kabuli gram 4 cm layer + Nachani 4 cm layer	Layer storage
T5	Kabuli gram 2 cm layer + Wheat 6 cm layer	Layer storage
T6	Kabuli gram 4 cm layer + Wheat 4 cm layer	Layer storage
T7	Kabuli gram 2 cm layer + Bajara 6 cm layer	Layer storage
T8	Kabuli gram 4 cm layer + Bajara 4 cm layer	Layer storage
T9	Kabuli gram 2 cm layer + Maize 6 cm layer	Layer storage
T10	Kabuli gram 4 cm layer + Maize 4 cm layer	Layer storage
T11	Kabuli gram 8 cm layer	Control

2.2.2 Method of recording observations

2.2.2.1 Initial weight of Kabuli gram seeds

The initial weights of 100 Kabuli gram seeds were recorded from each treatment in order to calculate weight loss at 30, 60 and 90 days after introduction of bruchids.

2.2.2.2 Adult survival duration

Adult survival duration of *C. maculatus* in different treatments was recorded in days as duration of adult survival after introduction of adults in different treatments up to the death of adults. In each treatment 5 pairs of adult *C. maculatus* were introduced and their average survival duration was calculated.

2.2.2.3 Measurement of movement of mated *C. maculatus* females in different treatments

To record the movement of mated *C. maculatus* female in the different treatments, a separate experimental setup was arranged. For this 33 glass test tubes of 2.5 X 15 cm size were used. Each test tube was marked at equal distance of 2 cm from the bottom. At the bottom of each test tube, grains of Kabuli gram were filled either up to 2 cm layer or 4 cm layer. Above the layer of Kabuli gram grains, layers of different cereal grains *viz.*, red rice, wheat, nachani, bajara and maize were filled either up to 6 cm or 4 cm respectively, according to the treatments. In the test tubes of control treatment only Kabuli gram grains were filled up to 8 cm layer. Five mated females of *C. maculatus* were separate out from the laboratory culture maintained in separate plastic jars and released at the top of each test tube. Movement of each female was recorded by measuring the distance probe (depth) by each female in the test tubes from the top layer at an interval of every two hours till 12 hours. (Plate 2)

2.2.2.4 Number of eggs laid on Kabuli gram and cereals grains

To enumerate the number of eggs laid by *C. maculatus* females on the grains of Kabuli gram and cereals in different treatments five pairs of freshly mated *C. maculatus* adults were isolated from laboratory reared culture of *C. maculatus* and released in containers containing cereals and Kabuli gram in layer form. Numbers of eggs in different treatments were recorded by observing 100 grains of Kabuli gram and cereals from each treatment at 30, 60 and 90 days after inoculation.

2.2.2.5 Number of grains of Kabuli gram and cereals damaged by *C maculatus*

Number of grains of Kabuli gram and cereals damaged by *C. macualtus* in different treatments were recorded by counting number of infested grains on the basis of adult emergence holes of *C. maculatus* observed on 100 grains of Kabuli gram and cereals at 30, 60 and 90 days after storage.

2.2.2.6 Adult emergence

Total number of adult *C. maculatus* emerged from each treatment were counted at 30, 60 and 90 days after storage and expressed as number of *C. maculatus* adult emerged per treatments. After counting they were put back in the treatment.

2.2.2.7. Percent loss in grain weight

Percent loss in grain weight of Kabuli gram was worked out by recording initial weight of Kabuli gram before release of bruchids and recording the final weight at 30, 60 and 90 days after release of bruchids. Before counting the final weight all the emerged adults of bruchids were removed from the infested grains. Percent loss in grain weight in each treatment worked out by using following formula.

$$\text{Percent loss in grain weight} = \frac{\text{Initial weight of grains - Final weight of grains}}{\text{Total weight of grains}} \times 100$$

Plate 1: Maintenance of culture of *C. maculatus*

Plate 2: Experimental setup to record the movement of female *C. maculatus* in different treatments

Plate 3: Cereals and kabuli gram kept in layers in bottles to study effect on infestation and development of *C. maculatus*

3. Results and Discussion

The results of present laboratory studies are elaborated and discussed below under different headings.

3.1 Adult survival duration of *C. maculatus* in different treatments after introduction

All the treatments recorded comparatively shorter adult survival duration than control. Adult survival duration varied among different treatments from minimum 3 days to maximum 11 days. The range of adult survival duration was recorded lowest (3 to 5 days) in the treatments comprised of layers of nachni followed by treatments comprised of layers of bajara (5 to 7 days) and red rice (5 to 8 days). The treatments comprised of layers of maize and wheat recorded comparatively more range of adult survival duration *i.e.* 8 to 10 days and 7 to 9 days, respectively.

As regard average adult survival duration, the maximum average adult survival duration (10.2 days) was observed in control treatment while it was minimum (4.2 days) in treatment with 6 cm layer of nachani above Kabuli gram. In rest of the treatments average adult survival duration varied between 4.5 to 9.3 days. Thus, from the data it is obvious that different layers of cereals have significant effect on the adult survival duration of *C. maculatus*. The results obtained are coherence with Solanki and Mittal (2018) [15] who reported average adult survival 9.6 days on gram while Jaiswal *et al.* (2018) observed that it was ranged between 8-12 on same host. Similarly, Hosamani *et al.* (2018) [7] reported adult survival period 9 ± 0.38 days whereas, Sekender, *et al.* (2020) [13] reported it as of 8.2 ± 0.33 days in gram

Table 1: Adult survival duration of *C. maculatus* in different treatments after introduction

Sr.no	Treatments	Total no of adults observed	Adult survival duration (days)	
			Range	Average
1	Kabuli gram 2 cm layer + Red rice 6 cm layer	10	5-8	6.2
2	Kabuli gram 4 cm layer + Red rice 4 cm layer	10	5-8	6.5
3	Kabuli gram 2 cm layer + Nachni 6 cm layer	10	3-5	4.2
4	Kabuli gram 4 cm layer + Nachni 4 cm layer	10	3-5	4.5
5	Kabuli gram 2 cm layer + Wheat 6 cm layer	10	7-9	8.5
6	Kabuli gram 4 cm layer + Wheat 4 cm layer	10	7-9	8.2
7	Kabuli gram 2 cm layer + Bajara 6 cm layer	10	5-7	6.2
8	Kabuli gram 4 cm layer + Bajara 4 cm layer	10	5-7	6.5
9	Kabuli gram 2 cm layer + Maize 6 cm layer	10	8-10	9.3
10	Kabuli gram 4 cm layer + Maize 4 cm layer	10	8-10	9.1
11	Kabuli gram 8 cm layer	10	9-11	10.2

3.2 Movement of adult *C. maculatus* in different treatments at different interval of time.

Data on host searching ability of mated *C. maculatus* female recorded as distance (depth) probe by female through different layers of cereals place above the layer of Kabuli gram. Female *C. maculatus* failed to orient towards Kabuli gram grains if either 4 cm or 6 cm layers of nachni, red rice or bajra is put above the layer of Kabuli gram. Nachani was found to completely disorient female *C. maculatus* as upward movement of females towards the cotton plug were observed. In case of bajara some females observed to probe downward but failed to probe beyond 1 cm depth. In case of wheat female *C. maculatus* successfully probe through the layer and are observed at average depth of 1.5, 2.5, 4.0, 3.5, 2.0 and 3.0 cm at 2, 4, 6, 8, 10 and 12 hours after release in the treatment with 6 cm layer of wheat while at 1.0, 2.0, 3.0, 3.3, 2.0 and 3.0 cm depth at 2, 4, 6, 8, 10 and 12 hours after release in a treatment with 4 cm layer of wheat, respectively.

In case of maize female can able to probe even more depth and were observed at 0.0, 5.0, 3.5, 2.6, 6.5 and 5.5 cm distance in the treatment of 6 cm layer and at 4.0, 3.0, 3.5, 2.5, 4.0 and 3.3 cm depth in the treatment with 4 cm layer at 2, 4, 6, 8, 10 and 12 hours after release of females in the

treatment, respectively. In case of control females were observed at an average depth of 5.0, 6.0, 4.5, 6.5, 5.0 and 7.0 cm at 2, 4, 6, 8, 10 and 12 hours after release, respectively. These results can be supported by the observation mentioned in Vikaspedia (2016) [18] that the adult pulse beetles, being very weak and having a short life, cannot move in grain mass and are restricted to top 15 cm layer. Even the adults emerging out of the infected material cannot move in inter-granular space and could die before mating. They further reported that, movement of adult pulse beetle can be prevented by placing 7-10 cm layer of sand at the top of grain mass. Similarly, Sunitha *et al.* (2013) [16] reported effectiveness of 2.5 cm layer of sand above the grains of cowpea over other treatments including insecticidal seed treatment. Effectiveness of sand layer in preventing pulse beetle infestation was also reported by Gopal swamy *et al* (2018) [5]. This clearly indicates that inter-granular space has significant effect on the movement of *C. maculatus*. As grains of nachni, bajra and red rice are smaller than wheat, maize and gram the inter-granular spaces between these cereals is also less and this may be the reason we can say affect adversely the movement of *C. maculatus*

Table 2: Probing depth (cm) of *C. maculatus* female in different treatments at 2, 4, 6, 8, 10 and 12 hours after introduction (Average of five females)

Sr.no	Treatments	Probing depth of adult *C. maculatus* female (cm) at					
		2 hrs	4 hrs	6 hrs	8 hrs	10 hrs	12 hrs
1	Kabuli gram 2 cm layer + Red rice 6 cm layer	0	0	0	0	0	0
2	Kabuli gram 4 cm layer + Red rice 4 cm layer	0	0	0	0	0	0
3	Kabuli gram 2 cm layer + Nachni 6 cm layer	0	0	0	0	0	0
4	Kabuli gram 4 cm layer + Nachni 4 cm layer	0	0	0	0	0	0
5	Kabuli gram 2 cm layer + Wheat 6 cm layer	1.5	2.5	4	3.5	2	3
6	Kabuli gram 4 cm layer + Wheat 4 cm layer	1	2	3	3.3	2	3
7	Kabuli gram 2 cm layer + Bajara 6 cm layer	1	0	0	0	0	0
8	Kabuli gram 4 cm layer + Bajara 4 cm layer	0	1	0	0	0	0
9	Kabuli gram 2 cm layer + Maize 6 cm layer	0	5	3.5	2.6	6.5	5.5
10	Kabuli gram 4 cm layer + Maize 4 cm layer	4	3	3.5	2.5	4	3.3
11	Kabuli gram 8 cm layer	5	6	4.5	6.5	5	7

3.3 Numbers of eggs laid by *C. maculatus* per 100 grains of Kabuli gram in different treatments at 30, 60 and 90 days after storage.

The data on number of eggs laid by *C. maculatus* on Kabuli gram in different treatments clearly shows significant difference amongst treatments. No oviposition was recorded in the treatments comprised of either 6 cm or 4 cm layers of red rice, nachni and bajara at 30, 60 and 90 days after storage. Treatments comprised of 6 cm and 4 cm layer of wheat recorded 8.33, 16.00, 26.00 and 9.33, 19.00, 30.66 eggs per 100 grains of Kabuli gram respectively at 30, 60 and 90 days after storage respectively. Similarly, treatment with 6 cm and 4 cm layer of maize recorded 11.00, 19.33, 36.33 and 11.66, 20.00, 42.00 eggs per 100 grains of Kabuli grams respectively at 30, 60 and 90 days after storage respectively. However, control treatment recorded significantly highest number of eggs *i.e.* 30.66, 61.33 and 122.00 per 100 grains of kabuli gram respectively at 30, 60 and 90 days after storage. These results cannot be compared directly with earlier results due to lack of similar type of literature. However, observations reported in Vikaspedia, (2016) [18] gives some clue on this as they observed that when inert material is mixed with stored beans it inhibits sexually matured beetles to find mate and copulate as well laying eggs on seeds. In addition to this Caswell, (1956) studied bionomics of *Callasobruchus maculatus* and reported that the females lay on an average of 55 eggs and half of them being laid in first two days after emergence. Pandey and Singh (1997) reported maximum daily egg laying of *C. chinensis* in first 24 hours, the number gradually dropped till the last day of oviposition. Similarly, Rathi and Sashi (2008) reported that egg laying of *callosobruchus maculatus* gradually decreases with the increase in adult life up to 8-9 days. From these findings we can say that two factors *i.e.* inter-granular space between the grains and age of mated *C. maculatus* female have significant effect on egg laying. As the inter-granular spaces between the grains of Nachni, Bajara and Red rice are less, the females are not able to probe through these layers and as a result there is no egg laying on Kabuli gram which were placed below the layers of these cereals. However, treatments comprised of layer of wheat and maize grains had somewhat more inter-granular spaces that facilitate female to probe downward through these layers but take some time and hence laid somewhat less eggs on Kabuli gram than control.

3.4 Numbers of grains damaged by *C. maculatus* per 100 grains of Kabuli gram in different treatments at 30, 60 and 90 days after storage

The data on numbers of grains damaged by *C. maculatus* per 100 grains of kabuli gram in different treatments at 30, 60 and 90 days after inculation, There were significant differences amongst the treatments in respect of number of damaged Kabuli gram grains. At 30, 60 and 90 days after storage, no damaged Kabuli gram grains were recorded in the treatments comprised of either 6 cm or 4 cm layer of red rice, nachni or bajra. Treatment comprised of 6 cm layer of wheat recorded 8.66, 15.33 and 25.66 damaged kabuli gram grains per 100 grains, respectively at 30, 60 and 90 days after storage while treatment comprised of 4 cm layer of wheat recorded 9.00, 19.33 and 29.66 damaged Kabuli gram grains at 30, 60 and 90 days after storage, respectively. Whereas, treatment with 6 cm layer of maize and 4 cm layer of maize recorded 10.33, 19.00 and 36.33 and 11.66, 19.66 and 42.00 damaged Kabuli gram grains at 30, 60 and 90 days after storage, respectively. However, highest damaged Kabuli gram grains were recorded in control *i.e.* 29.33, 60.33 and 86.33 per 100 grains of Kabuli gram at 30, 60 and 90 days after storage respectively. Thus it is very obvious that, treatments comprised of either 4 cm or 6 cm layers of red rice, nachni or bajra were effective in controlling *C. maculatus* damage than the treatments comprised layers of wheat or maize. These observations can be compared with that of Sunitha *et al.* 2013 [16] who reported only 10 percent seed damage in cow pea seeds after six months storage when they were stored below the 2.5 cm layer of sand. Similarly, Gopala Swamy *et al.* (2018) [5] also

reported zero percent damage in green gram, black gram seeds and only 0.11 percent grain damage in pigeon pea seed at 3 months after storage when these seeds were stored under 3 cm layer of sand. Venkatesham *et al.* (2015) [17] reported the mean seed damage in gram up to 7.87 percent at 30 days after release of *Callosobruchus chinensis* which increased with the storage duration resulting in 99.33 after 120 days.

3.5 Total number of adult *C. maculatus* emerged in different treatments at 30, 60 and 90 days after storage

The data on total number of adult *C. maculatus* emerged in different treatments at 30, 60 and 90 days after storage showed that. No adult emergence was recorded at any storage intervals in the treatments comprised of either 4 cm or 6 cm layer of red rice, nachni or bajara. However, treatments comprised of 4 cm or 6 cm layers of either wheat or maize recorded some adult emergence at 30, 60 and 90 days after storage which were significantly less than control. Treatment with 6 cm layer of wheat recorded 12.74, 24.48 and 39.78 adults while treatment with 4 cm layer of wheat recoded 29.48, 60.04 and 96.88 adults at 30, 60 and 90 days after storage, respectively. In case of maize, treatment with 6 cm layer recorded 17.93, 60.04 and 96.88 adults while that with 4 cm layer recorded 36.37, 62.4 and 131.04 adults at 30, 60 and 90 days after storage, respectively. In control, 221.24, 340.00 and 620.00 adults were recorded at 30, 60 and 90 days after storage, respectively. These results cannot be compared with earlier result due to lack of literature. However, results of adult emergence in control treatment can be compare with the findings of Das *et al*. (2002) [4] who recorded maximum adult emergence (257) from Kabuli gram. Similarly, Sekender, *et al.* (2020) [13] also reported maximum adult emergence of *C. chinensis* from gram (65.2 ± 7.58).

3.6 Percent weight loss in different treatments at 30, 60 and 90 days after storage.

The data on percent weight loss in different treatments at 30, 60 and 90 days after storage is presented in Table 4 and depicted in fig 1. All the treatments were found effective in reducing weight loss due to *C. maculatus* than control. The treatments comprised of 4 cm or 6 cm layer of red rice, nachni or bajara recorded no weight loss at 30, 60 and 90 days after storage. The treatment comprised of 6 cm and 4 cm layer of wheat recoded 14.40, 25.50, 42.70 and 14.90, 32.3, 49.4 percent weight loss at 30, 60 and 90 days after storage, respectively. Whereas, treatment with 6 cm and 4 cm layer of maize recoded 17.20, 31.20, 66.20 and 19.40, 32.70, 69.80 percent weight loss at 30, 60 and 90 days after storage, respectively. Significantly highest weight loss was observed in control i.e., 59.90, 75.00 and 80.10 percent at 30, 60 and 90 days after storage, respectively. The findings are in conformity with Venkatesham, *et al.* (2015) [17] who reported weight loss in chickpea due to pulse beetle *Callosobruchus chinensis* up to 4.19 percent at 30 days after release of beetle which increased with the storage duration and reach to 48.73 percent after 120 days. Present finding can also be compared with Pradhan (2018) who reported mean percent weight loss due to pulse beetle between 37.99 to 64.00 percent in different chickpea genotype.

Table 3: Effect of different treatments on egg laying, grain damage and adult emergence at 30, 60 and 90 days after introduction

Sr.no	Treatments	Numbers of eggs laid per 100 grains of kabuli gram at			Numbers of grain damaged by per 100 grains of kabuli gram at			Total number of adult emerged in different treatments at		
		30 Days	60 Days	90 Days	30 Days	60 Days	90 Days	30 Days	60 Days	90 Days
1	Kabuli gram 2 cm layer + Red rice 6 cm layer	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 (0.71)*	0.00 (0.71)	0.00 (0.71)
2	Kabuli gram 4 cm layer + Red rice 4 cm layer	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 (0.71)	0.00 (0.71)	0.00 (0.71)
3	Kabuli gram 2 cm layer + Nachni 6 cm layer	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 (0.71)	0.00 (0.71)	0.00 (0.71)
4	Kabuli gram 4 cm layer + Nachni 4 cm layer	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 (0.71)	0.00 (0.71)	0.00 (0.71)
5	Kabuli gram 2 cm layer + wheat 6 cm layer	8.33 (2.97)	16.00 (4.05)	26.00 (5.14)	8.66 (3.02)	15.33 (3.97)	25.66 (5.09)	12.74 (3.56)	24.48 (4.94)	39.78 (6.30)
6	Kabuli gram 4 cm layer + wheat 4 cm layer	9.33 (3.13)	19.00 (4.39)	30.66 (5.58)	9.00 (3.08)	19.33 (4.39)	29.66 (5.48)	29.48 (5.42)	60.04 (7.74)	96.88 (9.84)
7	Kabuli gram 2 cm layer + Bajara 6 cm layer	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 (0.71)	0.00 (0.71)	0.00 (0.71)
8	Kabuli gram 4 cm layer + Bajara 4 cm layer	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 (0.71)	0.00 (0.71)	0.00 (0.71)
9	Kabuli gram 2 cm layer + Maize 6 cm layer	11.00 (3.39)	19.33 (4.45)	36.33 (6.06)	10.33 (3.28)	19.00 (4.40)	36.33 (6.06)	17.93 (4.23)	31.50 (5.61)	59.21 (7.69)
10	Kabuli gram 4 cm layer + Maize 4 cm layer	11.66 (3.48)	20.00 (4.53)	42.00 (6.52)	11.66 (3.49)	19.66 (4.48)	42.00 (6.52)	36.37 (6.03)	62.4 (7.89)	131.04 (11.44)
11	Kabuli gram 8 cm layer	30.66 (5.55)	61.33 (7.86)	122.00 (11.06)	29.33 (5.46)	60.33 (7.8)	86.33 (9.37)	211.24 (14.53)	340 (18.43)	620 (24.89)
Mean		6.45 (2.07)	12.33 (2.68)	23.39 (3.51)	6.26 (2.05)	12.15 (2.66)	20.08 (3.34)	27.97 (3.45)	47.12 (4.44)	86.08 (5.85)
S.Em. ±		0.05	0.10	0.08	0.06	0.18	0.11	1.78	2.30	3.10
C.D at 5%		0.17	0.31	0.24	0.19	0.54	0.34	5.21	6.74	9.09

*Figures in parenthesis are √n+0.5 transformed values

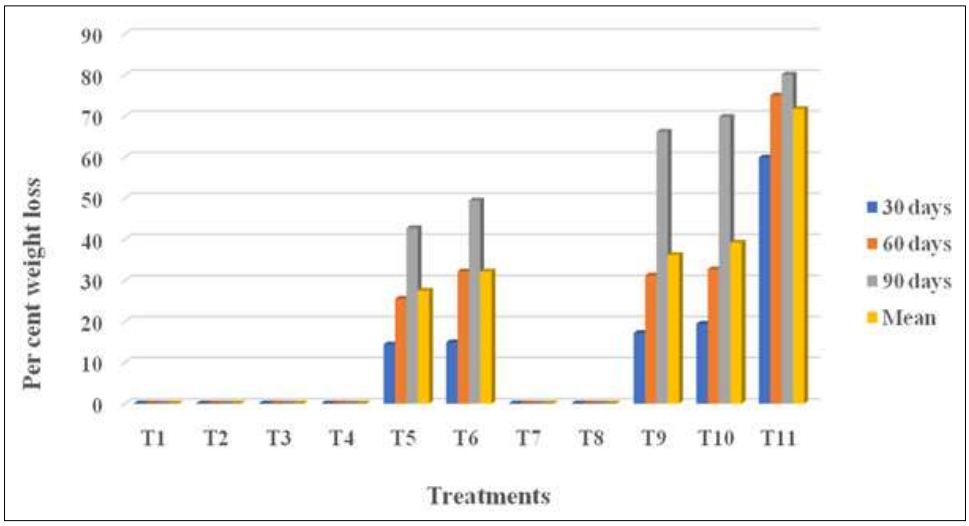

Fig 1: Percent weight loss in different treatments at 30, 60 and 90 days after storage

4. Conclusion

The considerable differences in the adult survival duration, probing depth, egg laying, grain damage, adult emergence, and weight loss of *C. maculatus* were noticed during the present study which possibly may be due to non preference of *C. maculatus* to cereals and the size of pore spaces present between grain of cereals. The minimum adult survival duration, probing depth, egg laying, grain damage, adult emergence and weight were observed in treatments layered with nachani, bajara, red rice as compared to treatments layered with maize and wheat.

5. Acknowledgement

Authors are thankful to Department of Agricultural Entomology, College of Agriculture, Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli-415712, dist- Ratnagiri, Maharashtra (India), to provide necessary facility and valuable suggestion during investigation.

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