

RESEARCH ARTICLE

Evaluation of botanicals for management of pulse beetle, *Callosobruchus maculatus* in stored green gram

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ABSTRACT

Different plant powders and plant oils were evaluated for their grain protectant efficacy against *C. maculatus* in green gram (variety GM-4). Custard apple seed powder (25g /kg seed), orange peel powder (150g/kg seed), coconut oil (10 ml/kg seed) and clove oil (10 ml/kg seed) completely prevented oviposition, adult emergence and grain damage on number and weight base even after four months of storage and found most effective grain protectants, while clove flower bud powder (10 flower buds powder/kg seed) and red chilli fruit powder (5 g / kg seed) allowed cent per cent damage due to high oviposition and adult emergence after four months of storage and found ineffective as grain protectants, but significantly less than neem seed kernel powder, neem leaf powder (both, 25 g/kg seed), chrysanthemum flower powder and pomegranate peel powder (both, 25 g/kg seed) which were found least effective grain protectants against *C. maculatus*. Groundnut oil, olive oil and safflower oil (all at 10 ml/kg seed) were also found effective grain protectants. Rest of the treatments viz., neem seed kernel powder, neem leaf powder (both, 25g/ kg seed), chrysanthemum flower powder and pomegranate peel powder (both, 25g/ kg seed) which were found least effective grain protectants against *C. maculatus*.

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INTRODUCTION

Green gram [*Vigna radiata* (L.) Wilczek] is the third most popular pulse crop cultivated throughout India. In India green gram is grown on about 3.55 million ha with production and yield as 1.80 m tones and 512 kg/ha, respectively. It is grown mainly in Rajasthan, Maharashtra, Andhra Pradesh, Karnataka and Orissa (Anonymous, 2012). In India, most of the grains produced are being stored at the farmer's place and under most primitive conditions of storage they become vulnerable to a variety of insect pests. Out of these, the major one is the pulse beetle of the family *Bruchidae* belonging to genus *Callosobruchus*. It is an interesting worldwide group, most abundant in tropics, whose larvae develop inside the seeds and mostly prefer the hosts belong to the family Leguminosae. Banto and Sanchez (1972) reported that when green gram

seeds with 9.9 per cent seed infestation by *C. chinensis* stored for three months, it resulted into total destruction of seeds showing the importance of this storage pest. The pulse beetle being an internal feeder is hard to control with insecticides. It is also not advisable to mix insecticides with food grains. Fumigation being the most effective method cannot be inside the residential areas.

Plant materials which are being traditionally used by some farmers practiced in our villages because the storage structures are not air tight and are mostly built are quite safe and appear to be the most promising as grain protectants. The potential hazards for mammals from synthetic insecticides, the ecological consequences and the increase of insect resistance to pesticides had led to a search for new classes of insecticides with lower mammalian toxicity and a lower persistence in the environment (Regnault-Roger and Hamraoui, 1993). Keeping

Sr.No.	Name of botanicals	Scientific name	Part used	Doses
1.	Neem	<i>Azadirachtaindica</i> A.Juss	Dried leaf powder	25g/kg seed
2.	Neem	<i>Azadirachtaindica</i> A. Juss	Seed kernal powder	25g/kg seed
3.	Custard apple	<i>Annona squamosa</i> Linn.	Seeds powder	25g/kg seed
4.	Red chilli	<i>Capsicum annum</i> Linn.	Five fruit powder	5g/ kg seed
5.	Orange	<i>Citrus sinensis</i> (Linn.) Osbeck	Dried peel powder	150g/kg seed
6.	Chrysanthemum	<i>Chrysanthemum cinerarifolium</i> Linn.	Dried flower powder	150g/kg seed
7.	Pomegranate	<i>Punica granatum</i> Linn.	Dried peel powder	150g/kg seed
8.	Coconut	<i>Cocos nucifera</i> Linn.	Oil	10ml/kg seed
9.	Groundnut	<i>Arachis hypogaea</i> Linn.	Oil	10ml/kg seed
10.	Olive	<i>Oleo europaea</i> Linn.	Oil	10ml/kg seed
11.	Clove	<i>Cinnamomum verum</i> J. Presl	Ten flower buds powder	0.50g/kg seed
12.	Safflower	<i>Carthamus tinctorius</i> Linn.	Oil	10 ml/kg seed
13.	Clove	<i>Cinnamomum verum</i> J. Presl	Oil	10 ml/kg seed
14.	Control (untreated)	-	-	-

these views in mind, the present experiment was designed to investigate the insecticidal potency of some botanicals against the pulse beetle on green gram seeds.

MATERIALS AND METHODS

Pulse beetle were reared on variety GM-4 in 1 kg plastic bottle covered with two folds of muslin cloth tightened with rubber band. Thirteen treatments were used for the present investigation at doses described:

Entire experiment was carried out in BOD incubator (27±0.5°C, 60-65% RH). Seeds that were used in the experiment were sun dried to kill any prior infestation, if present. Two hundred seeds were taken in a plastic container and were assigned as one replication. Seeds were treated according to the doses mentioned above and five pair of freshly emerged adults were released in each treatment. Each treatment was replicated thrice. Plastic container was covered with two fold of muslin cloth. A control set was also taken for comparison. The adult beetle pairs were removed after seven days and observations as mentioned below made by taking were taken from two hundred seeds from each repetition.

Observations recorded :

- Number of eggs laid after 30, 60, 90 and 120 days
- Number of adult emerged after 30, 60, 90 and 120 days from each repetition
- Per cent seed damage was calculated in two ways:

On number base :

Two hundred seeds were taken at random and infested seeds were counted after every 30, 60, 90 and 120 days and it was converted to percentage.

$$\text{Per cent damage grain} = \frac{\text{Number of infested seeds from 200 seeds taken}}{\text{Total number of seeds taken(200 seeds)}} \times 100$$

On weight base :

Sample of two hundred seeds were taken at random and it was weighed after every 30, 60, 90 and 120 days and the weight loss was compared with the non- infested seeds.

$$\text{Weight loss (\%)} = \frac{\text{Number of healthy seeds - weight of infested seeds}}{\text{Weight of non - infested seeds}} \times 100$$

RESULTS AND DISCUSSION

The results of the present study as well as relevant discussions have been presented under following sub heads:

Number of eggs on grains :

The data on number of eggs/100 grains laid by *C. maculatus* after 7, 30, 60, 90 and 120 days in different treatments (Table 1) revealed significant effectiveness of all the botanicals tested. Custard apple seed powder, orange peel powder, coconut oil and clove oil prevented oviposition even after four months of storage. Other treatments which showed significantly least oviposition after 7, 30, 60, 90 and 120 days were safflower oil (2.00, 3.67, 9.67, 15.00 and 19.67 eggs, respectively), olive oil (4.67, 11.00, 14.67, 23.33 and 35.33 eggs, respectively), groundnut oil (4.00, 13.67, 22.67, 31.00 and 36.33 eggs, respectively) and neem seed kernel (4.00, 11.67, 16.00, 27.33 and 52.33 eggs, respectively). Whereas, significantly least effective treatments were red chilli fruit powder showing

higher oviposition (15.00, 71.00, 87.67, 175.00 and 184.00 eggs, respectively) and clove flower bud powder (16.00, 56.67, 82.67, 156.00 and 177.67 eggs, respectively). Ali *et al.*, (1983) reported that coconut oil (1.00%) prevented oviposition of *C. chinensis* in green gram. Juneja and Patel (1994) observed that the seed powder of custard apple and peel of orange both at 5 parts per 100 parts (w/w) of green gram completely prevented the females of *C. analis* from laying eggs until 60 days after treatment. The oils get absorbed and they enter the egg through its micropyle which ultimately coagulates the protoplasm consequently causing mortality in eggs as reported by Sharma and Srivastava (1984).

Adult emergence :

The result on number of adults emerged after 30, 60, 90 and 120 days (Table 2A and 2B) indicated that not a single adult of pulse beetle emerged from grains mixed with custard apple seed powder, orange peel powder, coconut oil and clove oil which were significantly superior to other botanicals. After 30, 60, 90 and 120 days of treatment significantly less adult emergence was observed in safflower oil (5.67, 11.67, 18.33 and 25.67 beetles, respectively), groundnut oil (5.00, 15.00, 29.67, 42.67 beetles, respectively) and olive oil (10.00, 22.67, 26.33 and 31.67 beetles, respectively). Significantly maximum adult emergence was noticed in clove flower bud powder (128.33, 855.00, 1366.67 and 1503.33 beetles, respectively) and

red chilli fruit powder (126.67, 850.67, 1375.33 and 1502.00 beetles, respectively) after 30, 60, 90 and 120 days, respectively).

From the above results it can be concluded that clove oil, coconut oil, custard apple seed powder and orange peel powder gave complete protection against *C. maculatus* even after four months of storage. This may be probably due to the very fact that custard apple seeds contain an active ingredient anonaine which is an alkaloid and act as a contact and stomach poison. Similarly, clove oil has eugenol, isoeugenol and methyl eugenol as active ingredient (contact and fumigant action of toxicity) which were probably responsible for the protection (Anonymous, 2008) whereas, olive oil has oleic acid which has probably the insect deterrent property. Chrysanthemum flower powder contains natural pyrethrin which has contact toxic action against insects (Mulungu *et al.*, 2011). Orange peel contains pinene and limonene which has insecticidal deterrent action. Orange peel powder is quite abrasive due to its silica or silica like component (Dawit and Bekelle, 2010).

Per cent damaged grains :

On number base and weight base :

After four months of storage, no damaged grains and weight loss (Table 3 A and B) were observed in treatments of custard apple seed powder, orange peel powder, coconut oil and clove oil. After 1, 2, 3 and 4 months of storage, significantly

Table 1: Oviposition of <i>C. maculatus</i> on green gram treated with various grain protectants						
Sr. No.	Treatments	No. of eggs laid / 100 grains after indicated days of storage				
		7 days	30 days	60 days	90 days	120 days
1.	Custard apple seed powder @ 2.5 % (w/w)	0.70* (0.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)
2.	Neem seed kernel powder @ 2.5 % (w/w)	2.10 (4.00)	3.48 (11.67)	4.05 (16.00)	5.27 (27.33)	7.26 (52.33)
3.	Orange peel powder @ 15 % (w/w)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)
4.	Neem leaf powder @ 2.5 % (w/w)	2.91 (8.00)	4.80 (22.67)	7.56 (56.67)	8.51 (72.00)	9.56 (91.00)
5.	Chrysanthemum flower powder 15 % (w/w)	3.23 (10.00)	5.14 (26.00)	6.20 (38.00)	7.35 (53.67)	8.21 (67.00)
6.	Pomegranate peel powder 15 % (w/w)	3.80 (14.00)	5.63 (31.33)	6.79 (45.67)	8.19 (66.67)	8.68 (75.00)
7.	Red chilli (5 g/kg seeds)	3.93 (15.00)	8.45 (71.00)	9.38 (87.67)	13.24 (175.00)	13.58 (184.00)
8.	Clove flower bud (0.5g/ kg seeds)	4.06 (16.00)	7.56 (56.67)	9.11 (82.67)	12.50 (156.0)	13.34 (177.67)
9.	Coconut oil @ 1% (v/w)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)
10.	Groundnut oil @ 1% (v/w)	2.11 (4.00)	3.75 (13.67)	4.81 (22.67)	5.60 (31.00)	6.06 (36.33)
11.	Olive oil @ 1% (v/w)	2.25 (4.67)	3.38 (11.00)	3.87 (14.67)	4.87 (23.33)	5.98 (35.33)
12.	Clove oil @ 1% (v/w)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)
13.	Safflower oil @ 1% (v/w)	1.55 (2.00)	2.02 (3.67)	3.18 (9.67)	3.91 (15.00)	4.48 (19.67)
14.	Control (untreated)	5.82 (30.67)	10.68 (113.67)	12.53 (156.67)	14.01 (196.00)	14.28 (203.67)
	S.E.±	0.10	0.13	0.10	0.12	0.07
	C.D. at 5 %	0.29	0.37	0.30	0.35	0.21
	C.V. %	7.24	5.45	3.67	3.39	1.93

*Figures outside the parentheses are $\sqrt{x+0.5}$ values and those inside are retransformed values

Table 2 (A) : Adult emergence of *C. maculatus* in green gram seeds treated with various grain protectants

Sr. No.	Treatments	No. of adult emerged					
		After one month			After two months		
		Live	Dead	Total	Live	Dead	Total
1.	Custard apple seed powder @ 2.5 % (W/W)	0.70* (0.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	0.70(0.00)
2.	Neem seed kernel powder @ 2.5 % (W/W)	2.73 (7.00)	4.56 (20.33)	5.27 (27.33)	3.23 (10.00)	6.84(46.33)	7.53 (56.33)
3.	Orange peel powder @ 15 % (w/w)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)
4.	Neem leaf powder @ 2.5 % (W/W)	3.89 (14.67)	4.90 (23.67)	6.22 (38.33)	4.88 (23.33)	24.93 (621.00)	25.39 (644.33)
5.	Chrysanthemum flower powder 15 % (w/w)	4.29 (18.00)	6.86 (46.67)	8.07 (64.67)	7.44 (55.00)	24.40(596.00)	25.50 (651.00)
6.	Pomegranate peel powder 15 % (w/w)	5.66 (31.67)	8.57 (73.00)	10.22 (104.67)	10.44 (108.67)	25.05(627.33)	27.13 (736.00)
7.	Red chilli (5g/ kg seeds)	6.49 (41.67)	9.24 (85.00)	11.27 (126.67)	11.14 (123.67)	26.97(727.00)	29.17 (850.67)
8.	Clove flower bud (0.5g/ kg seeds)	6.62 (43.33)	9.22 (84.67)	11.33 (128.00)	11.02 (121.0)	27.10(734.00)	29.30 (855.00)
9.	Coconut oil @ 1% (v/w)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)
10.	Groundnut oil @ 1% (v/w)	1.46 (1.67)	1.95 (3.33)	2.33 (5.00)	2.11(4.00)	3.38 (11.00)	3.93 (15.00)
11.	Olive oil @ 1% (v/w)	1.55 (2.00)	2.91 (8.00)	3.23 (10.00)	2.02 (3.67)	4.41 (19.00)	4.80 (22.67)
12.	Clove oil @ 1% (v/w)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)
13.	Safflower oil @ 1% (v/w)	1.17 (1.00)	2.25 (4.67)	2.44 (5.67)	1.95 (3.33)	2.96 (8.33)	3.48 (11.67)
14.	Control (untreated)	6.49 (41.67)	9.35 (87.00)	11.36 (128.67)	11.15 (124.00)	27.22(740.67)	29.36 (864.67)
	S.E.±	0.12	0.10	0.11	0.09	0.21	0.20
	C.D. at 5 %	0.34	0.31	0.32	0.26	0.62	0.60
	C.V. %	6.73	4.17	3.68	3.21	2.95	2.70

*Figures outside the parentheses are $\sqrt{x+0.5}$ values and those inside are retransformed values

Table 2 (B) : Adult emergence of *C. maculatus* in green gram treated with various grain protectants

Sr. No.	Treatments	No. of adult emerged					
		After three months			After four months		
		Live	Dead	Total	Live	Dead	Total
1.	Custard apple seed powder @ 2.5 % (w/w)	0.70* (0.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)
2.	Neem seed kernel powder @ 2.5 % (w/w)	4.74 (22.00)	21.46 (460.33)	21.97 (482.33)	0.72 (51.67)	28.55 (814.67)	29.44 (866.33)
3.	Orange peel powder @ 15 % (w/w)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)
4.	Neem leaf powder @ 2.5 % (w/w)	3.48 (11.67)	35.58(1266.00)	35.75 (1277.67)	9.29 (86.00)	37.63(1411.33)	38.70(1497.33)
5.	Chrysanthemum flower powder 15 % (w/w)	9.85 (96.67)	30.29 (917.33)	31.85 (1014.00)	9.87 (97.00)	34.98(1223.33)	36.34(1320.33)
6.	Pomegranate peel powder 15 % (w/w)	9.77 (95.00)	33.05(1092.33)	34.46 (1187.33)	8.57 (73.00)	36.47(1330.00)	37.463(1403.00)
7.	Red chilli (5g/ kg seeds)	10.63(112.67)	35.49(1259.67)	37.09 (1375.33)	9.31 (86.33)	37.63(1415.67)	38.76(1502.00)
8.	Clove flower bud (0.5g/ kg seeds)	9.84 (96.33)	35.64(1270.33)	36.97 (1366.67)	9.15 (83.33)	37.68(1420.00)	38.77(1503.33)
9.	Coconut oil @ 1% (v/w)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)
10.	Groundnut oil @ 1% (v/w)	2.18 (4.33)	5.07 (25.33)	5.49 (29.67)	2.72 (0.00)	6.01 (35.67)	6.56 (42.67)
11.	Olive oil @ 1% (v/w)	2.31 (5.00)	4.67 (21.33)	5.17 (26.33)	2.60 (6.33)	5.07 (25.33)	5.66 (31.67)
12.	Clove oil @ 1% (v/w)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)	0.70 (0.00)
13.	Safflower oil @ 1% (v/w)	2.25 (4.67)	3.74 (13.67)	4.31 (18.33)	2.84 (7.67)	4.29 (18.00)	5.11 (25.67)
14.	Control (untreated)	10.59(111.67)	35.58(1266.00)	37.12 (1377.67)	4.51 (20.00)	40.53(1643.00)	40.78(1663.00)
	S.E.±	0.11	0.10	0.10	0.11	0.07	0.08
	C.D. at 5 %	0.33	0.29	0.30	0.33	0.21	0.24
	C.V. %	4.06	1.00	0.99	4.01	0.66	0.73

*Figures outside the parentheses are $\sqrt{x+0.5}$ values and those inside are retransformed values

Table 3 (A) : Damage (number base) by *C. maculatus* to green gram seeds

Sr. No.	Treatments	Per cent grain damage after months indicated			
		1 month	2 months	3 months	4 months
1.	Custard apple seed powder @ 2.5 % (w/w)	4.05* (0.00)	4.05 (0.00)	4.05 (0.00)	4.05 (0.00)
2.	Neem seed kernel powder @ 2.5 % (w/w)	8.77 (1.83)	11.26 (3.33)	23.16 (15.00)	37.94 (37.33)
3.	Orange peel powder @ 15 % (w/w)	4.05 (0.00)	4.05 (0.00)	4.05 (0.00)	4.05 (0.00)
4.	Neem leaf powder @ 2.5 % (w/w)	7.76 (1.33)	25.58 (18.16)	45.93 (51.16)	75.38 (93.00)
5.	Chrysanthemum flower powder 15 % (w/w)	14.73 (6.00)	24.71 (17.00)	41.24 (43.00)	61.43 (76.67)
6.	Pomegranate peel powder 15 % (w/w)	18.09 (9.16)	27.95 (21.50)	41.24 (43.00)	69.87 (87.67)
7.	Red chilli (5g/kg seeds)	20.54 (11.83)	40.08 (41.00)	52.12 (61.83)	88.15 (100)
8.	Clove flower bud (0.5g/ kg seeds)	19.50 (10.67)	40.28 (41.33)	52.51 (62.50)	88.15 (100)
9.	Coconut oil @ 1% (v/w)	4.05 (0.00)	4.05 (0.00)	4.05 (0.00)	4.05 (0.00)
10.	Groundnut oil @ 1% (v/w)	6.16 (0.67)	10.70 (3.00)	14.35 (5.67)	18.09 (9.16)
11.	Olive oil @ 1% (v/w)	7.39 (1.16)	9.33 (2.16)	11.24 (3.33)	16.92 (8.00)
12.	Clove oil @ 1% (v/w)	4.05 (0.00)	4.05 (0.00)	4.05 (0.00)	4.05 (0.00)
13.	Safflower oil @ 1% (v/w)	6.60 (0.83)	10.21 (2.67)	13.74 (5.16)	16.23 (7.33)
14.	Control (untreated)	24.32 (16.50)	40.86 (42.33)	64.63 (81.16)	88.15 (100)
	S.E.±	0.40	0.47	0.41	0.58
	C.D. at 5 %	1.17	1.36	1.19	1.69
	C.V. %	6.57	4.46	2.66	2.47

*Figures outside parentheses are arcsin transformed values and those inside are retransformed values

Table 3 (B) : Damage (Weight base) by *C. maculatus* to green gram seeds

Sr. No.	Treatments	Per cent weight loss after months indicated			
		1 month	2 months	3 months	4 months
1.	Custard apple seed powder @ 2.5 % (w/w)	4.05* (0.00)	4.05 (0.00)	4.05 (0.00)	4.05 (0.00)
2.	Neem seed kernel powder @ 2.5 % (w/w)	5.93 (0.57)	8.60 (1.75)	16.79 (8.01)	28.57 (22.44)
3.	Orange peel powder @ 15 % (w/w)	4.05 (0.00)	4.05 (0.00)	4.05 (0.00)	4.05 (0.00)
4.	Neem leaf powder @ 2.5 % (w/w)	6.99 (0.99)	20.43 (11.69)	35.32 (32.95)	51.36 (60.54)
5.	Chrysanthemum flower powder 15 % (w/w)	12.03 (3.86)	19.76 (10.94)	32.05 (27.69)	45.27 (50.01)
6.	Pomegranate peel powder 15 % (w/w)	13.77 (5.19)	22.24 (13.84)	32.05 (27.69)	49.00 (56.50)
7.	Red chilli (5 g/kg seeds)	15.32 (6.51)	28.85 (22.97)	39.65 (40.25)	53.66 (64.42)
8.	Clove flower bud (0.5g/ kg seeds)	16.54 (7.62)	31.24 (26.42)	39.21 (39.50)	53.66 (64.43)
9.	Coconut oil @ 1% (v/w)	4.05 (0.00)	4.05 (0.00)	4.05 (0.00)	4.05 (0.00)
10.	Groundnut oil @ 1% (v/w)	5.50 (0.42)	9.79 (2.40)	11.73 (3.64)	14.68 (5.93)
11.	Olive oil @ 1% (v/w)	6.36 (0.73)	8.16 (1.52)	9.24 (2.10)	13.94 (5.32)
12.	Clove oil @ 1% (v/w)	4.05 (0.00)	4.05 (0.00)	4.05 (0.00)	4.05 (0.00)
13.	Safflower oil @ 1% (v/w)	6.94 (0.96)	9.37 (2.16)	11.26 (3.32)	13.19 (4.72)
14.	Control (Untreated)	19.65 (10.84)	31.62 (27.00)	45.72 (50.80)	54.23 (65.37)
	S.E.±	0.37	0.67	0.60	0.42
	C.D. at 5 %	1.09	1.95	1.75	1.22
	C.V. %	7.33	7.93	5.09	2.60

*Figures outside parentheses are arcsin transformed values, those inside are retransformed values

highest per cent grain damage was observed in red chilli fruit powder (11.83, 41.00, 61.83 and 100 per cent, respectively) and clove flower bud powder (10.67, 41.33, 62.50 and 100 per cent, respectively). Significantly highest weight loss was after 1, 2, 3 and 4 months of storage was observed in red chilli fruit powder (6.51, 22.97, 40.25 and 64.42 per cent, respectively) and clove flower bud powder (7.62, 26.42, 39.50 and 64.43 per cent, respectively). Whereas, significantly minimum weight loss was observed in safflower oil (0.96, 2.16, 3.32 and 4.72 per cent, respectively), olive oil (0.73, 1.52, 2.10 and 5.32 per cent, respectively) and groundnut oil (0.42, 2.40, 3.64 and 5.93 per cent, respectively).

Over all, custard apple seed powder, orange peel powder, coconut oil and clove oil were most effective; groundnut oil, olive oil and safflower oil as least as intermediate; neem seed kernel powder, chrysanthemum flower powder and pomegranate seed powder as least effective; while clove flower bud powder and red chilli fruit powder as ineffective grain protectants against *C. maculatus*.

REFERENCES

- Ali, S.I., Singh, O.P. and Misra, U.S. (1983).** Effectiveness of plant oils against pulse beetle, *Callosobruchus chinensis* (L.). *Indian J. Entomol.*, **45** (1):6-9.
- Anonymous (2008).** Marin municipal water district vegetation management plan, District vegetation management plan, Herbicide Risk Assessment draft, 18pp.
- Anonymous (2012).** AICRP on MULLaRP, Project Coordinator's Report. 16pp.
- Banto, S.M. and Sanchez, F.F. (1972).** The biology and chemical control *Callosobruchus chinensis* (L.) (Coleoptera: Bruchidae). *Philippine Entomologist*, **2**:167-182.
- Dawit, K.Z. and Bekelle, J. (2010).** Evaluation of orange peel *citrus sinensis* (L.) as a source of repellent, toxicant and protectant against *Zabrotessubfasciatus* (Coleoptera: Bruchidae). *Momona Ethiopian J.Sci.*, **2**(1): 61-75.
- Juneja, R.P. and Patel, J.R. (1994).** Botanical materials as protectant of green gram, [*Vigna radiata* (L.) Wilczek] against pulse beetle, *Callosobruchus analis*. *Gujarat Agric. Univ. Res. J.*, **20** (1): 84-87.
- Mulungu, L.S., Ndilahomba, B., Nyange, C.J., Mwatawala, M.W., Mwalilino, J.K., Joseph, C.C. and Mgina, C.A. (2011).** Efficacy of *Chrysanthemum cinerariaefolium*, *Neorautaneniemitis* and *Gnidiakraussiana* against larger grain borer (*Prostephanus truncatus* Horn) and maize weevil (*Sitophilus Zeamay* Motschulsky) on maize (*Zea mays* L.) grain seeds (*Sitophiluszeamay* Motschulsky) on maize (*Zea mays* L.) grain seeds. *J.Entomol.*, **8**: 81-87.
- Regnault-Roger, C. and Hamraoui, A. (1993).** Efficiency of plants from the south of France used as traditional protectants of *Phaseolus vulgaris* L. against bruchid *Acanthocelidesobtectus* (Say). *J. Stored Products.Res.*, **29**: 259-264.
- Sharma, A.K. and Srivastava, R.C. (1984).** Effect of groundnut oil on the embryonic development of *Callosobruchus chinensis* L. *Bull. Grain Technol.*, **22**:221-224.
