INTERNATIONAL JOURNAL OF PLANT PROTECTION
VOLUME 10 | ISSUE 2 | OCTOBER, 2017 | 303-310

● e ISSN-0976-6855 | Visit us : *www.researchjournal.co.in*

IJPP

RESEARCH PAPER

DOI : 10.15740/HAS/IJPP/10.2/303-310

Efficacy of various seed protectants against *Callosobruchus chinensis* (L.) on cowpea (*Vigna unguiculata* L.) under storage condition

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ARITCLE INFO

Received : 10.04.2017
Revised : 15.08.2017
Accepted : 27.08.2017

KEY WORDS :
Plant oils, Botanical leaf powders, Insecticides, Seed protectants, Cowpea, *Callosobruchus chinensis* Linnaeus

ABSTRACT

Investigations were carried out at Department of Entomology, B. A. College Agriculture, Anand Agricultural University, Anand, Gujarat (India) during 2011-12 for the evaluation of plant oils, botanical leaf powders as well as synthetic insecticides as seed protectants against *Callosobruchus chinensis* Linnaeus on stored cowpea. Cowpea seeds treated with castor, *Neem* and pongam oil @ 1% (v/w) recorded significantly higher adult mortality (≥57%) of *C. chinensis* during storage period of 6 months with higher half-life values (about 2.5 months), higher gross persistency (4707 to 3597), lower population growth (3.87 to 5.36 adult emergence) and lower per cent loss in germination (19.45 to 22.36%). Among the various leaf powders; *Neem*, eucalyptus and *Tulsi* @ 2% recorded higher per cent adult mortality (> 43%), higher half-life (about 3 months) and higher gross persistence (≥2909) values, lower number of adult emergence (≤ 2.67) and higher germination count (≥70%) and were found to be more effective. Among synthetic insecticides; deltamethrin 2.8 EC, cypermethrin 10 EC, spinosad 45 SC and fenvalerate 20 EC @ 4 ppm were significantly more effective against *C. chinensis* and recorded significantly higher mortality (> 71%) with higher half-life values (3 to 8 months), higher persistency (≥ 5121) and lower number of adult emergence (≤ 2.63). The same insecticides also exhibited lower per cent loss (10.16 to 18.66%) in germination of cowpea seeds.

How to view point the article : Choudhary, Mamta Devi, Bharpoda, T.M., Deb, Sushma and Choudhary, Suman (2017). Efficacy of various seed protectants against *Callosobruchus chinensis* (L.) on cowpea (*Vigna unguiculata* L.) under storage condition. *Internat. J. Plant Protec.*, **10**(2) : 303-310, **DOI : 10.15740/HAS/IJPP/10.2/303-310**.

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INTRODUCTION

Cowpea (*Vigna unguiculata* L.), commonly known as *Lobia*, is cultivated as pulses, fodder and a green manure crop. Being rich in protein and many other nutrients, it is also known as vegetable meat. During the storage of cowpea, major three species of pulse beetles *viz.*, *Callosobruchus chinensis* Linnaeus,

Callosobruchus maculatus (Fabricius) and *Callosobruchus analis* Fabricius were found damaging to seeds (Semple *et al*., 1992). The damage incurred in terms of per cent weight loss of cowpea due to *C. chinensis* remained about 18.6 per cent (Rawat and Srivastava, 2011). The young larvae of the beetle bore into the seed and complete in development inside. Pulse beetles are major constraint in tropics and subtropical regions where cheap and effective control methods are needed. Although, synthetic insecticides such as deltamethrin, malathion, chlorpyriphos and fumigant like phosphine were primarily used for seed protection (Arthur, 1996).

In recent years, attempts are being made to replace synthetic pesticides with natural pesticides of plant origin which are cheap, safe, eco-friendly, less persistent and more specific. Large numbers of natural products consisting of different plant parts have been explored for their insecticidal activities both at field and storage levels (Prakash and Rao, 1997). The insecticidal activity of many plant derivatives against cereal stored product pests have been demonstrated earlier by Weaver and Subramanyam (2003). In view of above consideration and relative paucity of data, investigation was carried out to find out the efficacy of various seed protectants against *C. chinensis* in stored cowpea at Department of Entomology, B. A. College of Agriculture, AAU, Anand during 2011-12.

MATERIAL AND METHODS

Evaluation of plant oil as grain protectant:

The study was carried out during 2011-12. For initiation of culture, about 300 adults of *C. chinensis* were introduced in plastic jar (20 cm height and 14 cm diameter) containing one kg cowpea (var. NRC-37) seeds previously sterilized at 55 °C temperature for 4 hours in oven. Each jar was covered tightly with muslin cloth affixed with rubber band to prevent the adults from escaping. The adults of *C. chinensis* thus obtained from the laboratory culture were used for further experimentation.

Nine plant oils *viz*., *Neem* (*Azadirachta indica* A. Juss), pongam (*Pongamia glabra* Vent), mahua (*Madhuca longifolia* Macbride), castor (*Ricinus communis* Linnaeus), mustard (*Brassica juncea* Coss), coconut (*Cocus nucifera* Linnaeus), sesame (*Sesamum indicum* Linnaeus), safflower (*Carthemus tictorious* Linnaeus) and palm (*Elaeis guineensis* Jacq.) were evaluated at @ 1% (v/w) level for their efficacy as seed protectant. Mortality, half-life, gross persistency, population growth and germination loss were recorded. Each oil was applied to 500 g previously sterilized cowpea seeds by smearing @ 1 per cent. An untreated and sterilized bulk of 500 g cowpea seeds was kept as control treatment and all the 10 bulks were stored in air tight plastic bottles at room temperature and utilized for further experimentation.

Adult mortality was evaluated based on three samples of 50 g each of treated cowpea seeds (one sample for one repetition) drawn from each bulk of treatment. Twenty adults (two days old) of *C. chinensis* were released in each of the plastic tube covered tightly with two fold muslin cloth affixed with rubber band. The experiments were repeated at 15 days interval. The observations on number of dead adults out of total adults were recorded after seven days of adult release and per cent mortality worked out. Insects showing movement of legs or antennae were considered alive. The periodic data on per cent mortality was corrected using Abbott's formula (Abbott, 1925) and subjected to ANOVA after transforming the values to arc sin (Steel and Torrie, 1980).

Different oils were also evaluated for their efficacy as grain protectant based on mortality half- life in days. It was worked out using the formula: Mortality half-life ($M_{1/2}$) = log $2/K_1$. Gross persistency of different plant oils was also worked out using the following formula of Pawar and Yadav (1980).

$$\text{Gross persistency} = \frac{\text{Sum of (\% mortality x Period in days)}}{\text{Number of observations}}$$

The mortality half-lives in days and gross persistency were worked out repetition-wise for each treatment.

To carry out the study on population growth of *C. chinensis* in each treatment, twenty adults (two days old) were released in each of three tubes for egg laying and were discarded from each tube after seven days. The observations on number of adults (live + dead) developed in each of three repetitions were recorded after three and six month storage period and subjected to ANOVA after square root transformation.

For efficacy of various plant oils based on germination loss, three samples (one sample as one repetition) of cowpea seeds (100 seeds each collected

randomly from each sample) were drawn from each treatment. The test was carried out on circular Whatman number 1 filter paper kept in Petri-plates (diameter 10 cm) and maintained moist for germination of seeds. The seeds were spread on filter paper at uniform distance in each Petri-plate. The Petri-plate was covered with a lid carrying moist filter paper and kept in a seed germinator maintained at 21 ± 1°C temperature and 95 ± 2 per cent relative humidity. Small quantity of distilled water was sprinkled on filter paper once a day to keep it moist. The number of seeds germinated was counted after seven days of incubation. Based on germination counts, the percentage of germination before and six months after adult release were calculated repetition-wise and subjected to ANOVA after transforming them to arc sin (Steel and Torrie, 1980).

A study was also undertaken to see the presence or absence of disagreeable smell or odour in cowpea seeds smeared with non-edible oil (*Neem*, pongam, mahua and castor). For the purpose, three samples were cooked and offered to five persons to speak opinion on smell and taste after six months of storage. Marks (1 to 10) were assigned on the basis of smell and taste. More disagreeable smell and taste were awarded less marks and *vice-versa.*

Evaluation of botanical leaf powders as grain protectant :

Nine botanical leaf powders *viz*., *Neem* (*A. indica*), custard apple (*Annona squamosa* Linnaeus), garlic (*Allium sativum* Linnaeus), pongam (*P. glabra*), *Tulsi* (*Ocimum sanctum* Linnaeus), mint (*Mentha arvensis* Linnaeus), ardusi (*Ailanthus excelsa* Roxb.), eucalyptus (*Eucalyptus globulus* Labil) and kalmegh (*Andrographis paniculata* Nees) were evaluated @ 2% for their protectant efficiency against *C. chinensis* on cowpea based on adult mortality, half-life, gross persistency, population growth of the pest and germination loss as per the methodology described in case of plant oils.

Evaluation of synthetic insecticides as seed protectant :

Nine insecticides (dichlorvos 76 EC, chlorpyriphos 20 EC, deltamethrin 2.8 EC, fenvalerate 20 EC, cypermethrin 10 EC, spinosad 45 SC, bifenthrin 10 EC and endosulfun 35 EC all @ 4 ppm and malathion 50 EC @ 10 ppm) were also evaluated for their protectant efficiency based on adult mortality, half-life, gross persistency and population growth of the pest and germination loss as per the methodology described under plant oils.

RESULTS AND DISCUSSION

The findings of the present study as well as relevant discussion have been presented under the following heads:

Plant oils as grain protectant :

Among the different plant oil @ 1%; castor recorded significantly the highest adult (*C. chinensis*) mortality (73.06%) followed by *Neem* (68.15%) and pongam oil (57.11%) at different storage period of cowpea and to be considered as more effective oils (Table 1). Mahua oil (53.04%) stood next in order. Mustard (42.47%) and sesame oil (39.55%) proved mediocre in respect to adult mortality of *C. chinensis* at varying period. Among the oils, safflower (29.87%) and coconut oil (33.34%) were found less effective against this pest in cowpea. Naik and Dumbre (1985) also reported that *Neem* oil (1%) protected the cowpea seed upto 150 days from *C. chinensis*. Bhargava and Meena (2002) found that castor oil (1%) recorded higher adult mortality of *C. chinensis* in cowpea. Further, they also reported coconut oil and safflower oil as least effective oils against *C. chinensis* in cowpea.

The higher half-life value (2.5 to 3 months) was recorded in *Neem*, castor and pongam oils against *C. chinensis* in stored cowpea (Table 1). It was about two months in mahua, mustard, palm, coconut and sesame oils, whereas it was below two months in safflower oil. Similarly, higher gross persistency value (3359.48 to 4707.48) was noted in mahua, pongam, *Neem* and castor oils under the present study. This value was above 2000 and below 3300 in coconut, sesame, mustard and palm oils, whereas the value was the lowest (>2000) in safflower oil. Deb (2011) reported that *Neem* and castor oil had higher half-life as well as gross persistency values in stored maize against *Sitophilus oryzae* Linnaeus.

Based on population growth (adult developed) of *C. chinensis* after storage period; castor, *Neem* and pongam oils were found highly effective as less number of adults (<5.36) emerged out under the present investigation (Table 1). The adult emergence was medium

to high in mahua, palm, mustard and sesame oil treatments. In contrast to this, safflower (14.79) and coconut oil (12.39) were less effective as the adult emergence was comparatively higher in cowpea. Haghtalab *et al*. (2009) observed that castor oil (9 ml/ kg seed) suppressed the progeny production of the *C. maculatus* in cowpea.

Based on organoleptic test, castor oil was found to be organoleptically more acceptable followed by *Neem*, pongam and mahua oil (Table 1). Kher (2006) also reported castor oil as organoleptically acceptable oil in wheat followed by pongam and *Neem.*

On the basis of per cent loss in germination (Table 1); *Neem*, castor and pongam oils were most effective with less per cent germination loss. Mahua, palm, mustard and sesame oils were medium in performance. Safflower and coconut oils were least effective with higher loss in germination. However, Khaire *et al*. (1992) noted that there was no adverse effect of castor and mustard oil (1%) on germination of pigeonpea. This might be due to the different nature and characteristics of pigeonpea than cowpea used under present investigation.

Botanical leaf powders as grain protectant :

Based on adult mortality; *Neem*, eucalyptus, *Tulsi* and pongam leaf powders all @ 2 per cent recorded higher (37.58%) adult (*C. chinensis*) mortality in stored cowpea (Table 2). Custard apple (34.52%), garlic (29.70%), mint (25.59%) and kalmegh (23.21%) leaf powders also differed significantly with each other. Ardusi (20.77%) leaf powder recorded significantly the lowest adult mortality and proved to be the least effective botanical against *C. chinensis* infesting cowpea in storage. Subramanya *et al*. (1994) reported that

Table 1: Effectiveness of various plant oils as grain protectant against *C. chinensis* in stored cowpea

Treatments (1%)	Mortality (%)**	Half-life (days)	Gross persistency	No. of adults emerged*	Germination (%)		Loss in germination (%)	Organoleptic rank (Out of 10)
					Before treatment	6 months after treatment		
Neem oil	55.64f	84.04f	4424.88e	2.09a	69.23	66.95bcd	26.17a	2.50c
	(68.15)			(3.87)	(88.45)	(84.67)	(19.45)	(5.75)
Pongam oil	49.09e	72.91e	3596.08d	2.42ab	66.15	70.29cd	28.22a	2.24b
	(57.11)			(5.36)	(84.66)	(88.63)	(22.36)	(4.52)
Mahua oil	46.74d	67.67de	3359.48cd	2.88bc	68.46	71.48d	34.11b	1.86a
	(53.04)			(7.79)	(85.63)	(89.91)	(31.45)	(2.96)
Castor oil	58.73g	84.79g	4707.48e	2.09a	70.48	65.73bcd	27.09a	2.46bc
	(73.06)			(3.87)	(88.07)	(83.10)	(20.74)	(5.55)
Mustard oil	40.67bc	61.88bcd	2752.83b	3.29cde	64.70	58.56b	39.47cd	-
	(42.47)			(10.32)	(81.44)	(72.79)	(40.41)	
Coconut oil	35.27a	58.69abc	2125.87a	3.59ef	58.61	67.15bcd	43.50de	-
	(33.34)			(12.39)	(72.87)	(84.92)	(47.38)	
Sesame oil	38.97b	58.21ab	2593.00b	3.43de	66.40	62.87bcd	43.16d	-
	(39.55)			(11.26)	(84.06)	(79.21)	(46.79)	
Safflower oil	33.13a	52.69a	1989.46a	3.91fg	62.42	60.77bc	47.99ef	-
	(29.87)			(14.79)	(78.28)	(76.15)	(55.21)	
Palm oil	41.76c	65.33cd	3258.65c	3.10cd	62.87	64.25bcd	35.14bc	-
	(44.36)			(9.11)	(79.56)	(81.13)	(33.13)	
Control	-	-	-	4.37g	64.53	35.21a	51.93f	2.80d
				(18.60)	(81.61)	(33.24)	(61.98)	(7.34)
S.E. ±	0.82	2.18	96.75	0.14	3.39	3.42	1.59	0.78
C. D. (P=0.05)	2.29	6.79	287.48	0.46	NS	10.08	4.70	0.23
C. V. %	9.49	5.88	5.24	6.71	8.99	9.50	7.32	7.35

Treatment means with letter (s) in common are not significant at 5 per cent level of significance within a column.
The periodical data on per cent mortality were corrected by Abbott's formula.
Figures in parentheses are retransformed, those outside are $\sqrt{x+0.5}$ * and arc sin** transformed values NS= Non-significant

application of dry leaf powder of *E. citriodora* (5%) was most effective against *C. chinensis*. Sharvale and Borikar (1998) recorded higher effectiveness of *Neem* leaves against this pest in stored cowpea.

The highest (97.95 days) half-life was registered in *Neem* leaf powder followed by eucalyptus (94 days) and the treatments were at par with each other (Table 2). *Tulsi*, custard apple, pongam, mint, garlic and ardusi leaf powders recorded half-life from 86.24 to 76.16 days and they were at par with each other. The lowest (75.26 days) half-life value was obtained in kalmegh leaf powder. *Neem*, eucalyptus and *Tulsi* leaf powders recorded higher gross persistency in stored cowpea in the present study.

Based on gross persistency value, *Neem* leaf powder recorded significantly the highest (3641.70) gross persistency followed by eucalyptus (3313.90) and *Tulsi* (2908.06) leaf powders (Table 2). Pongam and custard apple leaf powders noted gross persistency of 2564.34 and 2311.31, respectively and they were at par with each other. Mint recorded gross persistency as 1650.94 and it at par with kalmegh (1476.49). The lowest (1339.73) gross persistency was registered in ardusi leaf powder and it was at par with kalmegh (1476.49) and proved to be less effective against *C. chinensis*. Tanzubil (1991) also observed that *Neem* products protected the stored cowpea from the damage due to *C. chinensis* upto four months.

On the basis of population growth (Table 2); *Neem*, eucalyptus, pongam and *Tulsi* leaf powders were found more effective (with < 2.00 adult emergence) against *C. Chinensis* in stored cowpea. Kalmegh and ardusi

Table 2 : Effectiveness of botanicals as grain protectant against *C. chinensis* in stored cowpea

Treatments (Leaf powder @ 2%)	Mortality (%)**	Half-life (days)	Gross persistency	No. of adults emerged*	Germination (%)**		Loss in germination (%)**
					Before adult release	6 months after infestation	
Neem	46.44h	97.95c	3641.70g	1.50a	65.79	57.97d	20.56a
	(52.51)			(1.75)	(83.18)	(71.87)	(12.33)
Custard apple	35.98e	87.07abc	2311.31d	1.72bc	66.15	52.37cd	29.84cd
	(34.52)			(2.46)	(83.65)	(62.72)	(24.76)
Garlic	33.02d	77.15ab	1943.58c	1.82c	60.43	48.42bc	30.89cd
	(29.70)			(2.81)	(75.65)	(55.95)	(26.36)
Pongam	37.81e	86.24abc	2564.34d	1.63ab	70.22	58.27d	24.37ab
	(37.58)			(2.16)	(88.55)	(72.34)	(17.03)
Tulsi	41.15f	87.73bc	2908.06e	1.78bc	69.14	57.01d	26.85bc
	(43.30)			(2.67)	(87.32)	(70.35)	(20.40)
Mint	30.39c	80.41ab	1650.94b	2.08d	63.60	48.04bc	33.35de
	(25.59)			(3.83)	(80.23)	(55.30)	(30.22)
Ardusi	27.11a	76.16ab	1339.73a	2.30e	62.24	43.25ab	39.01f
	(20.77)			(4.79)	(78.31)	(46.95)	(39.62)
Eucalyptus	43.32g	94.40c	3313.90f	1.63ab	66.23	57.21d	23.47ab
	(47.07)			(2.16)	(83.75)	(70.67)	(15.86)
Kalmegh	28.80b	75.26a	1476.49ab	2.30e	62.93	45.74b	36.05ef
	(23.21)			(4.79)	(79.29)	(51.29)	(34.63)
Control	-	-	-	2.78f	65.39	38.41a	46.87g
				(7.23)	(82.66)	(38.60)	(53.26)
S.E.±	0.46	4.12	87.08	0.05	3.38	2.04	1.74
C. D. (P=0.05)	1.39	12.25	258.75	0.17	NS	6.04	5.13
C. V.%	8.35	8.43	6.41	8.27	8.98	6.99	9.69

Treatment means with letter(s) in common are not significant at 5 per cent level of significance within a column.

Figures in parentheses are retransformed values, those outside are $\sqrt{x+0.5}$ * and arc sin** transformed values.

The periodical data on per cent mortality were corrected by Abbott's formula. NS= Non-significant

leaf powders recorded significantly higher number of adults (4.79) and found to be least effective. Verma *et al.* (2004) reported that neem leaf powder reduced the adult population built up as compared to control. Gundannavar and Deshpande (2006) reported that mint leaf powder (5%) reduced significantly the emergence of *C. chinensis* in soybean.

Based on germination loss after six months of storage; *Neem,* eucalyptus, pongam and *Tulsi* leaf powders maintained more than 70 per cent germination and were considered as more effective botanicals (Table 2). Custard apple, garlic and mint leaf powders were observed as mediocre in their effectiveness. Ardusi and kalmegh had lower germination count. Kudachi and Balikai (2009) reported that *Neem* 5 per cent recorded minimum germination loss of sorghum due to *R. dominica*.

Synthetic insecticides as seed protectant :

On the basis of per cent adult mortality; deltamethrin, cypermethrin, spinosad and fenvalerate recorded more than 50 per cent adult mortality upto 150 days and came out as more effective seed protectants against *C. chinensis* in stored cowpea (Table 3). Srivastava and Jha (2007) found that deltamethrin 0.8 per cent was the most toxic against *C. maculatus, C. chinensis* and *C. analis* infesting cowpea seeds. Spinosad 45 SC @ 2 ppm and deltamethrin 2.8 EC @ 2.5 ppm were most toxic and recorded lower number of adult emergence of *C. chinensis* whereas malathion 50 EC @ 20 ppm recorded higher adult emergence of *C. chinensis* and proved to be poor in its efficacy (Rajput,

Table 3: Effectiveness of various synthetic insecticides as seed protectant against *C. chinensis* in stored cowpea

Treatments	Mortality (%) **	Half-life (days)	Gross persistency	No. of adults emerged *	Germination (%) **		Loss in germination (%) **
					Before adult release	6 months after infestation	
Dichlorvos 76 EC @ 4 ppm	52.78bc	144.64ab	5100.38c	2.11cd	61.85	50.01bc	32.49f
	(63.41)			(3.95)	(77.74)	(58.70)	(28.85)
Chlorpyriphos 20 EC @ 4	54.21cd	156.97abc	4513.57b	1.75bc	62.84	51.79bcd	30.05cd
ppm	(65.80)			(2.56)	(79.16)	(61.74)	(25.08)
Deltamethrin 2.8 EC @ 4	68.01g	249.65e	5969.23d	1.28a	67.96	61.78e	18.59a
ppm	(85.98)			(1.14)	(85.92)	(77.20)	(10.16)
Fenvalerate 20 EC @ 4 ppm	57.96e	181.05bcd	5121.09c	1.77bc	67.35	57.20de	25.59d
	(71.86)			(2.63)	(85.17)	(70.66)	(18.66)
Cypermethrin 10 EC @ 4	62.53f	209.34de	5578.22d	1.45a	65.15	58.25e	21.47ab
ppm	(78.72)			(1.60)	(82.34)	(72.31)	(13.40)
Spinosad 45 SC @ 4 ppm	58.23e	195.37cd	5319.09cd	1.58ab	62.66	55.80cde	22.55bc
	(72.28)			(2.00)	(78.91)	(68.41)	(14.71)
Bifenthrin 10 EC @ 4 ppm	55.66d	170.57abc	4747.12b	1.86bc	67.76	56.19cde	27.55e
	(68.18)	d		(2.96)	(85.67)	(69.04)	(21.39)
Endosulfan 35 EC @ 4 ppm	51.24ab	139.97ab	4147.72a	2.19cd	66.15	50.36bc	33.75g
	(60.80)			(4.30)	(83.65)	(59.30)	(30.87)
Malathion 50 EC @ 10 ppm	49.92a	136.88a	3941.75a	2.38d	63.10	47.09b	35.80g
	(58.54)			(5.16)	(79.53)	(53.64)	(34.22)
Control	-	-	-	2.85e	67.03	41.50a	45.95g
				(7.62)	(84.77)	(43.91)	(51.66)
S.E. ±	0.61	14.18	91.27	0.11	2.45	2.13	1.01
C.D. (P=0.05)	1.70	42.13	271.19	0.35	NS	6.30	3.00
C. V. %	7.85	13.95	3.20	7.10	6.50	6.99	5.99

Note: Treatment means with letter(s) in common are not significant at 5 per cent level of significance within a column.
Figures in parentheses are retransformed values, those outside are $\sqrt{x+0.5}$ *and arc sin** transformed values.
The periodical data on per cent mortality were corrected by Abbott's formula. NS= Non-significant

2010). Raheem and Sridevi (2011) also reported the highest adult mortality (96.66%) of *C. chinensis* in pigeonpea seeds treated with deltamethrin.

The half-life and gross persistency values of deltamethrin, cypermethrin, spinosad and fenvalerate were higher against *C. chinensis* in stored cowpea (Table 3). Rajput (2010) also recorded higher persistence value from spinosad 45 SC and deltamethrin 2.8 EC treated cowpea seeds.

Based on population growth (Table 3), deltamethrin, cypermethrin, spinosad and fenvalerate were highly effective with less than 2.5 adult emergence. Rajput (2010) reported that spinosad 45 SC @ 2 ppm and deltamethrin 2.8 EC @ 2.5 ppm proved to be more effective insecticides by recording lower adult emergence of *C. chinensis.*

As far as per cent germination is concerned; deltamethrin, cypermethrin, spinosad and fenvalerate recorded lower germination loss (Table 3). Bifenthrin, chlorpyriphos and dichlorvos were summarized in mediocre group of insecticides looking to the loss of germination. Malathion and endosulfan adversely affected the germination of cowpea seed and recorded higher per cent loss of germination. As per the report of Kher (2006), chlorpyriphos at 4 ppm moderately affected in the germination of wheat whereas malathion and endosulfan recorded higher germination loss.

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