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Evaluation of different plant powders as seed protectants against rice moth, *Corcyra cephalonica* Stainton

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Abstract: The present study was aimed to develop the eco-friendly and economic approaches to keep the stored food grains free from insect attack would be using the plant products as grain protectants. In the context of biological control as an alternative to chemical control, under laboratory conditions, different plant powders *viz.,* dharak kernel and leaf (*Melia azadirach* L.), neem kernel and leaf (*Azadirachta indica* Adr. Juss), karanj kernel (*Pongamia glabra*), aak leaf (*Calotropis procera* Br.), datura leaf (*Datura alba* Nees.), citrus leaf (*Citrus lemon* L.), podina leaf (*Mentha arvensis*) and tulsi leaf (*Ocimum sanctum* L.) were compared, at three rate of application (1.0, 2.5 and 5.0 g per 100 g seeds), as protectants against infestation of sorghum (*Sorghum bicolor* (L.) Moench) seeds by the storage pest *Corcyra cephalonica* Stainton. The larval period of test insect got progressively increased with the increase in dose level of different plant powders. The maximum (77.83%) and minimum (37.83%) reduction in adult emergence was observed in dharak kernel powder and tulsi leaf powder, respectively. The test insect developed on seeds treated with dharak kernel powder laid significantly (P> 0.5) minimum number of eggs (80.33 eggs/ female) followed by neem kernel powder (85.66 eggs/female). The dharak and neem kernel powders were found most effective in reducing the longevity of male (3.96 and 5.13 days) and female adults (4.63 and 4.97 days), respectively. The results suggest that these materials tested have the potential in the development of post-harvest protection technology against, *C. cephalonica*, the major pest of stored grains.

Keywords: *Corcyra cephalonica,* Egg viability, Plant powders, Seed protectants, Stored grains

INTRODUCTION

In India, post-harvest losses caused by the unscientific storage, rodents, insects, micro-organisms and moisture etc. account for about 10 percent of total food grains. Amongst the various stored grain insect-pests, rice moth, *Corcyra cephalonica* Stainton (Lepidoptera: Pyralidae) is a cosmopolitan in distribution and cause a serious damage to the stored grains (Pandey *et al.,* 1985; Singh and Mishra, 1989; Patel and Patel, 2007; Yadav *et al.*, 2011[a]). The excreta, exuviae and dead bodies also get mixed up in the food stuff, hence damage in both quantitative and qualitative loss. Hence, effective storage protection strategies are urgently required. Current control measures for the *C. cephalonica* included chemical insecticide, fumigation and biological control. These methods are expensive and cannot be afforded by the small-scale farmers in developing countries. Success achieved so far in making the stored products free from pests has been largely dependant on pesticides alone. Pesticides are the most powerful tool available for pest control. Despite these credentials, the long and indiscriminate use of pesticides has been found ecologically unsound. It has been owing to the man's tendency to substitute pesticides for effective bio-environmental controls rather than restrict their use to emergent situations, necessitating the concept of pest management in present format. One of the eco-friendly and economic approaches to keep the stored food grains free from insect attack would be using the plant products as grain protectants for managing the insect population in stored products. Controlling them with chemicals is a serious concern as it leads to environmental contamination and health hazards (Tillman and Mulrooney, 2000). To test the powders from different plants, we used doses of 1.0, 2.5 and 5.0 g per 100 g seeds, Every dose of plant powders were tested on different biological aspects of the insect in a constant temperature (28^{o}C) and relative humidity (72%±5). The interest in this kind of work is the search for plants that can be used locally as bio-pesticide for protection of this precious commodity. Use of naturally occurring or locally available plant materials to protect agriculture products against insect pests is an

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old-age common traditional practice in many parts of the world for medicinal purposes and in agriculture (Mukanga *et al*., 2010 and Khani *et al.,* 2013). The principal advantage of botanicals is the farmers are able to provide their own protectants (Isman, 2008; Mukanga *et al*., 2010). Extracts from different plants have been known to possess insecticidal properties against a wide range of insect pests (Abdullahi and Muhammad, 2004; Pathak and Tiwari, 2010). Plants with insecticidal properties offer a cheaper sustainable alternative to synthetic insecticides, store design, fumigation and thermal distribution methods. They could be an abundant source of locally available pest control agents that can be grown at the village level. The insecticidal specificity of some plant extracts and their lack of negative impacts on the food and the environment make them ideal candidates for incorporation into an integrated pest management strategy.

Exact quantities of botanicals from these plants that give optimum insecticidal effects are unknown. It is thus desirable to quantify the amount of the plant derived materials that provide adequate protection against insect pests and to determine how these affect insect behaviour, growth and reproduction (Jilani, 1992 and Meena and Bhargava, 2005). Equally, plant species that are found to be effective and popular locally with the farmers need to be subjected to safety testing, at least involving basic toxicological studies (Jilani, 1992). The principal advantage of botanicals is that farmers are able to provide their own protectants (Isman, 2008). There are encouraging reports on the use of certain indigenous plant products as grain protectants (Pandey *et al.,* 1985; Jacob and Sheila, 1990; Bhargava, 1997; Sharma and Bhargava, 2001; Pathak and Tiwari, 2010; Yadav *et al*., 2011[b]). The use of powders aromatized with essential oils, has a twofold advantage due to combined effects of mechanical action, blocking the insect's articulations (Ramaswamy *et al.,* 1995; Mukanga *et al.*, 2010). In case of rice moth, *C. cephalonica*, meager information is available in literature regarding the efficacy of indigenous plant materials. Plants with insecticidal properties offer a cheaper sustainable alternative to synthetic insecticides, store design, fumigation and thermal distribution methods. They could be an abundant source of locally available pest control agents that can be grown at the village level. The insecticidal specificity of some of the plant extracts and their lack of negative impacts on the food and the environment make them ideal candidates for incorporation into an integrated pest management strategy. The purpose of our tests is the comparative study of the biocidal effects of powders of different plants on different biological parameters of the test insect. Under the present investigation, therefore, many plant products have been evaluated to find out their effectiveness against *C. cephalonica* pest.

MATERIALS AND METHODS

The experiment was conducted under laboratory conditions in the Department of Agricultural Zoology and Entomology, S.K.N. College of Agriculture, Jobner campus of Rajasthan ($75^0$28' East longitude, $26^0$05' North latitude). The eggs were obtained from Biocontrol Research Laboratory, Pest Control (India) Ltd., Bangalore. One C.C. (measuring in cubic centimeter which is containing approximately 16000–18000) eggs were released in 3 kg of broken sorghum grains. The culture was maintained in culture box of glass jars containers lined with black folded thick paper on the sides and blotting paper at the bottom. These glass jars were kept at 28 ± 1^0C and 70 ± 5 percent relative humidity. The chamber was covered with double layer of muslin cloth after releasing freshly emerged active adults. Most of the eggs were laid between the double layer of muslin cloth from where these were collected daily with the help of a soft brush and kept in separate petri dishes. The time and date of egg laying were recorded in order to select the eggs of known age that ensured continuous supply of eggs needed for the present study.

The powder of different plant products *viz.,* dharak kernel and leaf (*Melia azadirach* L.), neem kernel and leaf (*Azadirachta indica* Adr. Juss), karanj kernel (*Pongamia glabra*), aak leaf (*Calotropis procera* Br.), datura leaf (*Datura alba* Nees.), citrus leaf (*Citrus lemon* L.), podina leaf (*Mentha arvensis*) and tulsi leaf (*Ocimum sanctum* L.) were prepared by drying them in shade and then grinding them in electric grinder to get fine powder. The powder was sieved through 60 mesh sieve. Powders of all the plant products were mixed with seeds at the rate of 1.0, 2.5 and 5.0 g per 100 g of grains (w/w). For mixing the powder with seeds, 500 g grains were placed in a plastic bag (25 x 20 cm) and desired amount of powder was added to it; each treatment was replicated thrice. The bag was then held from both the ends and shaken horizontally for 5 minutes to ensure through mixing. An aliquot from the powder mixed sample was used for the experimentation in each treatment. Untreated grains were used as control. Twenty five newly hatched larvae were released in the plastic container containing treated food. The observations recorded were larval period, pupal period, ovipositional response, reduction in adult emergence, fecundity, egg viability and longevity of adults. The larval period was worked out by recording the date of releasing newly hatched larvae and date of formation of silken web and the period between web formation and adult's emergence was considered as pupal period on treated food with different doses of test compounds. For recording the fecundity and ovipositional period of adult, which emerged from the larvae developed on treated food, were kept in separate jars for egg laying. The total number of eggs laid by each female was counted daily till the death of female in each treatment. For egg viability, a random sample of 50 eggs was taken from each replication and placed in separate container. The eggs hatched or unhatched were counted with the help of binocular microscope. The longevity of male, female adults and total number of

Table 1. Effect of powdered plant products on larval period of *C. cephalonica.*

Dose (Parts per 100 parts of grain w/w)	Larval period (days)*										
	Dharak kernel powder	Neem kernel powder	Dharak leaf powder	Karanj kernel powder	Neem leaf powder	Aak leaf powder	Datura leaf powder	Citrus leaf powder	Podina leaf powder	Tulsi leaf powder	Mean
1.0	39.00	37.66	37.00	35.66	36.33	37.00	35.66	35.00	34.66	34.00	36.87
2.5	44.33	43.33	42.33	41.66	38.66	40.00	40.66	37.33	36.66	37.00	40.83
5.0	48.66	47.00	46.00	48.00	42.00	43.66	43.00	39.33	39.00	38.33	42.87
Mean	44.00	44.89	41.78	41.78	39.00	40.22	39.78	37.22	36.78	36.44	
Control	34.00										

	SEm+	C.D. at 5%	C.V. %
Treatment	0.33	0.94	
Dose	0.18	0.51	2.49
Treatment x Dose	0.57	1.62	

*Data based on 75 individuals (Three replications of 25 in each).

adults emerged from treated food with different concentrations/doses of test compounds, were recorded.

The response of the test insects in the treated food were corrected using the modified Abbott's formula i.e. 100 (Number of insects in control – Number of insects in treatment)/ (Number of insects in control). The data obtained on various characters/ parameters were subjected to analysis of variance technique applicable for completely randomized design (CRD). The level of significance used in 'F' test was P=0.05 where ever F calculated was significant, critical difference values were calculated for treatment comparisons. The values obtained in percentages were transformed in to angular values and subjected to analysis of variance (ANOVA).

RESULTS AND DISCUSSION

Mixing of different plant materials with grains for the protection of insect pest constitutes one of the age old and indigenous practices adopted by the farmers, particularly in developing and under developed countries. Different plants are known to possess insecticidal properties and as such they have been used in protecting the grains against the damage of number of stored grain pests in different parts of country according to local availability of such materials. Many workers (Miah *et al*., 1993; Zibokere, 1994; Pandey and Singh, 1997; Patel and Patel, 2002; Meena and Bhargava, 2005; Righi Assia *et al*., 2010; Yadav *et al*., 2011[b]; Pathak and Tiwari, 2012) have used products from several plant species for the protection of stored grains from insect pests.

Effect on larval period: When the newly hatched larvae were fed with treated food with test compounds in the present study, all the doses (1.0, 2.5 and 5.0 g per 100 g seeds) of different plant powders were significantly better at 5 percent level in enhancing the larval period of test insect over control. The larval period of test insect got progressively increased with the increases in dose level of all tested compounds. The maximum duration of larva observed on seeds treated with neem kernel powder (44.89), which was at par with dharak kernel powder (44.00) shown in Table 1. These findings are in agreement with the results obtained by Chander and Ahmed (1986), Pandey *et al.* (1985), Jhansi Rani (1984) and Khan and Thakare (1997) who reported that larval period of one week old *Corcyra* larvae was significantly enhanced at 5 percent level when fed on grains treated with neem seed powder at 1.0 percent. This increase in the larval period is certainly due to antifeedent effect of plant products (Pandey *et al.,* 1985; Veeranki and Reddy, 2004). This finding is in close conformity with the findings of Pathak and Tiwari (2010a) who reported that the larvicidal and pupicidal effects of neem leaf on the third instar larvae of *Corcyra cephalonica* Stainton. Veeranki and Reddy (2004) reported that custard apple seed powder, neem leaf, seed kernel powder and inert dusts (attapulgite and palygorskite) as effective treatment against *C. cephalonica* and *S. cerealella* ,also support the present findings. Tiwari and Tiwari (2008) observed that diatomaceous earth formulation at 0.02 percent checked 93.8, 98.1, 100.0, 100.0, 100.0 percent progeny of *R. dominica, S. oryzae, T. castaneum, S. cerealella and C. Cephalonica,* respectively. Pathak and Tiwari (2010b) reported controlled 100% larval mortality of *C. cephalonica* with neem seed extract at 0.11% active ingredient (a.i.).

Effect on pupal period: In the present investigation, results obtained as regard to pupal period in different doses i.e. 1.0, 2.5 and 5.0g per 100g seeds and all tested compounds which mentioned in material and methods, were at par at 5 percent level with the control. Hence, the plant powders had no effect on pupal period, when the newly hatched larvae were developed on food treated with different plant powders (Table 2). The present investigations corroborate with that of Pandey *et al.* (1985) who reported that neem kernel and neem leaves powders at the rate of 1.0, 2.5 and 5.0

Table 2. Effect of powdered plant products on pupal period of *C. cephalonica.*

Dose (Parts per 100 parts of grain w/w)	Pupal period (days)*										
	Dharak kernel powder	Neem kernel powder	Dharak leaf powder	Karanj kernel powder	Neem leaf powder	Aak leaf powder	Datura leaf powder	Citrus leaf powder	Podina leaf powder	Tulsi leaf powder	Mean
1.0	10.66	11.00	10.33	10.33	9.66	9.66	10.00	9.66	9.33	9.00	9.90
2.5	11.00	11.33	10.66	10.33	9.66	9.66	10.33	10.00	9.66	9.33	10.20
5.0	11.00	11.66	11.33	10.66	10.00	10.00	10.66	10.00	10.33	9.66	10.47
Mean	10.89	11.33	10.78	10.44	9.78	9.78	10.33	9.89	9.78	9.33	
Control 9.00											

	SEm+	C.D. at 5%	C.V. %
Treatment	0.19	NS	
Dose	0.07	NS	4.93
Treatment x Dose	0.32	NS	

*Data based on 75 individuals (Three replications of 25 in each). NS = Non-significant

Table 3. Effect of powdered plant products on reduction in adult emergence of *C. cephalonica.*

Dose (Parts per 100 parts of grain w/w)	% reduction in adult emergence*										
	Dharak kernel powder	Neem kernel powder	Dharak leaf powder	Karanj kernel powder	Neem leaf powder	Aak leaf powder	Datura leaf powder	Citrus leaf powder	Podina leaf powder	Tulsi leaf powder	Mean
1.0	64.67	61.20	55.98	50.33	48.00	44.65	41.98	40.67	39.37	28.27	47.16
	(53.53)#	(51.47)	(48.44)	(45.09)	(43.85)	(41.93)	(40.39)	(39.62)	(38.86)	(32.12)	(43.37)
2.5	76.33	69.67	64.00	60.67	55.66	51.98	48.65	45.98	45.33	40.00	56.02
	(60.89)	(56.58)	(53.13)	(51.16)	(48.25)	(46.14)	(44.23)	(42.70)	(42.32)	(39.23)	(48.46)
5.0	88.04	84.04	80.02	74.01	70.00	66.65	60.33	55.66	50.00	45.66	68.30
	(69.77)	(66.45)	(63.45)	(59.35)	(56.79)	(54.73)	(50.96)	(48.25)	(45.00)	(42.51)	(55.73)
Mean	77.08	72.33	67.12	61.92	58.05	54.55	50.35	47.43	43.73	37.83	
	(61.40)	(58.26)	(55.01)	(51.89)	(49.63)	(47.61)	(45.20)	(43.53)	(41.40)	(37.96)	
Control 13.96 (21.94)											

	SEm+	C.D. at 5%	C.V. %
Treatment	0.33	0.93	
Dose	0.18	0.51	2.05
Treatment x Dose	0.57	1.61	

* Data based on 75 individuals (Three replications of 25 in each); #Percentage transformed to angles; outside values are its back transformation to percentages.

Table 4. Effect of powdered plant products on egg viability of *C. cephalonica.*

Dose (Parts per 100 parts of grain w/ w)	% reduction in egg viability*										
	Dharak kernel powder	Neem kernel powder	Dharak leaf powder	Karanj kernel powder	Neem leaf powder	Aak leaf powder	Datura leaf powder	Citrus leaf powder	Podina leaf powder	Tulsi leaf powder	Mean
1.0	45.18	43.77	41.92	36.57	38.80	30.40	31.45	34.12	23.33	22.97	36.78 (37.34)
	(42.22)#	(41.42)	(40.39)	(37.21)	(38.53)	(33.46)	(34.11)	(35.74)	(28.88)	(28.63)	
2.5	54.63	49.50	46.67	41.70	43.30	37.73	40.72	35.98	30.66	24.98	40.33 (39.43)
	(47.66)	(44.71)	(43.09)	(40.22)	(41.15)	(37.90)	(39.65)	(36.86)	(33.62)	(29.99)	
5.0	65.67	60.33	54.00	53.61	48.18	45.98	44.65	39.68	32.87	29.90	47.43 (43.53)
	(54.13)	(50.96)	(47.29)	(47.07)	(43.96)	(42.70)	(41.93)	(39.05)	(34.98)	(33.15)	
Mean	55.16	51.22	47.56	43.90	43.38	37.93	38.85	36.58	28.85	25.95	
	(47.96)	(45.70)	(43.59)	(41.50)	(41.21)	(38.02)	(38.56)	(37.22)	(32.49)	(30.63)	
Control 13.96 (21.94)											
		SEm+		C.D. at 5%		C.V. %					
Treatment		0.40		1.13							
Dose		0.22		0.62		3.05					
Treatment x Dose		0.69		1.95							

*Data based on 150 eggs (Three replications of 50 in each); # Percentage transformed to angles; outside values are its back transformation to percentages.

Table 5. Effect of powdered plant products on ovipositional period of adult of *C. cephalonica.*

Dose (Parts per 100 parts of grain w/w)	Ovipositional period (days)*										
	Dharak kernel powder	Neem kernel powder	Dharak leaf powder	Karanj kernel powder	Neem leaf powder	Aak leaf powder	Datura leaf powder	Citrus leaf powder	Podina leaf powder	Tulsi leaf powder	Mean
1.0	5.16	5.23	5.00	5.26	5.12	5.36	5.44	5.38	5.55	5.49	5.30
2.5	4.80	4.95	4.70	4.90	4.98	5.00	5.38	5.23	5.39	5.42	5.07
5.0	3.75	3.88	4.00	3.60	4.10	4.68	4.80	4.76	4.98	5.00	4.35
Mean	4.57	4.69	4.57	4.59	4.73	5.01	5.21	5.12	5.31	5.30	
Control 5.60											
		SEm+		C.D. at 5%		C.V. %					
Treatment		0.33		0.94							
Dose		0.18		0.51		2.49					
Treatment x Dose		0.57		1.62							

*Data based on 150 eggs (Three replications of 50 in each);# Percentage transformed to angles; outside values are its back transformation to percentages.

ercent (w/w) had no effect on pupal period of *C. cephalonica* but Pathak and Tiwari (2010[b]) observed larvicidal and pupicidal effects of neem seed extract at 0.11% (a.i.) on the third instar larvae of *C. cephalonica*.

Effect on adult emergence: It is apparent from the data that all the doses of plant powders tested were found to be significantly superior at 5 percent level in reducing the adult emergence over control. In the present investigation, the maximum reduction in adult emergence was observed in the treatment of dharak kernel powder (77.08) followed by neem kernel (72.33), dharak leaf (67.12), karanj kernel (61.92), neem leaf (58.05), aak leaf (54.55), datura leaf (50.35), citrus leaf (47.43), podina leaf (43.73) and tulsi leaf powder (37.83) are shown in Table 3. The present findings are in conformity with Jhansi Rani (1984) who found poor adult emergence *in C. cephalonica* when wheat flour was treated with neem kernel powder 2.0 percent (w/w). Pandey *et al*. (1985) also found that mixing of neem oil, kernel, cake, leaves and flowers with wheat seed at the rate of 0.1, 1.0, 5.0 (w/w) caused less percent adult emergence in *C. cephalonica*, support the present findings. Senguttuvan *et al.* (1995) also showed that neem leaf powder was effective in controlling the rice moth, *C. cephalonica* in groundnut kernels and pods under both artificial and natural conditions. Such type of findings was also reported by Singh and Srivastava (1980) in *R. dominica* when seed kernel powder mixed with wheat grain at the rate of 1.0, 2.5 and 5.0 percent (w/w). The percent reduction in adult emergence was 72.33 in neem kernel, 61.92 in karanj kernel and 58.05 in neem leaf, these results The present findings can be compared with those of Khan and Thakare (1997) who observed adult emergence was significantly reduced at 5 percent level when lar-

Table 6. Effect of powdered plant products on fecundity of adult of *C. cephalonica.*

Dose (Parts per 100 parts of grain w/ w)	No. of egg laid/ female (fecundity)*										
	Dharak kernel powder	Neem kernel powder	Dharak leaf powder	Karanj kernel powder	Neem leaf powder	Aak leaf powder	Datura leaf powder	Citrus leaf powder	Podina leaf powder	Tulsi leaf powder	Mean
1.0	100.33	104.33	109.66	116.66	118.66	126.33	133.33	142.33	150.66	159.33	126.16
2.5	80.00	85.66	88.00	95.33	92.00	100.00	98.00	115.66	112.00	123.33	98.90
5.0	60.66	67.00	70.33	75.00	79.33	82.66	85.66	88.00	90.33	94.66	79.36
Mean	80.33	85.66	89.33	95.66	96.66	103.00	105.66	115.33	117.66	125.44	
Control	170.00										

	SEm+	C.D. at 5%	C.V. %
Treatment	1.62	4.57	
Dose	0.89	2.50	4.68
Treatment x Dose	2.80	7.91	

*Data based on 75 individuals (Three replications of 25 in each).

vae of *C. cephalonica* were exposed to grains treated with karanj, neem and castor oils (0.5 and 0.1%). Patel and Patel (2002) observed mixing of *Neem* and eucalyptus leaf powder at 2 percent and mustard oil at 0.5 percent were interfere with adults emergence, development period and growth index of the pest as well as weight loss of grains.

Effect on ovipositional period: In the present investigations, all the doses of different plant powders were significantly better at 5 percent level in reducing the oviposition period of test insect.

The minimum ovipositional period were observed in dharak kernel powder (4.57), which was at par with dharak leaf (4.57), karanj kernel (4.59), neem kernel (4.69) and neem leaf powder (4.73), while podina leaf powder (5.71) was proved least effective (Table 4). The present findings. are in conformity with Patel and Patel (2007), Mukanga *et al.* (2010), Pathak and Tiwari (2010[a]), Khani *et al.* (2013), Shukla and Tiwari (2012) who found that neem seed and kernel extract, karanj kernel extract, guava and other plant products at the rate of 0.1, 0.5, 0.1, 2.5 and 5.0 g/ 100 g seeds were effective against immature stages of *C. cephalonica* and other stored grain pests.

Effect on fecundity: In the present investigations, all the doses of different plant powders were significantly better at 5 percent level in reducing the egg laying capacity of test insect over control. The test insect developed on seeds treated with dharak kernel powder laid significantly minimum at 5 percent level number of eggs (80.33) over rest of treatments are given in Table 5. The results of present investigation get corroborated with the observations of Khan and Thakare (1997) and Patel and Patel (2002) who reported that the adult emergence and egg laying capacity were significantly reduced when larvae of C. cephalonica were exposed to grains treated with karanj, neem and castor oils (0.5 and 0.1%). . This reduction in fecundity may be attributed the toxic effect of the tested all plant powders in the experiment, the fine powder may also cause physical injury and block the spiracles, thereby affecting the normal physiology of the insects. Deterent and inhibition on egg hatchabilities of citrus leaf powder on oviposition of *C. maculates* was reported by Don-Pedro (1985) and insecticidal action of neem seed acetone extract against the life cycle stages of *C. cephalonica* was reported by Pathak and Tiwari (2012), which support the present findings.

Effect on egg viability: All the doses (1.0, 2.5 and 5.0 g/ 100 g seeds) of different plant powders were significantly better at 5 percent level in reducing the egg viability over control. The maximum (55.16) and minimum (25.95) reduction in egg viability were observed in dharak kernel powder and tulsi leaf powder, respectively (Table 6). Pandey *et al.* (1985) and Meena and Bhargava (2010) reported significant reduction in egg hatchability of *C. cephalonica* by the treatments of neem kernel powder and neem leaf powder at the dose level of 1.0 g /100 g seeds, which support the present findings.

Effect on longevity of male and female adults: The effect of powdered leaves and kernels on the longevity of both adults of test insect was also observed in the present study. It is apparent from the data that the longevity of male and female adults gradually decreased with the increase in dose level of the treatments. Assessing the results of different plant powders, it was observed that the dharak kernel powder and neem kernel powder were the most effective in reducing the longevity of male and female adults (Table 7). Not much work is available on the effect of plant powders and on the longevity of male and female adults, however, Pandey *et al.* (1985), Khan and Thakare (1997) and Jain and Kumar (2001) found significant effect at 5 percent level of neem kernel powder and neem leaf powder on the longevity of male and female adults of *C. cephalonica*, which support the present findings. Pacheco *et al.* (1995) and Rajapakse and Vanemden (1997) have also demonstrated the effectiveness of treatment with neem, soybean and castor oils at the rate of 0, 5 and 10 ml/ kg seeds different oils against *Callosobruchus maculates* in reducing longevity and egg lying without affecting the germination of seeds, which support the present findings. Yadav *et al.* (2011)

Table 7. Effect of powdered plant products on longevity of male and female adults of *C. cephalonica.*

Dose (Parts per 100 parts of grain w/w)	Longevity of male and female adult (days)*																					
	Dharak kernel powder		Neem kernel powder		Dharak leaf powder		Karanj kernel powder		Neem leaf powder		Aak leaf powder		Datura leaf powder		Citrus leaf powder		Podina leaf powder		Tulsi leaf powder		Mean	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
1.0	4.60	5.00	5.60	5.30	6.00	5.60	5.90	6.60	6.00	6.00	6.00	6.30	6.60	6.90	6.60	6.60	6.30	7.60	6.90	7.60	6.01	6.35
2.5	4.00	4.60	5.30	5.00	5.00	5.30	5.30	6.30	5.60	5.60	5.60	6.00	6.00	6.60	6.30	6.30	6.00	7.30	6.60	7.60	5.96	6.06
5.0	3.30	4.30	4.50	4.60	4.60	4.30	4.60	5.00	5.00	5.30	5.30	5.60	5.60	5.60	5.30	6.00	5.60	7.00	5.90	7.30	5.08	5.50
Mean	3.96	4.63	5.13	4.97	5.20	5.07	5.27	5.97	5.53	5.63	5.63	5.97	6.06	6.37	6.06	6.30	5.96	7.30	6.46	7.50		

Control (male) 7.00, (female) 8.60

	Male			Female		
	SEm+	C.D. at 5%	C.V. %	SEm+	C.D. at 5%	C.V. %
Treatment	0.14	0.41		0.08	0.21	
Dose	0.08	0.22	7.63	0.04	0.12	3.91
Treatment x Dose	0.25	0.71		0.13	0.37	

*Data based on 75 individuals (Three replications of 25 in each). M = Male, F = Female

also found effective of different botanical pesticides like neem, karanj, castor, tulsi as both powder and oil form on the development of *C. cephalonica.,*support the present findings.

Effect of plant powders on germination of sorghum seeds: In the present study, the effect of ten plant powders on germination of sorghum seeds revealed that no significant harmful effect was observed after 0, 90 and 150 days of treatment. It indicated that there was no adverse effect of any dose of all plant powders on the germination of sorghum seeds at any interval. The present observations are in agreement with those of Prakash *et al.* (1984), Yadav and Bhatnagar (1987) and Chiranjeevi (1991) who found no adverse effect of different plant powders on germination of different grains. Pacheco *et al.* (1995) and Rajapakse and Vanemden (1997) have also demonstrated the effectiveness of treated with different plant products oils against *Callosobruchus maculates* in reducing longevity and egg lying without affecting the germination of seeds, support the present findings.

Conclusion

The present study concluded that different plant powders *viz.,* dharak kernel and leaf (*Melia azadirach* L.), neem kernel and leaf (*A. indica* Adr. Juss), karanj kernel (*P. glabra*), aak leaf (*C.s procera* Br.), datura leaf (*D. alba* Nees.), citrus leaf (*C. lemon* L.), podina leaf (*M. arvensis*) and tulsi leaf (*O. sanctum* L.) were compared, at three rate of application (1.0, 2.5 and 5.0 g per 100 g seeds), tested as natural organic insecticide as well as grain protectants have the potential in development of post-harvest protection technology against *C. cephalonica*, the major pest of stored grains. The kernel and leaf powders of these plants were tested for their effect on the biology of *C. cephalonica* such as larval period, pupal period, ovipositional response, reduction in adult emergence, fecundity, egg viability and longevity of adults. The maximum (77.83) and minimum (37.83) percent reduction in adult emergence was observed in dharak kernel powder and tulsi leaf powder, respectively. Leaf powders suppressed the emergence of *C. cephalonica* populations in stored food grains. The reproduction potential was reduced but not completely inhibited. The effect was observed to be plant specific and dose related. Dharak kernel,, neem kernel and leaf powder showed excellent reproduction and growth inhibitory effect. The mean percent reduction in egg viability ranged from 25.95 to 55.16 percent and 36.78 to 47.43 percent in different doses and treatments, respectively. The repellency effect of the powders was sustained throughout the study period. In general, the amounts and toxicity of the compounds in the leaf, kernel powders will depends on the maturity of the plants, the season (temperature, photoperiod, hygrometry) and the geographical and pedological conditions. Besides exhibiting the repellency, antifeeding and reproduction inhibition effects, the kernel and leaf extract exhibited vapour and con-

tact toxicity on *C. cephalonica.* The presence of toxicants and growth inhibitors in these plants suggest good potential for their use in storage pest management especially farm stored grain. It is recommended that other doses and other plants should be used later to try and produce a range of organic insecticides that can be used at any time when the pest occurs.

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