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Estimation of grain damage and weight loss by *Callosobruchus chinensis* L. in pigeon pea in storage

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Abstract
The experiment was conducted at the Department of Entomology, Post Graduate College of Agriculture of Dr. Rajendra Prasad Central Agricultural University, Pusa, (Bihar) during two consecutive years *i.e*., 20220-2021 and 2021-2022 in completely Randomised Block Design with ten treatments and three replications. Each treatment consisting of 50 g of pigeon pea seeds in a plastic jar to which five pairs of adults were released in order to estimate the grain damage and weight loss. The observations were recorded at 30, 60, 90 and 120 days after insect release (DAIR). On the basis of pooled mean of the two years data, the lowest per cent grain damage and weight loss were recorded 0.87, 1.19, 2.14, 3.14 and 0.54, 0.65, 1.38, 1.81 per cent at 30, 60, 90 and 120 DAIR, respectively when seeds were treated with cypermethrin (10EC) @ 0.05 ml/kg seed as against untreated control (15.56, 36.37, 57.10, 74.89 % and 10.43, 16.03, 32.27 and 55.51 % grain damage and weight loss at 30, 60, 90 and 120 DAIR, respectively. All the treatments were found significantly superior over untreated control.

Keywords: *Callosobruchus* chinensis, grain damage, cypermethrin

Introduction
Pulses are the important major source of dietary proteins for human consumption in India and many other parts of the world. Because of their richness of proteins, vitamins and minerals and availability at a reasonable price to the poor people, considered as "Poor man's meat". Apart from human consumption, they are also important for the management of soil fertility due to their nitrogen fixing ability (Kantar *et al.* 2007) [1]. Among the pulses, pigeon pea [*Cajanus cajan* (L.)] is the one of the crucial grain legume crops in the sub-tropical and tropical regions of the world. Globally, it is cultivated in about 82 countries in an area of 5.40 Mha with a production of 4.49 million tonnes and an average productivity of 829 kg ha^{-1} (FAOSTAT, 2016) [2]. In India, it is cultivated in an area of 4.55 Mha with production of 3.31 Mt and 729 kg ha^{-1} productivity. Pigeon pea accounts for 20.54% share to the total production of pulses in India (Directorate of Economics and Statistics, 2017) [3].

Among the various insect pests attacking pigeon pea, the pulse beetles are vital insect pests attacking both in field condition as well as in storage (Bhalla *et al*. 2008) [4]. In storage, *Callosobruchus chinensis* caused around 40-50% losses (Gosh and Durbey, 2003) [5] leading to major constraint in large storage and small-scale traditional storage by farmers. Damage is caused by appearance of circular holes bored by the grubs while entering inside the seed and consume the inner contents of the grains which makes unfit for human consumption. Generally, fumigants and also synthetic insecticides are used for the management of storage insect pests (Atwal and Dhaliwal, 2005) [6] which possess many unwanted side effects and constraints. Use of synthetic insecticides in a haphazard manner for the control of storage insect pest mainly pulse beetle may lead to various health hazards and also elimination of beneficial insects and expansion of application cost. (Singh *et al*. 2001) [7].

Many other problems such as pest resurgence, genetic resistance, photo toxicity, residual toxicity, vertebrate toxicity and environmental hazards of the currently use chemical pesticides have directed the need for search of effective and biodegradable pesticides (Talukder and Howse, 2000) [8]. This consciousness has globally created interest in the evolution of alternative strategies and methods, together with the re-exploring of plant-based derivatives against storage insect pests. Plant derived materials are biodegradable, less toxic to mammals, more selective in action and may slow down the development of resistance as compared to

synthetic insecticides. Their main good point is that they are cheaply and easily produced by farmers and small enterprises as crude or partially refined extracts. In the last two decades, substantial efforts have been made in finding out plants possessing insecticidal properties and development of botanical insecticides against storage pests.

Materials and methods

An experiment was conducted on "estimation of grain damage and weight loss in stored pigeon pea caused by *Callosobruchus chinensis" i*n the Department of Entomology, Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar during the two consecutive years *i.e*., 2020-2021 and 2021-2022.

Rearing technique of test insect

Prior to release of the test insect, *Callosobruchus chinensis*, disinfestation of the host grains was done using Celphos fumigation @3 tablets (9grams) per tonnes for 72 hours and remain in open air (24 hours) for eliminating in the hidden infestation, if any. Twenty pairs of adult beetles (one day old) were released in jars and covered the mouth with muslin cloth and tightened with rubber band. The jars were kept in ambient condition in laboratory for continuous supply of beetles throughout the experiment. The newly emerged pulse beetle from the stock culture were used for the experiments.

Observations

The experiment was carried out on pigeon pea seeds. A total of ten treatments (including untreated control) were taken to evaluate their efficacy against *Callosobruchus chinensis*. Insect free healthy seeds with no eggs of pulse beetle were selected and taken into consideration for the experiment. The experiment was conducted in completely randomized block design and replicated three times. Fifty grams seeds of pigeon pea were weighed and put in the plastic jar and the required quantity of insecticides/plant products were measured and mixed thoroughly by shaking the jar to cover a thin film uniformly around the seeds. Five pairs of freshly emerged adult beetles were transferred into each plastic jar and covered with muslin cloth and fastened with rubber bands. After 10 days, the adult beetles were removed and the containers containing the exposed grains were kept at room temperature for emergence of adults. The data on percent grain damage and percent weight loss were recorded at different days interval *viz*., 30, 60, 90 and 120 days after release of insects.

From the representative sample of each treatment, total number of grains and damaged grains were counted and put through the formula given by Quitco and Quindoza (1986) [9].

$$\text{Percent grain damage} = \frac{\text{Total number of damaged grains}}{\text{Total number of grains}} \times 100$$

Assessment of percent weight loss was conducted from 25 g of each sample. Separation of damaged and undamaged portion were done and counted. Each portion was weighed using electrical weighing balance and subjected to the formula given by Adams and Schulten (1978) [10].

$$\text{Percent weight loss} = \frac{\{(UNd)-(DNu)}{\{U(Nd+Nu)\}} \times 100$$

Where,

U= weight of undamaged grains

Nu= Number of undamaged grains

D= Weight of damaged grains

Nd= Number of damaged grains

Results and Discussion

The data pertaining to the grain damage in pigeon pea treated with various protectants at 30, 60, 90 and 120 days after insect release during the year, 2020-2021 and 2021-2022 and pooled data of both the years are presented in Table 1 and 2, respectively. Also, data on per cent weight loss of pigeon pea during the two years study period is shown in Table 3 and 4.

Effect of botanicals and insecticides on grain damage in pigeon pea against *C. chinensis*.

Results on effect of various protectants on percent grain damage revealed that there was significant increase in percent grain damage with increase in the storage period in both the study period *i.e*., 2020-2021 and 2021-2022 as shown in Table 1 and all the treatments proved to be superior over control.

During the first year (2020-2021), there was less significant difference in per cent grain damage at 30 days after insect release. It was observed that cypermethrin (10 EC) @ 0.05 ml/kg seed proved to be the most efficient with 0.79 per cent grain damage which was followed by spinosad (45 SC) @ 4 ppm/kg seed (1.59%) as next best treatment. Mustard oil @ 5 ml/kg seeds also gave maximum protection among oils with 1.98 per cent which was statistically at par with turmeric leaf oil @ 5 ml/kg of seed (2.06%) and garlic extract @ 5% (3.13%). Neem oil @ 5 ml/kg seeds and NSKE @5 ml/kg seed provided intermediate protection with 3.80 and 5.07 per cent grain damage, respectively. Among the treatments, YBSE @ 5 ml/kg seed and YBSP @ 5 g/kg seed provided lowest protection with percent grain damage 6.95 and 8.07 per cent, respectively. All the treatments were found to be superior over control (14.96%) as shown in Table 1.

At 60, 90 and 120 days after insect release, the same trend in the damage scenario was observed after 30 days after inside release. Minimum percent damage was recorded in Cypermethrin (10 EC) @ 0.05 ml/kg seed treated pigeon pea seeds *viz*., 0.95, 1.90 and 2.85 per cent at 60, 90 and 120 days, respectively (Table 1). Spinosad (45 SC) @ 4 ppm/kg seed and mustard oil @ 5 ml/kg seed at their respective doses were also found lowest damage by *Callosobruchus chinensis.* Spinosad (45 SC) @ 4 ppm/kg seeds was next best treatment (2.40, 3.50 and 5.41 % damage at 60, 90 and 120 days). YBSP @ 5 g/kg seeds was the least effective among all treatments at 60, 90 and 120 days with 16.74, 25.63 and 27.36 %, respectively as against untreated control (14.96, 35.03, 53.50 and 73.25 % at 30, 60, 90 and 120 days after insect release.

During the second year (2021-2022), it was observed that there was same trend in the damage to that of the first year while cypermethrin (10 EC) @ 0.05 ml/kg treated seeds recording minimum damage (0.95%). It was observed that treatment with spinosad (45 SC) @ 4ppm/kg, mustard oil @ 5ml/kg and turmeric leaf oil @ 5 ml/kg were statistically at par with values recording 2.06, 2.37 and 2.75 per cent damage, respectively. At 90 days after insect release, Cypermethrin 10 EC@ 0.05 ml/kg treated seeds recorded minimum per cent grain damage (2.39) while the least effective treatment was recorded in YBSP @ 5 g/kg (29.07) which was statistically at par with YBSE @ 5 ml/kg (27.65).

While at 120 DAIR, damage recorded in Spinosad 45 SC@ 4 ppm/kg treated seeds (6.69) was found to be statistically similar with mustard oil (7.48). Also, highest was recorded in YBSP @ 5 g/kg (29.54) which was on par with YBSE @ 5 ml/kg (28.91) as shown in Table 1. Pooled mean analysis of both the years have been shown in Table 2, which followed the same trend in per cent grain damage with that of the first and second year.

From the above results, it clearly showed that all the grains protectants showed superior performance over control. Safer insecticides such as cypermethrin and spinosad provided better protection as compared to oils and other botanicals. The present findings were supported by work done by Vishwamitra *et al*. (2014) [11] who also reported that use of synthetic pyrethroid *i.e*., deltamethrin 2.8 EC @ 0.04 ml/kg seeds and spinosad provided maximum protection in stored pigeon pea against *Callosobruchus chinensis* with no egg laying thus no damage on grain while spinosad treated seeds recorded so less damage with only 0.7%. Also, work done by Kobir *et al*. (2019) [12] reported that mustard oil is effective in reducing the grain damage by pulse beetle recording 0.37, 0.55, 0.97, 2.15 % at 30, 60, 90 and 120 days after insect release. Similar results were also shown by Venkatesham *et al.* (2014) [13] who reported mustard oil as the best effective treatment among oils against pulse beetle which also supported the present findings.

Effect on per cent weight loss

The data recorded in per cent weight loss of grains revealed that per cent damage is directly correlated to the per cent weight loss of pigeon pea seeds damaged by pulse beetle. Per cent weight loss ranged from 0.38 to 9.95 at 30 DAIR and 1.53 to 54.11 at 120 DAIR as shown in Table 3. It was observed that in the first-year study (2020-2021), in all four months *i.e*., 30, 60, 90 and 120 DAIR, cypermethrin 10 EC@ 0.05 ml/kg treated seeds recorded minimum weight loss (0.38, 0.58, 1.23 and 1.53, respectively). At 30 DAIR, per cent weight loss in mustard oil (1.14) treated seeds was on par with turmeric leaf oil @ 5 ml/kg (1.27). Maximum per cent weight loss was recorded in YBSP @ 5 g/kg (23.19) at 120 DAIR which was statistically alike with YBSE @ 5 ml/kg (22.32) at 120 days after insect release and found to be superior over control (54.11).

During the second year trial (2021-2022), per cent weight loss ranged from 0.70 to 10.92 at 30 days after insect release and 2.11 to 56.91 at 120 days after insect release (Table 2). At 30 DAIR, there was less difference among all the treatments but proved to be superior over control (10.92). Treatment with cypermethrin 10 EC @ 0.05 ml/kg (0.70) was at par with spinosad 45 SC @ 4 ppm/kg (0.92) At 60, 90 and 120 days, cypermethrin 10 EC @ 0.05 ml/kg proved be the best treatment recording least per cent weight loss with 0.73, 1.54 and 2.11, respectively. At 120 days, weight loss in spinosad 45 SC @ 4 ppm/kg (4.67) treated seeds recorded as next best treatment and was found to be at par with mustard oil @ 5 ml/kg (5.04) which was followed by turmeric leaf oil @ 5 ml/kg (15.93), garlic extract @ 5% (17.14), neem oil @ 5 ml/kg (20.53), NSKE @ 5 ml/kg (22.49), YBSE @ 5 ml/kg (23.89) and YBSP @ 5 ml/kg (25.32). All the treatments were proved to be significantly superior over untreated control (56.91). Pooled mean analysis of both the study period recorded same trend in the per cent weight loss with least in cypermethrin (0.54) and maximum in YBSP (5.86) at 30 DAIR. Similar trend was observed in 60, 90 and 120 DAIR and all the treatments were proved t be superior over control as shown in Table 4.

The present findings are in line with the work done by Ashok *et al*. (2020) [14] who recorded that there was minimum seed damage and weight loss in deltamethrin treated seeds recording 0.33% and 2.67%, respectively at 15 days of storage and also at 30 days of storage period (1.67 and 6.33 %). Similar results were shown by work done in pigeon pea by Pandey *et al*. (2013) [15] and Tripathi *et al*. (2003) [16]. Work done by Kobir *et al.* (2020) [17] reported that mustard oil @ 3 ml/kg seeds gave effective protection against pulse beetle with minimum weight loss of 0.48, 0.64 and 0.89% at 30, 60 and 90 days after treatment. Similar results were shown by work conducted by Khanzada *et al*. (2012) [18].

Table 1: Efficacy of botanicals and insecticides on grain damage by *Callosobruchus chinensis* in pigeon pea during 2020-2021 and 2021-2022.

Treatment	Treatments	*Average grain damage (%)							
		30 DAIR		60 DAIR		90 DAIR		120 DAIR	
		2020-2021	2021-2022	2020-2021	2021-2022	2020-2021	2021-2022	2020-2021	2021-2022
T_1	Mustard oil	1.98(7.92)**	2.37 (8.86)	3.33 (10.50)	4.14 (11.70)	4.59 (12.34)	6.45 (13.21)	6.49 (14.73)	7.48 (15.83)
T2	Neem oil	3.80 (11.24)	4.80 (12.65)	11.27 (19.61)	12.54 (20.73)	18.45 (25.43)	20.42 (26.85)	23.22 (28.79)	24.68 (29.75)
T3	Garlic extract	3.13 (10.19)	3.95 (11.46)	9.55 (17.98)	10.77 (19.15)	17.06 (24.38)	18.87 (25.73)	21.33 (27.50)	22.34 (28.19)
T4	Turmeric leaf oil	2.06 (8.25)	2.75 (9.54)	8.22 (16.66)	9.31 (17.75)	15.82 (23.42)	16.81 (24.85)	19.36 (26.09)	20.50 (26.91)
T5	YBSE	6.95 (15.28)	8.05 (16.48)	15.49 (23.17)	17.37 (24.62)	24.84 (29.87)	27.65 (31.71)	25.93 (30.60)	28.90 (32.51)
T6	YBSP	8.07 (16.49)	9.33 (17.77)	16.61 (24.04)	18.80 (25.69)	25.63 (30.40)	29.07 (32.61)	27.36 (31.52)	29.54 (32.91)
T7	Spinosad	1.59 (7.23)	2.07 (8.26)	2.54 (9.11)	3.34 (10.45)	3.50 (10.74)	4.93 (12.81)	5.41 (13.41)	6.69 (14.97)
T8	Cypermethrin	0.79 (5.11)	0.95 (5.47)	0.95 (5.58)	1.43 (6.80)	1.90 (7.90)	2.39 (8.87)	2.85 (9.70)	3.34 (19.51)
T9	NSKE	5.07 (13.01)	6.22 (14.44)	12.36 (20.57)	13.90 (21.88)	19.85 (26.45)	22.12 (28.04)	23.96 (29.29)	26.03 (30.66)
T10	Untreated Control	14.96 (22.74)	16.16 (23.69)	35.03 (36.27)	37.72 (37.87)	53.50 (46.99)	60.70 (51.16)	73.25 (58.83)	76.54 (61.01)
CD (P=0.05)		0.37	0.83	0.83	1.31	1.31	1.46	1.46	1.55
S.Em (±)		0.12	0.28	0.28	0.44	0.44	0.49	0.49	0.52
CV		1.84	3.77	3.77	3.89	3.89	3.31	3.31	3.19

Table 2: Efficacy of botanicals and insecticides on grain damage by *Callosobruchus chinensis* in pigeon pea based on pooled mean data of two years 2020-2021 and 2021-2022.

S. No.	Treatments	*Average grain damage (%)			
		30 DAIR	60 DAIR	90 DAIR	120 DAIR
1	Mustard oil	2.14(8.40) **	3.73 (11.13)	5.52 (12.80)	6.99 (15.31)
2	Neem oil	4.30 (11.97)	11.91 (20.18)	19.44 (26.14)	23.95 (29.28)
3	Garlic extract	3.54 (10.84)	10.16 (18.57)	17.96 (25.06)	21.83 (27.85)
4	Turmeric leaf oil	2.40 (8.91)	8.77 (17.21)	16.32 (24.14)	19.93 (26.50)
5	YBSE	7.50 (15.89)	16.43 (23.90)	26.24 (30.80)	27.42 (91.56)
6	YBSP	8.70 (17.14)	17.71 (24.88)	27.35 (31.52)	28.45 (32.21)
7	Spinosad	1.83 (7.76)	2.94 (9.87)	4.22 (11.84)	6.05 (14.24)
8	Cypermethrin	0.87 (5.34)	1.19 (6.24)	2.14 (8.42)	3.10 (10.12)
9	NSKE	5.65 (13.74)	13.13 (21.24)	20.99 (27.26)	25.00 (25.98)
10	Control	15.56 (23.22)	36.37 (37.08)	57.10 (49.07)	74.89 (59.91)
CD (P=0.05)		0.42	0.61	0.81	1.00
S.Em (±)		0.14	0.20	0.27	0.33
CV		1.99	1.89	1.92	2.10

DAIR: Days after Insect Release
*Mean of three replications
** Figures in parentheses are angular transformed values

Table 3: Efficacy of botanicals and insecticides on weight loss by *Callosobruchus chinensis* in pigeon pea during 2020-2021.

Treatment.	Treatments	*Per cent weight loss (%)							
		30 DAIR		60 DAIR		90 DAIR		120 DAIR	
		2020-2021	2021-2022	2020-2021	2021-2022	2020-2021	2021-2022	2020-2021	2021-2022
T_1	Mustard oil	1.14 (6.12)**	1.32 (6.58)	1.62 (7.31)	1.98 (8.07)	2.98 (9.94)	4.45 (12.17)	4.51 (12.23)	5.04 (12.94)
T2	Neem oil	1.94 (8.01)	2.49 (9.08)	8.45 (16.90)	9.66 (18.10)	14.37 (22.27)	15.83 (23.44)	18.57 (25.51)	20.53 (26.91)
T3	Garlic extract	1.56 (7.17)	2.06 (8.26)	6.50 (14.76)	7.64 (6.19)	13.79 (21.79)	14.64 (22.47)	16.54 (23.99)	17.15 (24.45)
T4	Turmeric leaf oil	1.27 (6.46)	1.61 (7.28)	5.46 (13.51)	6.19 (14.38)	12.21 (20.44)	13.64 (21.66)	15.15 (22.90)	15.93 (23.52)
T5	YBSE	4.47(12.20)	5.23 (13.22)	12.42 (20.63)	14.09 (22.04)	20.07 (26.61)	21.96 (27.93)	22.32 (28.17)	23.89 (29.25)
T6	YBSP	5.41 (13.44)	6.32 (14.55)	13.26 (21.35)	15.14 (22.89)	22.05 (28.00)	24.65 (29.76)	23.19 (28.77)	25.32 (30.20)
T7	Spinosad	0.74 (4.92)	0.92 (5.50)	1.39 (6.75)	1.66 (7.39)	2.37 (8.84)	3.23 (10.34)	3.75 (11.12)	4.67 (12.47)
T8	Cypermethrin	0.38 (3.53)	0.70 (4.81)	0.58 (4.35)	0.73 (4.87)	1.23 (6.26)	1.54 (7.11)	1.53 (7.09)	2.11 (8.34)
T9	NSKE	3.26 (10.40)	4.33 (12.00)	9.03 (17.48)	10.18 (18.60)	15.27 (23.00)	16.77 (24.16)	19.07 (25.88)	22.49 (28.30)
T10	Untreated Control	9.45 (18.38)	10.91 (19.29)	15.37 (21.07)	16.70 (24.11)	30.57 (33.56)	33.97 (35.64)	54.12 (47.34)	56.91 (48.95)
CD (P=0.05)		0.20	0.28	0.52	0.59	0.84	0.87	1.11	1.28
S.Em (±)		0.07	0.09	0.18	0.20	0.28	0.29	0.38	0.43
CV		1.29	1.62	2.07	2.21	2.44	2.36	2.79	3.04

DAIR: Days after Insect Release
*Mean of three replications
** Figures in parentheses are angular transformed values

Table 4: Efficacy of botanicals and insecticides on weight loss by *Callosobruchus chinensis* in pigeon pea based on pooled mean data of two years 2020-2021 and 2021-2022.

S. No	Treatments	*Per cent weight loss			
		30 DAIR	60DAIR	90DAIR	120DAIR
1	Mustard oil	1.22 (6.36)**	1.78 (7.70)	3.71 (11.11)	4.77 (12.59)
2	Neem oil	2.21 (8.55)	9.05 (17.51)	15.10 (22.86)	19.55 (26.22)
3	Garlic extract	1.81 (7.73)	7.07 (15.41)	14.21 (22.13)	16.84 (24.22)
4	Turmeric leaf oil	1.43 (6.88)	5.82 (13.96)	12.92 (21.06)	15.54 (23.21)
5	YBSE	4.85 (12.72)	13.25 (21.34)	21.01 (27.28)	23.10 (28.72)
6	YBSP	5.86 (14.00)	14.20 (22.13)	23.35 (28.88)	24.25 (29.49)
7	Spinosad	0.82 (5.22)	1.52 (7.09)	2.84 (9.62)	4.20 (11.83)
8	Cypermethrin	0.54 (4.22)	0.65 (4.62)	1.38 (6.71)	1.81 (7.76)
9	NSKE	3.79 (11.23)	9.60 (18.05)	16.02 (23.59)	20.78 (27.11)
10	Control	10.43 (18.84)	16.03 (23.60)	32.27 (34.60)	55.51 (48.15)
CD (P=0.05)		0.13	0.37	0.71	0.91
S.Em (±)		0.04	0.12	0.24	0.31
CV		0.81	1.45	2.00	0.21

DAIR: Days after Insect Release
*Mean of three replications
** Figures in parentheses are angular transformed values

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