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Research Article

Bio-efficacy of Various Organic Products Against Pulse Beetle on Chickpea

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Abstract

The College of Agriculture at Nagpur conducted a laboratory experiment in 2015-2016 to study the effectiveness of various organic products in protecting chickpea seeds from pulse beetles. The experiment involved treating chickpea seeds with black pepper powder, vekhand powder, neem oil, castor oil, sesame oil, groundnut oil, and spinosad 45 SC. The study recorded observations on seed damage, weight loss, germination, oviposition, and adult emergence at 30, 60, 90, and 120-day intervals. The results showed that spinosad 45 SC, neem oil, and vekhand powder were effective in protecting the seeds, with neem oil being the most effective and cost-efficient option. These organic products were found to be safe for users and the environment.

Keywords: Cicer Arientinum; Neem Oil; Vekhand Powder; Spinosad; Callosobruchus Chinensis

Introduction

Pulses are often referred to as the unique jewels of Indian agriculture. They play a crucial role in the Indian diet, serving as the primary source of protein for the predominantly vegetarian population. Rich in energy, minerals, and vitamins, pulses are vital in combating malnutrition. In India, pulse production stands at approximately 18.5 million tonnes [1].

Chickpea (*Cicer arietinum*), a cool-season legume, is cultivated in several countries as a significant food source. The seeds, which are the main edible part of the plant, provide an excellent source of protein, carbohydrates, and minerals, especially for vegetarians. Like other legume crops, chickpea fixes atmospheric nitrogen through its symbiotic relationship with Rhizobium species, thereby enhancing soil quality for subsequent cereal crop cultivation. Chickpea is the third most important food legume globally, with India being the largest producer, contributing to 65% of the world's chickpea production [7].

Despite being the largest producer of chickpeas, India still imports this legume due to low productivity. To meet the ever-increasing demand, it is essential to improve production and expand the area under cultivation while minimizing stress on the crop. There are two recognized types of chickpeas: the white-seeded "Kabuli" and the brown-seeded "Desi." Kabuli chickpeas are relatively larger with thinner seed coats, while Desi chickpeas are smaller with thicker seed coats. The Desi type accounts for approximately 80% of total production, with Kabuli making up the remaining 20 per cent.

India is the world's largest producer of chickpeas. During the 2009-10 season, there was a significant increase in the area dedicated to chickpea cultivation, reaching 8.25 million hectares, resulting in a production of 7.48 million tonnes [8]. In Andhra Pradesh, the increase in chickpea area was particularly dramatic, expanding to 71,000 hectares. In the 2014-15 season, the total world production of pulses reached 65.5 million tonnes [2].

After harvesting pulse crops, farmers typically store the seeds throughout the year for sowing in the next season. However, these stored seeds are vulnerable to insect attacks. Among the various insects that infest pulses, species of *Callosobruchus*, belonging to the family Bruchidae, are particularly harmful. These insects are some of the most destructive pests of stored pulse grains globally. The genus *Callosobruchus* infests grain legumes in both pre- and post-harvest stages worldwide.

The insects spend their entire immature life within individual legume seeds, causing weight loss, reducing germination potential, and diminishing both the market and nutritional value of the grains. Bruchids attack leguminous pods in the field, from where they are subsequently transported to storage facilities.

Ovipositing females glue each egg to the seed coat. Upon hatching, the grub chews its way into the seed directly beneath the oviposition site, leaving the upper surface of the egg chorion intact on the seed. The grub destroys the endospermic portion of the seed, leaving only the seed coat. Pulse beetles are internal feeders that multiply rapidly under storage conditions, with as many as 8-10 or more grubs developing within a single seed. Heavily damaged legume seeds are riddled with emergence holes and defaced with egg covers, resulting in significant losses.

Typically, pesticides are used to control insect pests. However, due to their drawbacks related to toxicity and residual effects, researchers are exploring alternative pest control methods. The use of locally available indigenous plant materials for pest control is an ancient technology employed in many parts of the world [20]. The pest-controlling efficacy of many plant derivatives has already been proven against several storage pests [13,15]. These methods have a lower environmental impact in terms of insecticidal hazards and can benefit the agricultural sector. Moreover, botanical pesticides are cheaper, and easy to process, and raw materials are readily available at the village level.

Seed treatment with insecticides to protect against pulse beetles is one method, but toxic chemicals pose serious problems, including chronic and acute toxicity, residual toxicity hazards, and the development of resistance in insects. Among the various methods used to prevent and control stored grain pests, the use of vegetable oils as grain protectants has many advantages over insecticides. They do not have mammalian toxicity or health hazards, are less expensive, easily available, and easy to handle under storage conditions. Therefore, this study aims to evaluate the relative efficacy of various organic products for the safe storage of chickpea grains against *C chinensis* under laboratory conditions.

Material and Methods

The experiment titled "Bioefficacy of Various Organic Products Against Pulse Beetle on Chickpea" was conducted in the Biocontrol Laboratory of the Entomology Section at the College of Agriculture, Nagpur, Maharashtra, October to January 2015-2016, for 120 days. The study followed a Completely Randomized Design with three replications and eight treatments. Initially, infested chickpea seeds were obtained from the college farm stores and reared in the laboratory to cultivate the pulse beetle, *C. chinensis*. The identification key for *Callosobruchus* spp. provided by [16] was used.

Gunny bags with a capacity of 1 kg were used as storage containers for the infested seeds, which had 8% moisture content. After treating the seeds with different organic materials, they were placed in the gunny bags, and a separate lot of untreated seeds was also maintained. Three pairs of freshly emerged pulse beetles (*C. chinensis*) were introduced into each bag using a camel hairbrush, and the bags were tied with jute twine. Observations were recorded at 30, 60, 90, and 120 days after treatment (DAT) on the number of eggs laid, number of adults that emerged, percentage of seeds damaged, percentage weight loss of seeds, and germination percentage. The data were analyzed using statistical methods.

Results and Discussion

Effect of organic products on oviposition of C. chinensis in chickpea

The data on the average number of eggs laid by *C. chinensis* on 100 chickpea seeds treated with various organic and chemical products are presented in table 1.

Observations on oviposition at 30 days after seed treatment indicated that the insecticide Spinosad 45 SC at 0.3 ml/kg seeds (T_7) recorded the lowest number of eggs per 100 seeds, with an average of 1.66 eggs. This result was statistically similar to the treatments with neem oil at 5 ml/kg seeds (T_3), which recorded 2.33 eggs, and vekhand powder at 5 g/kg seeds (T_5), which recorded 5.33 eggs per 100 seeds. The next most effective treatments were vekhand powder (T5 - 5.33 eggs), castor oil (T_2 - 10.66 eggs), sesame oil (T_1 - 11.33 eggs), and groundnut oil (T4 - 14.33 eggs), all of which were statistically similar to each other. Specifically, castor oil (T_2) with

10.66 eggs, sesame oil (T_1) with 11.30 eggs, groundnut oil (T_4) with 14.33 eggs, and black pepper powder (T_6) with 17.66 eggs per 100 seeds were all found to be statistically comparable. The highest number of eggs was observed in the untreated control (T_8), which recorded 37.66 eggs per 100 seeds.

The observations on oviposition at 60 days after seed treatments showed that the treatment with Spinosad 45 SC at 0.3 ml/kg seeds (T_7) recorded significantly fewer eggs per 100 seeds, with an average of 4.33 eggs. This was statistically similar to the treatments with neem oil at 5 ml/kg seeds (T_3), which recorded 6.00 eggs per 100 seeds, and vekhand powder at 5 g/kg seeds (T_5), which recorded 15.00 eggs per 100 seeds. The next most effective treatments were vekhand powder (T_5), castor oil (T_2), sesame oil (T_1), and groundnut oil (T_4) at 5 ml/kg, which recorded 15.00, 25.00, 32.33, and 35.66 eggs per 100 seeds, respectively. These treatments were statistically similar to each other. Specifically, castor oil (T_2) with 25.00 eggs, sesame oil (T_1) with 32.33 eggs, groundnut oil (T_4) with 35.66 eggs, and black pepper powder at 5 g/kg (T_6) with 43.33 eggs per 100 seeds were found to be statistically comparable. The highest number of eggs was observed in the untreated control (T_8), which recorded 77.66 eggs per 100 seeds, showing parity with black pepper powder.

The effect on oviposition by *C. chinensis* at 90 days after seed treatments showed a similar trend to the results observed at 30 and 60 days after treatment (DAT). The Spinosad 45 SC treatment at 0.3 ml/kg seeds (T_7) recorded a significantly lower number of eggs, with 4.66 eggs per 100 seeds, and was statistically comparable to neem oil (T_3), which recorded 10.66 eggs, and vekhand powder (T_5), which recorded 28.66 eggs per 100 seeds. The next most effective treatments were neem oil (T_3) with 10.66 eggs per 100 seeds, vekhand powder (T_5) with 28.66 eggs per 100 seeds, castor oil (T_2) with 25.00 eggs per 100 seeds, and sesame oil (T_1) with 32.33 eggs per 100 seeds, all of which were statistically similar. However, vekhand powder (T_5) with 28.66 eggs, castor oil (T_2) with 42.66 eggs, sesame oil (T_1) with 44.00 eggs, groundnut oil (T_4) with 49.66 eggs, and black pepper powder (T_6) with 59.00 eggs per 100 seeds were also statistically comparable to each other. The untreated control (T_8) recorded the highest number of eggs, with 93.66 eggs per 100 seeds, which was statistically similar to castor oil (T_2) with 42.66 eggs, sesame oil (T_1) with 44.00 eggs, and black pepper powder (T_6) with 59.00 eggs per 100 seeds.

At 120 days after treatment, the seed treatment with Spinosad 45 SC at 0.3 ml/kg seeds (T_7) recorded the lowest number of eggs, with 1.33 eggs per 100 seeds. This result was statistically similar to the neem oil treatment (T_3), which had 16.66 eggs per 100 seeds, and the vekhand powder treatment (T_5), which had 43.66 eggs per 100 seeds. Other treatments, including neem oil (T3 - 16.33 eggs), vekhand powder (T5 - 43.66 eggs), castor oil (T2 - 65.00 eggs), sesame oil (T1 - 68.66 eggs), groundnut oil (T4 - 82.00 eggs), and black pepper powder (T6 - 94.66 eggs) per 100 seeds, were found to be statistically similar to each other. The untreated control (T8) recorded the highest number of eggs, with 124.33 eggs per 100 seeds, which was statistically comparable to vekhand powder (T5 - 28.66 eggs), castor oil (T2 - 42.66 eggs), sesame oil (T1 - 44.00 eggs), groundnut oil (T4 - 49.66 eggs), and black pepper powder (T6 - 59.00 eggs) per 100 seeds.

Similarly, [22] found that the mean number of eggs laid per 100 seeds was lowest with 5- and 10-ml neem oil treatments after six months. The present findings on the efficacy of neem oil against the pulse beetle align with those of [4], who confirmed the efficacy of vekhand powder (*A. calamus*) against *C. chinensis* L., reporting that the powder prevented egg laying at a ratio of 1.0 part per 100 parts of seed (w/w).

Similarly, [6] found that sweet flag was the most effective treatment based on fecundity parameters, which supports the current findings on vekhand powder. [17] reported that neem oil at 5 ml/kg prevented egg laying of *C. chinensis* L. on Bengal gram seeds, corroborating the present results.

The effectiveness of Spinosad 45 SC is consistent with the conclusions of [25] who found that Spinosad 45 SC was the most effective treatment against the pulse beetle, recording minimal fecundity in pigeon pea seeds. [11] also demonstrated that spinosad was particularly effective in safeguarding stored grain from insect pest infestations.

Sr. No.	Treatment	Dose/kg seed	Mean No. of eggs laid per 100 seeds at			
			30 DAT	60 DAT	90 DAT	120 DAT
T_1	Sesame oil	5 ml	11.33 (3.36)	32.33 (5.68)	44.00 (6.63)	68.66 (8.28)
T_2	Castor oil	5 ml	10.66 (3.26)	25.00 (5.00)	42.66 (6.53)	65.00 (8.06)
T_3	Neem oil	5 ml	2.33 (1.52)	6.00 (2.44)	10.66 (3.26)	16.66 (4.08)
T_4	Groundnut oil	5 ml	14.33 (3.78)	35.66 (5.97)	49.66 (7.04)	82.00 (9.05)
T_5	Vekhand powder	5 g	5.33 (2.30)	15.00 (3.87)	28.66 (5.33)	43.66 (6.60)
T_6	Blackpaper powder	5 g	17.66 (4.20)	43.33 (6.58)	59.00 (7.68)	94.66 (9.72)
T_7	Spinosad 45 SC	0.3ml	1.66 (1.29)	4.33 (2.08)	4.66 (2.16)	1.33 (1.15)
T_8	Untreated control	-------	37.66 (6.13)	77.66 (8.81)	93.66 (9.67)	124.33 (11.15)
'F' test			Sig.	Sig.	Sig.	Sig.
SE (m) ±			0.52	0.83	1.25	1.91
CD @ 5%			1.58	2.49	3.77	5.75

Table 1: Effect of organic products on oviposition of *C. chinensis* on chickpea seeds.

* Figures in parentheses are transformed square root values.

Effect of organic products on adult emergence.

The observations on the effect of organic products on adult emergence per 100 seeds at 30, 60, 90, and 120 days after seed treatments are presented in table 2.

At 30 days after treatment, the adult emergence of *C. chinensis* indicated that the Spinosad 45 SC treatment at 0.3 ml/kg seeds (T_7) recorded no adult emergence, with 0.00 adults per 100 seeds, which was statistically similar to the neem oil treatment at 5 ml/kg seeds (T_3) with 0.00 adults per 100 seeds. The next most effective treatments were vekhand powder at 5 g/kg (T_5) with 3.66 adults, castor oil (T_2) with 6.33 adults, sesame oil (T_1) with 7.66 adults, black pepper powder (T_6) with 10.00 adults, and groundnut oil (T_4) with 10.66 adults per 100 seeds. These treatments were statistically comparable to each other. The untreated control (T_8) recorded the highest number of adult emergences, with 27.00 adults per 100 seeds.

At 60 days after seed treatments, observations on adult emergence revealed that the treatment with Spinosad 45 SC at 0.3 ml/kg of seeds (T_7) resulted in the lowest number of adult emergences per 100 seeds, with just 1.00 adult. This result was statistically similar to the neem oil treatment (T_3) with 2.00 adults and the vekhand powder treatment (T_5) with 6.33 adults per 100 seeds. Furthermore, the vekhand powder (T_5-6.33 adults), castor oil (T_2-11.33 adults), sesame oil (T_1-15.00 adults), and groundnut oil (T_4-18.00 adults) treatments showed similar effectiveness. On the other hand, the black pepper powder treatment (T_6-28.66 adults/100 seeds) at 5 g/kg was comparable to the untreated control (T_8), which had the

highest number of adult emergences at 45.66 adults per 100 seeds.

At 90 days after the seed treatments, the Spinosad 45 SC treatment at 0.3 ml/kg (T_7) resulted in the lowest number of adult emergences, with just 2.00 adults per 100 seeds. This was comparable to the neem oil treatment (T_3) which had 6.33 adults, the vekhand powder treatment (T_5) with 15.66 adults, and the castor oil treatment (T_2) with 19.66 adults per 100 seeds. Other effective treatments included castor oil (T_2), sesame oil (T1), groundnut oil (T4), and black pepper powder (T_6), which recorded 19.66, 24.33, 33.66, and 44.33 adults per 100 seeds, respectively. These treatments showed similar effectiveness. The untreated control (T_8) had the highest adult emergence, with 70.00 adults per 100 seeds. This was comparable to the groundnut oil treatment (T_4) with 33.66 adults and the black pepper powder treatment (T_6) with 44.33 adults.

The treatment of seeds with spinosad 45 SC at 0.3 ml/kg resulted in the lowest number of adult insects emerging per 100 seeds, recording 0.00 adults at 120 days after treatment. This was comparable to neem oil, which had 8.00 adults per 100 seeds. Spinosad was identified as the most effective treatment, with a concentration of 0.24 ppm, resulting in minimal adult emergence. In terms of effectiveness, neem oil (8.00 adults), vekhand powder (22.66 adults), castor oil (25.33 adults), sesame oil (30.66 adults), and groundnut oil (38.33 adults) were all similarly effective in reducing adult emergence. In contrast, the untreated control recorded the highest number of adults, 91.33 per 100 seeds, which was significantly higher compared to the other treatments. Overall, the study found that the efficacy of organic treatments decreased over time, with an increasing number of adult insects observed as the treatment period extended to 120 days. The untreated control consistently showed the highest number of adult emergences.

The results are consistent with those obtained by [18] who tested various insecticides for seed treatments in cowpea and found spinosad to be the most effective, as also noted by Vishwamitra et al. (2014), with the least adult emergence (0.1%). Similar results were observed by [10] regarding the effectiveness of neem oil against beetles, as they reported that neem oil (at 0.5%, 0.75%, and 1%) prevented adult emergence of

Sr. No.	Treatment	Dose/kg seed	Mean number of adult emergences at			
			30 DAT	60 DAT	90 DAT	120 DAT
T_1	Sesame oil	5 ml	7.66 (2.76)	15.00 (3.87)	24.33 (4.93)	30.66 (5.53)
T_2	Castor oil	5 ml	6.33 (2.51)	11.33 (3.66)	19.66 (4.43)	25.33 (5.03)
T_3	Neem oil	5 ml	0.00 (0.00)	2.00 (1.41)	6.33 (2.51)	8.00 (2.82)
T_4	Groundnut oil	5 ml	10.66 (3.26)	18.00 (4.24)	33.66 (5.80)	38.33 (6.19)
T_5	Vekhand powder	5 gl	3.66 (1.91)	6.33 (2.51)	15.66 (3.95)	22.66 (4.76)
T_6	Blackpaper powder	5g	10.00 (3.16)	28.66 (5.35)	44.33 (6.65)	56.66 (7.52)
T_7	Spinosad 45 SC	0.3 ml	0.00 (0.00)	1.00 (1.00)	2.00 (1.41)	0.00 (0.00)
T_8	Untreated control	-------	27.00 (5.19)	45.66 (6.75)	70.00 (8.36)	91.33 (9.55)
'F' test			Sig.	Sig.	Sig.	Sig.
SE (m) ±			0.58	0.77	1.11	1.32
CD @ 5%			1.76	2.31	3.35	3.96

Table 2: Effect of organic products on adult emergence of *C. chinensis*.

* Figures in the parentheses are square root transformed values)

C. chinensis for up to 100 days in pigeon pea-treated seeds. This finding aligns with [19] who found that neem oil at 1 ml/kg seeds significantly reduced adult emergence in chickpea compared to untreated controls. The observations regarding vekhand powder are in accordance with [21], who recorded no adult emergence in cowpea seed treated with sweet flag powder and neem oil, noting that vekhand powder (0.5 g/100g) was significantly effective against the pulse beetle. Treatments with organic products like neem oil and vekhand powder generally recorded fewer adult emergences compared to untreated controls. However, except for spinosad 45 SC, all treatments saw an increase in oviposition and adult emergence over time, which ultimately affected seed quality.

Effect of organic products on percent seed damage caused by C. *chinensis*

The observations recorded on seed damage caused by pulse beetle at 30, 60, 90 and 120 days after seed treatments were shown in table 3.

The data on seed damage caused by *C. chinensis* after 30 days of various organic product treatments indicated that the treatment spinosad 45 SC @ 0.3 ml/kg seeds (T_7) observed no seed damage i.e. 0.00 per cent and found on par with the treatment neem oil @ 5 ml/kg seeds (T_3) and vekhand powder 5 gm/kg (T_5) observing 0.00 and 2.00 per cent seed damage per 100 seeds respectively. The next effective treatments viz., vekhand powder (T_5 - 2.00%), castor oil (T_2 - 5.33%), sesame oil (T_1 - 6.66%) and groundnut oil (T_4-7.66%) exhibited parity with each other in recording damage percentage. The treatment groundnut oil (T_4) and black paper powder (T_6) recorded 7.66 and 12.66 per cent seed damage per 100 seeds, respectively and found on par with each other. Untreated control (T_8) recorded maximum 33.33 per cent seed damage per 100 seeds.

The data on per cent seed damage at 60 days after seed treatments indicated that, the treatment spinosad 45 SC @ 0.3 ml/kg seeds recorded lowest seed damage i.e. (T_7- 0.33%/100 seeds) and found on par with neem oil (T_3- 1.66%/100 seeds). Next effective treatments neem oil (T_3 - 1.66%) and vekhand powder (T_5 - 5.66%) in recording damage per 100 seeds were found on par with each other. Other treatments *viz.,* vekhand powder (T_5), castor oil (T_2), sesame oil (T_1) and groundnut oil (T_4) recorded 5.66,10.66, 13.00 and 13.66 per cent seed damage per 100 seeds respectively and these were found on par with each other. The next effective treatment groundnut oil (T_4-13.66%) and black paper powder (T_6-26.00%) were found on par with each other. Untreated control (T_8) observed maximum per cent of seed damage i.e. 52.66 per cent.

The data on per cent seed damage at 90 days after seed treatments exhibited that, the treatment spinosad 45 SC @ 0.3 ml/kg seeds recorded lowest seed damage i.e. (T_7 - 1.00%/100 seeds) and found on par with neem oil (T_3 - 5.66%), vekhand powder (T_5 - 14.33%) and castor oil (T_2 - 18.66%). The next effective treatment vekhand powder (T_5 -14.66%/100 seeds) observed parity with castor oil (T_2-18.66%), sesame oil (T_1-22.33%), groundnut oil (T_4-27.66) and black paper powder (T_6 -43.33%) in registering damage per 100 seeds as compared to untreated control i.e., 63.33 per cent. However, untreated control (T_8) observed maximum per cent of seed damage i.e. 63.33% seed damage on 100 seeds which showed parity with sesame oil (T_1-22.33%), groundnut oil (T_4-27.66%) and black paper powder (T_6-43.33%) in recording damage per 100 seeds.

The seed treatment with spinosad 45 SC @ 0.3 ml/kg seeds (T_7) noticed practically no seed damage at 120 days after treatment which was found on par with neem oil (T_3 - 7.66% damage/100 seeds). Treatment neem oil recorded damage (T_3 - 7.66%/100 seeds) which was found on par with vekhand powder (T_5 - 21.33%), castor oil (T_2 - 25.00%), sesame oil (T_1 - 30.00%) and groundnut oil (T_4 -35.00%). Untreated control (T_8) recorded maximum per cent of seed damage i.e. 88.33% and showed similarity with sesame oil (T_1 - 30.00%), groundnut oil (T_4 - 35.00%) and black paper powder (T_6 - 54.00%) in recording damage percentage.

The present investigations corroborate with the research work of [11] who tested the toxicity of spinosad against pulse beetles and reported toxicity against *C. chinensis.* [9] stated that spinosad at 1 or 2 mg/kg was extremely effective in suppressing progeny production of pulse beetle [22] also reported that neem oil recorded least

Sr. No.	Treatment	Dose/kg seeds	Mean per cent seed damage at			
			30 DAT	60 DAT	90 DAT	120 DAT
T_1	Sesame oil	5 ml	6.66 (2.58)	13.00 (3.60)	22.33 (4.72)	30.00 (5.47)
T_2	Castor oil	5 ml	5.33 (2.30)	10.66 (3.26)	18.66 (4.32)	25.00 (5.00)
T_3	Neem oil	5 ml	0.00 (0.00)	1.66 (1.29)	5.66 (2.48)	7.66 (2.76)
T_4	Groundnut oil	5 ml	7.66 (2.76)	13.66 (3.69)	27.66 (5.25)	35.00 (5.91)
T_5	Vekhand powder	5 g	2.00 (1.41)	5.66 (2.38)	14.33 (3.38)	21.33 (4.61)
T_6	Blackpaper powder	5 g	12.66 (3.55)	26.00 (5.09)	43.33 (6.58)	54.00 (7.34)
T_7	Spinosad 45 SC	0.3 ml	0.00 (0.00)	0.33 (0.57)	1.00 (1.22)	0.00 (0.00)
T_8	Untreated control	-	33.33 (5.77)	52.66 (7.25)	63.33 (7.95)	88.33 (9.39)
'F' test			Sig.	Sig.	Sig.	Sig.
SE (m) ±			0.48	0.63	1.10	1.33
CD @ 5%			1.45	1.90	3.31	4.01

Table 3: Effect of organic products on per cent seed damage caused by *C. chinensis.*

*Figures in the parentheses are square root transformed values.

damage i.e., 9.2 and 15.00 per cent as against 96.00 per cent in untreated check due to pulse beetle infestation in chickpea seeds. The results in present findings in respect of vekhand powder are in conformity with the findings of [6] who studied the efficacy of plant materials against *C. chinensis* L. in green gram and reported that vekhand powder @ 3 g/kg, 5 g/kg and 10 g/kg was observed the most effective treatment in reducing the grain damage.

Present research findings are in confirmation with report of [3] they reported that, the powder of *A. calamus* rhizome @0.5 to 2.00 parts per 100 parts of mung bean seeds (w/w) effectively protected them for at least 100 days by preventing the damage caused by pulse beetle.

Effect of organic products on per cent seed weight loss caused by *C. chinensis*

The data recorded on seed weight loss caused by *C. chinensis* at 30, 60, 90 and 120 days after seed treatments are shown in table 4.

The observation on seed weight loss at 30 days after seed treatments revealed that, the insecticide treatment (T_7) spinosad 45 SC @ 0.3 ml/kg seeds absolutely recorded no weight loss and was found on par with neem oil (T_3 - 0.65%). The treatment neem oil @ 5 ml/kg seeds (T_3 - 0.65%), vekhand powder 5 gm/kg (T_5 - 1.33%) and castor oil (T_2 –2.00%) were found statistically on par with each other. The next effective treatments i.e., castor oil (T_2), groundnut oil (T_4), sesame oil (T_1), and black paper powder (T_6) noticed 2.00, 3.00, 3.40 and 4.36 per cent weight loss and were found on par with each other. Untreated control (T_8) recorded maximum per cent of seed weight loss i.e. 9.23 per cent.

The data on per cent seed weight loss at 60 days after seed treatments indicated that, the treatment spinosad 45 SC @ 0.3 ml/kg seeds recorded lowest seed weight loss i.e. (T_7 - 0.65%) and found on par with neem oil (T_3 - 1.00%) and vekhand powder (T_5 - 2.66%)

and castor oil (T_2 - 3.00%) in loosing seed weight. The other treatments *viz.,* vekhand powder (T_5), castor oil (T_2), sesame oil (T_1), and groundnut oil (T_4) recorded 2.66, 3.00, 4.66 and 5.33 per cent seed weight loss respectively and observed parity with each other. The next effective treatment sesame oil recorded (T_1 -4.66%) and found on par with groundnut oil (T_4 -5.33%) and black paper powder (T_6 - 9.66%) in loosing seed weight on percentage basis. Untreated control (T_8) recorded maximum per cent of seed weight loss i.e. 17.66 per cent at 60 DAT.

The data on per cent seed weight loss at 90 days after seed treatments showed that, the treatment spinosad 45 SC @ 0.3 ml/kg seeds recorded lowest seed weight loss i.e. (T_7 - 0.96%) and found on par with neem oil (T_3 - 2.33%), vekhand powder (T_5 - 4.66%) and castor oil (T_2 - 6.66%). The other promising treatments were vekhand powder (T_5), castor oil (T_2), sesame oil (T_1), groundnut oil (T_4) and black paper powder (T_6) recorded 4.66, 6.66, 7.66, 8.66 and 11.00 per cent seed weight loss, respectively and found on par with each other. Untreated control (T_8) registered maximum per cent of seed weight loss i.e. 18.00 per cent and found parity with sesame oil (T_1 7.66%), groundnut oil (T_4-8.66%) and black paper powder (T_6 -11.00%) in weight loss. Similar, trend of observations was seen at 120 days after treatments. The treatment spinosad 45 SC @ 0.3 ml/kg seeds recorded significantly lowest seed weight loss i.e. (T_7 -1.33%) which was observed on par with the treatment neem oil (T_3 -4.33%) vekhand powder (T_5 - 6.66%) and castor oil (T_2 - 9.74%). Untreated control (T_8) recorded maximum weight loss (21.43%) which was found on par with castor oil (T_2-9.74%), sesame oil (T_1-11.14%), groundnut oil (T_4 -13.21%) and black paper powder (T_6 -16.94).

This result corroborates with the findings of [23] who confirmed found green gram seed treated with neem oil showed promising results against *C. chinensis* L. by minimizing weight loss. The present findings also similar to the record of [6] which revealed that the vekhand powder found most effective treatment against *C. chinensis* L. in green gram seed based on the parameter of weight loss.

Present results were comparable with the research findings emphasizing the effectiveness of spinosad against pulse beetle was found in agreement with the conclusions obtained by [25] they stated that spinosad (1 ppm) caused significant reduction in seed weight loss against pulse beetle. Similar result findings about the impact of neem oil against the pulse beetle was observed by [23] they reported that, green gram seeds treated with neem oil showed promising results against C. *chinensis* by minimizing weight loss. [5] also reported that neem oil was most effective treatment which minimized the weight loss up to 0.11 (0.78) per cent.

Effect of organic products on seed germination of chickpea

The analyzed data on per cent seed germination as influenced by organic products and bruchid infestation at 30, 60, 90 and 120 days after treatment are shown in table 5.

The data on germination of seed after 30 DAT clearly indicated that, all the organic products didn't affect the seed germination, since there was no significant difference between different organic products and untreated controls. In this treatment spinosad 45 SC @ 0.3 ml/kg (T_7) recorded (94.33%) maximum germination percentage followed by neem oil (T_3 - 93.00%), vekhand powder (T_5), castor oil (T_2), sesame oil (T_1), untreated control (T_8), groundnut oil (T_4) and black paper powder (T_6) to the extent of 90.33, 89.66, 88.33, 87.33, 86.33 and 85.66 per cent germination respectively. However, at 60 days onwards, significant difference in seed germination was observed due to effect various seed treatments.

At 60 days after treatment, the seeds treated with spinosad 45 SC @ 0.3 ml/kg seeds recorded maximum seed germination i.e. (T_7 - 93.00%) and it was statistically on par with neem oil @ 5 ml/kg (T_3 - 92.33%). This result was also in agreement with [24] they recorded similar trend at 60, 90 and 120 days after treatment. The effect of different oils indicated that there was no adverse effect on germination of seeds at 60 and 120 days after treatment. The treatment vekhand powder recorded (T_5 - 91.00%) seed germination and found on par with neem oil (T_3 - 92.33%). The other treatments castor oil (T_2 - 87.00%) and sesame oil (T_1 - 85.66%) were also found on par with each other. The treatments sesame oil (T_1) recorded 85.66 per cent germination and groundnut oil (T_4) recorded 84.00 per cent germination and seen on par with each other. Among the botanicals, treatment black paper powder (T_6) was least performing treatment and showed 79.00 per cent seed germination but found better than untreated control (T_8 - 73.00%) in seed germination.

Sr. No.	Treatment	Dose/kg seeds	Per cent seed weight loss At			
			30 DAT	60 DAT	90 DAT	120 DAT
T_1	Sesame oil	5 ml	3.40 (1.84)	4.66 (2.16)	7.66 (2.76)	11.14 (3.33)
T_2	Castor oil	5 ml	2.00 (1.41)	3.00 (1.70)	6.66 (2.58)	9.74 (3.12)
T_3	Neem oil	5 ml	0.65 (0.81)	1.00 (1.00)	2.33 (1.52)	4.33 (2.08)
T_4	Groundnut oil	5 ml	3.00 (1.73)	5.33 (2.30)	8.66 (2.94)	13.21 (3.63)
T_5	Vekhand powder	5 g	1.33 (1.15)	2.66 (1.63)	4.66 (2.16)	6.66 (2.58)
T_6	Blackpaper powder	5 g	4.36 (2.08)	9.66 (3.10)	11.00 (3.31)	16.94 (4.11)
T_7	Spinosad 45 SC	0.3ml	0 (0.00)	0.65 (0.81)	0.96 (0.98)	1.33 (1.15)
T_8	Untreated control	-	9.23 (3.03)	17.66 (4.20)	18.00 (4.24)	21.43 (4.62)
'F' test			Sig.	Sig.	Sig.	Sig.
SE (m) ±			0.29	0.33	0.54	0.66
CD @ 5%			0.89	1.00	1.62	1.99

Table 5: Effect of organic products on per cent seed weight loss caused by *C. chinensis.*

(Figures in the parentheses are square root transformed values).

The data on seed germination at 90 days after treatment showed that, the treatment spinosad 45 SC @ 0.3 ml/kg seeds recorded maximum seed germination i.e. (T_7 - 92.33%) which was significantly superior than neem oil and vekhand powder @ 5 ml/kg and @ 5 g/kg seeds with (T_3 - 90.00%) and (T_5 - 89.66%) seed germination, respectively. The next effective treatments were castor oil (T_2 - 84.00%), groundnut oil (T_4 - 82.00%) and sesame oil (T_1 -81.00%) being on par with each other and found significantly superior than black paper powder (T_6 - 74.00%). Untreated control recorded (T_8 - 58.00%) lowest germination percentage of seed.

At 120 days after treatment, seed treatment with spinosad 45 SC @ 0.3 ml/kg seeds recorded maximum seed germination i.e. (T_7 - 90.66%) and was statistically superior over all the treatment. The next best organic treatment was sesame oil (T_1 - 75.33%) and groundnut oil (T_4 - 75.00%) which observed parity with each other. Other treatment black paper powder (T_6) recorded 67.00 per cent germination as compared to untreated control (T_8) recorded lowest 48.00 seed germination. Overall results on effect of seed treatments on seed germination exhibited that spinosad 45 SC @ 0.3ml/kg seeds, recorded highest seed germination while untreated control recorded lowest seed germination. All the organic material tested recorded significantly higher percentage of seed germination in considerable manner than untreated control.

These results in present studies are in agreement with those of [18] they reported that spinosad did not affect the germination of cowpea seeds. The treatment neem oil @ 5 ml/kg seeds (T_3 - 87.66%) and vekhand powder @ 5 g/kg seeds (T_5 - 87.00%) was found on par with each other in performance of seed germination parameter. The treatment castor oil (T_2) recorded 80.00 per cent germination. the results obtained by [12] they reported that rhizome powder of A. calamus each at concentration of 3.00 per cent did not show any adverse effect on germination of seed.

Sr. No.	Treatments	Dose/kg seeds	Mean per cent germination at			
			30 DAT	60 DAT	90 DAT	120 DAT
T_1	Sesame oil	5 ml	88.33 (70.02)	85.66 (67.74)	81.00 (64.15)	75.33 (60.21)
T_2	Castor oil	5 ml	89.66 (71.24)	87.00 (68.86)	84.00 (66.42)	80.00 (63.43)
T_3	Neem oil	5 ml	93.00 (74.65)	92.33 (73.92)	90.00 (71.56)	87.66 (69.43)
T_4	Groundnut oil	5 ml	86.33 (68.30)	84.00 (66.42)	82.00 (64.89)	75.33 (60.21)
T_5	Vekhand powder	5 g	90.33 (71.88)	91.00 (72.54)	89.66 (71.24)	87.00 (68.86)
T_6	Blackpaper powder	5 g	85.66 (67.74)	79.00 (62.72)	74.00 (59.34)	67.00 (54.93)
T_7	Spinosad 45 SC	0.3 ml	94.33 (76.22)	93.00 (74.65)	92.33 (73.92)	90.66 (72.20)
T_8	Untreated control	-------	87.33 (69.14)	73.00 (58.69)	58.00 (49.60)	48.00 (43.85)
'F' test			NS	Sig.	Sig.	Sig.
SE (m) ±			4.22	0.48	0.79	0.98
CD @ 5%			-	1.45	2.37	2.95

Table 5: Effect of organic products on germination of chickpea seeds damaged by *C. chinensis.*

*Figures in the parentheses are square root transformed values.

The present findings about effectiveness of vekhand powder was found in agreement with Similar results about the effectiveness of oils were observed by [10] who reported that neem, castor and groundnut oils when used against *C. chinensis* were safe from seed germination point of view.

Studies of [14] also supported the present findings who reported that level of bruchid infestation was directly proportional to population count and per cent infestation, but inversely proportional to germination percentage.

Conclusion

The research found that neem oil (5 ml/kg) and vekhand powder (5 g/kg) are effective organic alternatives to chemical insecticides such as spinosad 45 SC for protecting chickpea seeds from pulse beetle infestation during storage. Neem oil, in particular, demonstrated the highest efficacy and cost-benefit ratio, making it a highly recommended option for protecting stored chickpeas. The use of these organic products promotes sustainable and environmentally friendly agricultural practices.

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Conflict of Interest

Not Applicable.

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