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## Management of Khapra beetle on stored wheat with organic products

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**Abstract**

Wheat (*Triticum aestivum*.) is nutritionally important cereal crop and comprises major source of protein with minerals and vitamins. In Maharashtra, it is grown in rabi season. *Trogoderma granarium* is one of the most important and destructive pest of various stored cereals grains in India including wheat. The khapra beetle is not only causing quantitative losses but also cause qualitative losses in nutrition that makes most cereals unfit for marketing as well as human consumption. Utilization of insecticides is one of the important components of IPM programmes. Insecticides targeted against insect pest in field conditions and also damage the beneficial fauna in nature. Due to their several drawbacks, researchers are trying to adopt alternative methods of pest control. (Mahmud *et al.* 2002). Laboratory experiment was conducted to study "Management of khapra beetle on stored wheat with organic products" at Insectory Field laboratory of Entomology Section, College of Agriculture, Nagpur during 2016-2017 with the two plant powders i.e., black pepper powder, vekhand powder @ 10 g/kg seeds and five vegetable oils i.e., Neem oil, castor oil, mustard oil, karanj oil and coconut oil @ 10ml/kg seeds tested till 120 days of storage against khapra beetle (*Trogoderma granarium*) infesting stored wheat seeds. The observations on 100 seeds at 30, 60, 90 and 120 days on oviposition, adult emergence, grain damage, grain weight loss and per cent germination due to infestation of *Trogoderma granarium* were recorded. Considering the parameters like oviposition, adult emergence, seed damage, seed weight loss and per cent seed germination and ICBR, neem oil @ 10 ml/kg, found effective treatments against dermestid, *Trogoderma granarium* infesting wheat in storage. The findings of the present investigation indicated that organic derivatives might be useful as insect control agent for commercial use. On the basis of interpretation of data it can be concluded that, without wheat seed treatment the insect species *Trogoderma granarium* causes maximum damage to the extent of Rs. 519.30 during the storage at 120 days as against the organic seed treatment neem oil @ 10 ml/kg seed incurred expenditure Rs. 194.71 towards seed protectant. And hence it is advised for seed treatments.

**Keywords:** wheat grain (*T. astivum*.) khapra beetle (*T. granarium*), neem oil, karanj oil etc.

**Introduction**

Wheat (*Triticum aestivum* L., *T. durum* Desf.) is an important cereal crop in India. Wheat is the caryopsis type of fruit. Originally from the Levant region of the near east but now cultivated worldwide. Wheat is the world's most important cereal crop in terms of both area cultivated (221.73 million ha) and amount of grain produced (751 Million t). It is widely grown throughout the temperate zones (in Northern Europe up to 60 °N) and in some tropical/sub-tropical areas at higher elevations. World production of wheat was estimated to 751.36 million tons in 2016-2017. Last year world production was 735.23 million tons (Anonymous, 2017). In India, according to the second advance estimate of the government, Wheat production touched 96.64 Million tons in 2016-17 season over to 86.53 million tons in last year 315 lakh hectares area was under wheat crop this year as compared to 296 lakh hectares. Consumption of wheat in our country is about 89.90 lakh tons annually (Anonymous, 2017a). In Maharashtra, area under wheat is 9.11 lakh hectare with production 9.81 lakh tons (Anonymous 2017b). Wheat is used in various forms, viz., Chapattis, dalia, halwa, sweet meat etc. and is consumed by more than one thousand million human beings. In most of the urban areas in the country, the use of baked leavened bread, flakes, cakes, biscuits etc, is increasing at fast rate. Wheat possesses relatively a high content of niacin, thiamine and protein (gluten) which is essential for bakers. A recent estimate by the Ministry of Food and Civil supplies, Government of India, puts the total preventable post-harvest losses of food grains at tune of 10 per cent of the total production or about 20 million tones which is equivalent to the total food grains produced in Australia annually. The estimated post – harvest losses during 2003-04 in storage at farm level in wheat was 21.99 per cent or 0.95 kg/q (Basavaraja *et al.* 2007). A survey conducted by Mukherjee *et al.* (1998) revealed that the annual loss of grains due to

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insects was estimated to be 5.90 million tones, reflecting the intensity of insect pests problems in stores. Stored product insects can cause postharvest losses, estimated up to 9 per cent in developed countries to 20 per cent or more in developing countries (Philips and Thorne, 2010). Wheat is attacked by a number of insect pests under storage conditions, out of which the khapra beetle, *Trogoderma granarium* Everts is one of the world's most damaging pests of whole and ground cereals, oilseeds, dry fruits and other stored products. Its immense economic significance is due to its potential to cause huge loss in stored grains through voracious feeding and heating of grains, in larval ability to withstand starvation for up to three years as well as in its ability to live on food with very low moisture content. Beside the quantitative loss, the insect infestation in wheat grains reduce germination and produce unpleasant odour, dirty appearance and abhorrent taste due to contamination with insect fragments and excrement (Khare *et al.*, 1974). Severe infestations of grains by khapra beetle may make it unpalatable or un-marketable. Grain quality may decrease due to depletion of specific nutrients. Infestation levels of 75 per cent in wheat, maize, and sorghum grains results in significant decreases in crude fat, total carbohydrates, sugars and true protein contents and increases in moisture, crude fiber and total protein contents (Jood and Kapoor, 1993 and Jood *et al.*, 1993, 1996) Insect infestation, causing losses are the most serious problems in grain storage, particularly in villages and towns in developing countries because of humid- tropical conditions, poor sanitation and inappropriate storage facilities (Semple, 1985). In the present

The stored wheat undergoes qualitative and quantitative losses to varying degree, depending upon the storage structures / receptacles used and storage practices followed. Hence, the information about the storage conditions, practices and assessment of losses caused by *T. granarium* is discussed for better management of pest. 1.2 Importance and need of study Khapra beetle (*Trogoderma granarium* Everts) and other beetles of Dermestidae family are considered to be the most destructive stored product pests in the tropics and subtropics (Burges, 2008). The pest is of worldwide occurrence but requires hot conditions for rapid breeding. Moderately low temperature slow down development and induce diapause (Burges and Burrell, 1964). The primary natural foods of this pest are wheat, corn, oats, rice, peas, lentils, bajra, rye, pea nuts, oilseeds like linseed etc. Generally, the infestation occurs in superficial layers of the grain as the pest is not able to penetrate beyond some depths into the grain. The damage to grain is done by larvae while the adult is harmless. As a rule the larvae attack the embryo point but in case of heavy infestation other parts of the grain may also be damaged. The khapra beetle *T. granarium* can breed at 40°C in grains containing higher moisture content but rate of development is reduced considerably. In present research work, different seed protectants such as neem oil, black pepper powder, vekhand powder, mustard oil, neem oil, castor oil and coconut oil were evaluated for their efficacy against dermestid beetles. Keeping this in view, the foliage. Twisted and curled leaves are generally the first symptoms noticed. When larvae cause damages on leaf it become the severe infestation, ultimately the plant can retard the growth and yield, but their effect on mature trees is less serious than nursery. Such infestations usually occur in late summer. They rarely occur in spring because the production of new growth is prolific and synchronized and quickly becomes immune to attack

## Materials and Methods

The experiment on "Management of khapra beetle on stored wheat with organic products" was conducted in the Biocontrol laboratory of Entomology Section, College of Agriculture, Nagpur, Maharashtra, during November, 2016 to March, 2017 under the laboratory conditions lasting for a period of 120 days. Completely Randomized Design (CRD) was used with three replication eight treatments,

The procedure given in manual of the equipment. Maintenance of insect culture: To maintain the stock culture of *Trogoderma granarium*, the sound and healthy wheat grains of variety Lok-1 were cleaned and sieved to remove the fractions of grains or 30 insects. The grains sterilized at 60±5°C for 8 hrs in order to eliminate both apparent and hidden infestation of insects and mites. The initial infested seeds of wheat were obtained from the college farm stores and reared to obtain the culture of khapra beetle, *Trogoderma granarium*. The plastic vials of 1 kg capacity were used as storage containers. The material input required for conducting experiment like neem oil, vekhand powder, mustard oil, castor oil, karanj oil, coconut oil, black pepper powder, seeds of wheat, gunny bags and labels are used.

The observation on oviposition (egg laying), adult emergence per cent seed damage, per cent weight loss and germination percentage were recorded at interval of 30 days by drawing the uniform seed sample from each of the treatment. The uniform seed samples were drawn from each treatment and number of eggs laid on these seeds were recorded. The uniform seed samples were drawn from each treatment and number of seeds with exit holes (adult emergence) was counted. The data were further transformed into square root or arc sin values for statistical analysis.

## Results and Discussion

### 1. Effect of organic products on oviposition of *Trogoderma granarium* in wheat:

The data on average number of eggs laid by *Trogoderma granarium* on 100 seeds of wheat treated with different organic and chemical products are presented in Table 2 and depicted in Fig. 1 observations on eggs laid by khapra beetle on wheat seeds at 30 days after seed treatments revealed that the neem oil treatment @ 10 ml/kg wheat seeds observed superior over all the treatments in recording lowest (T3 - 7.00) number of eggs per 100 seeds, but found on par with treatment coconut oil @ 10 ml/kg seeds (T4 - 7.66 eggs), karanj oil @ 10 ml/kg seeds (T5 - 8.33 eggs) and 10 gm/kg per 100 seeds. The next effective treatment, castor oil (T2 - 10.66 eggs) found. The next effective treatment, castor oil (T2 - 10.66 eggs) found on par with vekhand powder (T7 - 8.66 eggs), karanj oil (T5 - 8.33 eggs) mustard oil (T1 - 11.33 eggs) and black pepper powder (T6 - 11.33 eggs). Maximum number of eggs was recorded in untreated control i.e. 17 eggs/100 seeds. The subsequent observations on oviposition recorded at 60 days shown similar effect by the treatments with neem oil (T3) @ 10.00 ml/kg (20.33 eggs), vekhand powder (T7) (20.66 eggs) and karanj oil (T5 - 21.33 eggs); all these treatments were found on par with each other. The treatment coconut oil (T4) observed 22.66 eggs and found next better treatment. The treatment black pepper powder (T6 - 27.33 eggs) and castor oil (T2 - 27.66 eggs) were found on par with each exhibited parity in laying eggs to the extent of 27.66 eggs in the treatment castor oil (T2); both these treatments were found on par with each other as compared to control (T8 - 32 eggs). The data on egg laying by *Trogoderma granarium* at 90 days after seed treatments indicated that the treatments neem

oil (T3 – 29.66eggs), karanj oil (T5 – 30.33 eggs) and coconut oil (T4 – 32.33 eggs) were found statistically significant over all the treatments and on par with each other. The treatment vekhand powder (T7 – 34.33 eggs) and black pepper powder (T6–37.66 eggs) were next effective treatments in order of recording minimum egg laying. The treatment castor oil (T2 – 43 eggs) and mustard oil (T1–45 eggs) had shown parity with each other as compared to untreated control where maximum 51.33 eggs/100 seeds was observed. The data analyzed and interpreted on oviposition by *Trogoderma granarium* at 120 days after treatment shown that, the treatment (T3) neem oil and (T5) karanj oil recorded lowest number of eggs to the extent of 47.66 and 49.66 eggs/ 100 seeds as against 74.66 in untreated control treatment.

Similar results about the effectiveness of neem oil against the khapra beetle was observed by Jakhar, (2004) [3] who reported that neem oil at 1ml/100 seeds prevented egg laying of khapra beetle *Trogoderma granarium* on wheat grains. Studies of Jood *et al.* (1993), Rolania and Bhargawa (2015) [5] Yadav *et al.* (2004) [8], Chander and Ahmed (1983) [2] confirmed

efficacy of vekhand powder against *Trogoderma granarium* and reported that, *Acorus calamus* powder prevented egg. Devi and Kalita (2011) Thus, these findings are in agreement with the results of present investigation and supported the data.

## 2. Effect of organic products on adult emergence:

The observations recorded on effect of organic products on adult emergence per 100 seeds at 30, 60, 90 and 120 days after seed treatments are shown in Table 3 and presented graphically in Fig. 2. The observations on adult emergence at 30 days after seed treatments exhibited that the treatment (T1) neem oil @ 10 ml/kg seeds recorded significantly no adult emergence on 100 seeds, which was found at par with the treatment karanj oil (T5), coconut oil (T4) and vekhand powder (T7). Other treatments with castor oil (T2), blackpepper powder (T6) registered 0.33 and

## 1. Effect of organic products on oviposition of *Trogoderma granarium* in wheat:

Sr No.	Treatment	Dose/kg seed	Mean No. of eggs laid per 100 seeds at			
			30 DAT	60 DAT	90 DAT	120 DAT
T <sub>1</sub>	Mustard oil	10ml	11.33 (19.61)	29.66 (32.98)	45.00 (42.12)	61.66 (51.75)
T <sub>2</sub>	Castor oil	10ml	10.66 (19.02)	27.66 (31.72)	43.00 (40.96)	61.33 (51.54)
T <sub>3</sub>	Neem oil	10ml	7.00 (15.31)	20.33 (26.78)	29.66 (32.98)	47.66 (43.66)
T <sub>4</sub>	Coconut oil	10ml	7.66 (15.92)	22.66 (28.41)	32.33 (34.64)	54.33 (47.49)
T <sub>5</sub>	Karanj oil	10ml	8.33 (16.68)	21.33 (27.48)	30.33 (33.41)	49.66 (44.80)
T <sub>6</sub>	Black pepper powder	10g	11.33 (19.64)	27.33 (31.50)	37.66 (37.84)	57.33 (49.21)
T <sub>7</sub>	Vekhand powder	10g	8.66 (17.07)	20.66 (27.03)	34.33 (35.85)	57.00 (49.02)
T <sub>8</sub>	Control	-----	17.00 (24.34)	32.00 (34.44)	51.33(45.76)	74.66 (59.79)
'F' test			Sig.	Sig.	Sig.	Sig.
SE (m) ±			1.01	0.73	1.00	1.11
CD at 5%			2.97	2.15	2.93	3.25

0.33 adults and found on par with each other. The treatment (T1) mustard oil @ 10 ml/kg noted 1.33 adults as compared to untreated control where maximum 2.66 adult emergence were observed. The observations on adult emergence at 60 days after seed treatments exhibited that the treatment neem oil (T3) @ 10 ml/kg seeds found statistically significant over all the treatments and observed lowest number of adult emergence per 100 seeds (7.33 adults). The treatment Karanj oil (T5 - 10.00 adults) found on par with coconut oil (T4-10.33 adults). The treatment with castor oil (T2) recorded 11.33adults per 100 seeds and found on par with vekhand powder (T7–12.33 adults), black pepper powder (T6– 12.66 adults) per 100 seeds and found on par with each other. The treatment mustard oil (T1) noted 14.33 adults as compared to

untreated control where highest number of adult emergence was found i.e. 19.33 adults/100 seeds. The effect of all organic treatments on adult emergence at 90days after seed treatment indicated that the treatment neem oil(T3) @10 ml/kg seeds recorded lowest number of adult emergence i.e. 18.33 per 100 seeds and found on par with the treatments vekhand powder (T7 - 19 adults), coconut oil (T4 - 20 adults). The other treatments karanj oil (T5 - 22.33 adults), castor oil (T2 - 23.66 adults) and blackpepper powder (T6 - 23.66 adults) were found on par with each other. The treatment mustard oil (T1) recorded 29.33 adults' emergence/100seeds as compared to untreated control treatment where highest

## Effect of organic products on adult emergence

Sr No.	Treatment	Dose/kg seed	Mean No. of eggs laid per 100 seeds at			
			30 DAT	60 DAT	90 DAT	120 DAT
T <sub>1</sub>	Mustard oil	10ml	11.33(19.61)	29.66 (32.98)	45.00 (42.12)	61.66 (51.75)
T <sub>2</sub>	Castor oil	10ml	10.66(19.02)	27.66 (31.72)	43.00 (40.96)	61.33 (51.54)
T <sub>3</sub>	Neem oil	10ml	7.00 (15.31)	20.33 (26.78)	29.66 (32.98)	47.66 (43.66)
T <sub>4</sub>	Coconut oil	10ml	7.66 (15.92)	22.66 (28.41)	32.33 (34.64)	54.33 (47.49)
T <sub>5</sub>	Karanj oil	10ml	8.33 (16.68)	21.33 (27.48)	30.33 (33.41)	49.66 (44.80)
T <sub>6</sub>	Black pepper powder	10g	11.33 (19.64)	27.33 (31.50)	37.66 (37.84)	57.33 (49.21)
T <sub>7</sub>	Vekhand powder	10g	8.66 (17.07)	20.66 (27.03)	34.33 (35.85)	57.00 (49.02)
T <sub>8</sub>	Control	-----	17.00 (24.34)	32.00 (34.44)	51.33 (45.76)	74.66 (59.79)
'F' test			Sig.	Sig.	Sig.	Sig.
SE (m) ±			1.01	0.73	1.00	1.11
CD at 5%			2.97	2.15	2.93	3.25

number of adult emergence was found i.e. 36.33 adults/100 seeds. The observations on seed treatment of various organic

products at 120 days after treatment indicated that the treatment neem oil (T3),coconut oil (T4), vekhand powder

(T7), and karanj oil (T5) expressed similar effect on adult emergence to the extent of 27.33, 28.66, 29.33, 30.33 adults respectively as compared to 55 adults found in untreated control treatment. The effectiveness of neem oil against the beetles were observed by Khaire *et al.* (1992), This result was also in agreement with Bhatnagar *et al.* (2001), Tiwary (1993) [7] who recorded the relative efficacy of some botanicals and synthetic seed protectants against *S. oryzae* on wheat and among botanicals, they found that vekhand powder (0.05%) was significantly effective against the beetle causing least adult emergence. The effectiveness of karanj oil against the beetles were observed by Michaelraj and Sharma (2006) [4] who reported that karanj oil prevented adult emergence of *S. oryzae* up to 100 days in wheat treated seeds. The next effective treatment was black pepper powder (T6 -34.66 adults) followed by castor oil (T2 - 36.66 adults) and these two treatments were found similar in effect adult emergence. The treatment mustard oil (T1) noted 43.33 adults as compared to 55 adult emergence found in untreated control treatment. Overall results on the observation on adult emergence revealed that, the effect of organic products was decreasing and not lasting till 120 days as the number of adult found on increasing trend. The highest number of adult emergence occurred in untreated control. The treatment with organic products has recorded relatively less number of adult emergence as compared to untreated control. In all the treatments, the rate of oviposition and adult emergence was found to be increased periodically and both these factors ultimately affect the seed quality.

### 3. Effect of organic products on per cent grain damage caused by *Trogoderma granarium*

The observations recorded on seed damage caused by khapra beetle at 30, 60, 90 and 120 days after seed treatments were shown in Table 4 and depicted in Fig. 3. The grain damage caused by *Trogoderma granarium* after 30 days of organic product treatments showed that, the treatment neem oil (T3) @ 10 ml/kg seeds and the treatment karanj oil (T5) @ 10 ml/kg seeds with were significantly superior over all the treatments with no seed damage. The treatment (T7) vekhand powder 10 gm/kg recorded grain damage to the extent of 2.33% and found next effective treatment as compared to untreated control where 27.33% grain damage was recorded. the treatment castor oil (T2 - 4.33%), mustard oil (T1 - 5.66%) were found on par with each other. The treatment coconut oil (T4) and black pepper powder (T6) was found on par with each other. The data on per cent seed damage at 60 days after seed treatments indicated that the treatment, neem oil (T3) @ 10 ml/kg seeds recorded lowest seed damage i.e. 4.33 per cent and found on par with karanj oil (T5 - 5.33%). The

treatment black pepper powder (T6) recorded 6.00% grain damage and found next effective treatment. The other treatments viz. vekhand powder (T7 -7.66%) and coconut oil (T4 -8%) were found on par with each other. The treatment castor oil (T2) and mustard oil (T1), recorded, 11.66 and 13.00 per cent grain damage, respectively and found on par as compared to untreated control which observed maximum per cent of grain damage i.e. 43.66 per cent. The grain damage percentage noted at 90 days after seed treatment exhibited that, the treatment with neem oil (T3) @ 10 ml/kg seeds recorded lowest seed damage i.e. 9.33 per cent and found statistically significant over all the treatments. The other treatments viz. karanj oil, vekhand powder, black pepper powder recorded 12.00, 13.00, 13.33 per cent seed damage respectively and these were on par with each other. Remaining treatments coconut oil, castor oil, mustard oil recorded, 16.66, 18.66 and 19.00 per cent seed damage respectively, as compared to untreated control which observed maximum per cent of grain damage i.e. 47.66 per cent. The grain damage observed at 120 days revealed that the seed treatment with neem oil (T3) @ 10 ml/kg seeds again recorded lowest seed damage i.e. 15.33 per cent but found at par with karanj oil (T5 -18.66%). The results of present investigations work of Jood *et al.* (1993) used neem oil @ 2 per cent (w/w) against larvae of *Trogoderma granarium*. They found that neem products completely prevented grain damage by an introduced larval population. Similar investigation was done by Sharma *et al.* (1999) [5], that neem oil (2%) protected maize for 5 months against *S. oryzae*, *S. cerealella*, *R. dominica* and *Trogoderma granarium*. Similar results about the effectiveness of karanj oil against the pulse beetle were observed by Rolania and Bhargawa (2015) [5] who reported that karanj oil was most effective as surface protectant to minimize the seed damage at (0.1, 0.5 and 1.0ml/100g seeds) against serricorne on fennel seeds. The other treatments, vekhand powder (T7 - 23.66%), black pepper powder (T6 - 24.66), castor oil (T2-25.33%), coconut oil (T4-25.66), mustard oil (T1 - 26.33%) were found on par with each other and observed next better to untreated control with maximum per cent seed damage i.e. 80.00 per cent

### 4 Effect of organic products on per cent seed weight loss caused by *Trogoderma granarium*

The data recorded on seed weight loss caused by *T. granarium* at 30, 60, 90 and 120 days after seed treatments are shown in Table 5 and presented graphically

### 5. Effect of organic products on per cent grain damage caused by *Trogoderma granarium*

Sr No.	Treatment	Dose/kg seed	Mean number of adult emergence per 100 seeds at			
			30 DAT	60 DAT	90 DAT	120 DAT
T <sub>1</sub>	Mustard oil	10ml	1.33 (1.35)	14.33 (3.83)	29.33 (5.45)	43.33 (6.61)
T <sub>2</sub>	Castor oil	10ml	0.33 (0.91)	11.33 (3.43)	23.66 (4.90)	36.66 (6.09)
T <sub>3</sub>	Neem oil	10ml	0.00 (0.71)	7.33 (2.77)	18.33 (4.32)	27.33 (5.26)
T <sub>4</sub>	Coconut oil	10ml	0.00 (0.71)	10.33 (3.28)	20.00 (4.51)	28.66 (5.39)
T <sub>5</sub>	Karanj oil	10ml	0.00 (0.71)	10.00 (3.23)	22.33 (4.76)	30.33 (5.55)
T <sub>6</sub>	Black pepper powder	10g	0.33 (0.91)	12.66 (3.62)	23.66 (4.90)	34.66 (5.92)
T <sub>7</sub>	Vekhand powder	10g	0.00 (0.71)	12.33 (3.57)	19.00 (4.40)	29.33 (5.45)
T <sub>8</sub>	Control	-----	2.66 (1.77)	19.33 (4.44)	36.33 (6.06)	55.00 (7.44)
'F' test			Sig	Sig	Sig.	Sig.
SE (m) ±			0.10	0.15	0.16	0.12
CD at 5%			0.29	0.44	0.46	0.35

in Fig.4. The data on grain weight loss at 30 days after seed treatments revealed that, the treatment neem oil (T3) @ 10 ml/kg seeds recorded 0.87 per cent weight loss and found statistically significant over all the treatments. The treatment karanj oil (T5) recorded 1.24 per cent weight loss and being the next best treatment. The remaining treatments castor oil (T2 - 1.78%), coconut oil (T4 - 1.99%), mustard oil (T1 - 2.25%) and vekhand powder (T7 - 2.33%) were found on par with each other. The treatment black pepper powder (T6 - 2.74%) found better as compared to untreated control which recorded maximum grain weight loss i.e. 8.22 per cent. The data on per cent grain weight loss at 60 days after seed treatments indicated that the treatment, neem oil (T3) @ 10 ml/kg seeds recorded 1.22 per cent weight loss and statistically significant over all the treatment. The treatment vekhand powder (T7 - 2.62%), karanj oil (T5 - 2.63%) and castor oil (T2 - 2.91%) were observed at par with each other. The other treatments mustard oil (T1) recorded 3.17 per cent weight loss and found on par with castor oil (T2). The treatments coconut oil (T4) and black pepper powder (T6) recorded 4.76 and 4.86 per cent seed weight loss respectively and found on par with each other and also better as compared to untreated control, which recorded maximum per cent seed weight loss i.e. 17.03 per cent at 60 DAT. other and recorded 6 per cent each grain damage as compared to untreated control where maximum damage to the tune of 27.33 per cent was observed. The data recorded on seed weight loss the percentage wheat seeds weight loss at 90 days after seed treatments showed that the treatment with neem oil (T3) @ 10 ml/kg seeds recorded weight loss to the tune of 2.62 per cent and found statistically significant over all the treatments. The treatment karanj oil (T5 - 3.92%) was found to be the next best treatment. The remaining treatments viz. coconut oil (T4), vekhand powder (T7), castor oil (T2) and mustard oil (T1) recorded 5.48, 6.00, 6.13 and 6.72 per cent seed weight loss respectively and found on par with each other. The treatment black pepper powder (T6 - 6.74%) performed better as compared to the untreated control, which recorded maximum per cent of seed weight loss i.e. 19.45 per cent. Similar trend of observations on wheat grain weight loss were seen at 120 days after treatments. The treatment neem oil (T3) @ 10 ml/kg seeds recorded 5.25 per cent grain weight loss and found statistically superior over all other treatment. The effectiveness of neem oil against the beetle were observed by Singh (2005) [6] who reported the significant effect of neem oil in seed weight due to *C. Chinensis* infesting Khesari seeds in storage. Bhardwaj and Verma (2013) [1] also reported that neem oil was most effective treatment which minimized the weight loss up to 0.11 (0.78) per cent. The treatment vekhand

powder (T7 - 7.19%), karanj oil (T5 - 7.24%) and coconut oil (T4 - 7.29%) were found to be on par with each other. The present findings in respect of vekhand powder are in conformity with Gawade *et al.* (2009) who reported that neem oil (2.5 ml/kg) and vekhand powder (2.5 g/kg) were significantly effective in reducing the per cent weight loss of treated cowpea seed. The remaining treatments black pepper powder (T6 - 9.24%), castor oil (T2 - 9.26%) and mustard oil (T1 - 10.21%) were found on par with each other and better as compared to untreated control (23.08%). Overall data indicated that the grains treated with neem oil @ 10 ml/g seeds proved significantly superior over the remaining treatments. Karanj oil, vekhand powder and coconut oil were at par with each other and next in order of excellence which recorded lowest seed weight loss during the storage periods. All the seed protectants tested recorded significantly lowest seed weight loss than untreated control.

#### 5. Effect of organic products on seed germination of wheat

The analyzed data on per cent seed germination as influenced by organic products and dermestid infestation at 30, 60, 90 and 120 days after treatment are shown in Table 6 and depicted in Fig. 5. The germination percentage of wheat seed treated with various organic products tested at 30 days after treatments clearly indicated that, all the organic products tested didn't affect the seed germination, since there was no significant difference between germination of seed with different organic products and untreated control. However at 60 days onwards, significant difference in seed germination was observed due to impact of various seed treatments. The treatment neem oil (T3) @ 10 ml/kg seeds recorded highest seed germination i.e. 93.00 per cent and it was statistically on par with karanj oil (T5), vekhand powder (T7) and castor oil (T2) with 92.00, 92.00 and 89.33 per cent seed germination, respectively. The treatments coconut oil (T4 - 84.33%), mustard oil (T1 - 84.00%) and black pepper powder (T6 - 80.66%) were found on par with each other and better as compared to untreated control 75.66 per cent seed germination. The data on seed germination, at 90 days after treatment showed that the treatment neem oil (T3) @ 10 ml/kg seeds recorded highest seed germination i.e. 91.33 per cent seeds and found on par with karanj oil (T5 - 88.33%) seed germination. The treatment vekhand powder (T7 - 87.66%), mustard oil (T1 - 86.33%) and coconut oil (T4 - 86.00%) and

#### 4 Effect of organic products on per cent seed weight loss caused by *Trogoderma granarium*

Sr. No.	Treatment	Dose/kg seeds	Mean per cent grain damage per 100 seeds at			
			30 DAT	60 DAT	90 DAT	120 DAT
T1	Mustard oil	10ml	5.66 (13.75)	13.00 (21.13)	19.00 (25.82)	26.33(30.85)
T2	Castor oil	10ml	4.33 (11.99)	11.66 (19.96)	18.667 (25.57)	25.33 (30.19)
T3	Neem oil	10ml	0.00 (0.00)	4.33 (12.01)	9.33 (17.74)	15.33 (23.03)
T4	Coconut oil	10ml	6.00 (14.14)	8.00 (16.42)	16.66 (24.07)	25.66 (30.42)
T5	Karanj oil	10ml	0.00 (0.00)	5.33 (13.34)	12.00 (20.25)	18.66 (25.58)
T6	Black pepper powder	10g	6.00 (14.14)	6.00 (14.17)	13.33 (21.40)	24.66 (29.75)
T7	Vekhand powder	10g	2.33 (6.74)	7.66 (16.06)	13.00 (21.10)	23.66 (29.08)
T8	Control	-----	27.33(31.51)	43.66 (41.35)	47.66 (43.66)	80.00 (63.47)
'F' test			Sig.	Sig.	Sig.	Sig.
SE (m) ±			0.67	0.71	0.79	0.92
CD at 5%			1.96	2.09	2.31	2.69

castor oil (T2 - 85.00%) were found on par with each other. The remaining treatment black pepper powder (T6 - 74.66%)

found next better treatment as compared to untreated control (T8 - 54.66%) which registered lowest germination

percentage of seed which means maximum loss of seed quality due to pest infestation in the absence of seed protectants. The analysis of data of seed germination and interpretation of results at 120 days after treatment, concluded that the treatment neem oil (T3) @ 10 ml/kg seeds recorded i.e. 85.33 per cent, vekhand powder (T7), karanj oil (T5), castor oil (T2) with 84.33, 83.33 and 80.00 per cent seed germination respectively and found statistically on par with each other. This result was in accordance with Bhatnagar *et al.* (2001) who observed that germination get decreased as the number of holes got increased. Studies of Singh and Sharma (2003) also supported the present findings who reported that the botanicals used @ 2.5, 5.0 and 10.00 ml/kg seeds at four different time intervals (4 to 6h and 3, 6 and 9 months post treatment). The botanicals could not affect the germination of the seeds. In the present study, all seed treatments had not affected the germination of seeds during 120 days of storage period. Thus, germination of stored wheat was improved due to the protection these organic treatments from damage by *Trogoderma granarium*. None of the treatments apparently reduced the seed germination indicating that these vegetable oils can be used safely for the control of *Trogoderma granarium*. Effectiveness of vekhand powder was found in agreement with the results obtained by Geetha Lakshmi and Venugopal (2007) who 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. Similar results about the effectiveness of oils were observed by Khaire *et al.* (1992) who reported that neem, castor, mustard and groundnut oils when used against *Callosobruchus chinensis* were safe from seed germination point of view. The remaining treatment mustard oil (T1 - 76.66%), coconut oil (T4 - 75.33%), black pepper powder (T6 - 71.33%) were the next best organic treatments as compared to untreated control (49.00%), in registering germination percentage at 120 days after treatment.

Overall results of seed germination exhibited that neem oil @ 10ml/kg seeds recorded highest seed germination (85.33%) and it was found on par with karanj oil @ 10ml/kg seeds and vekhand powder @ 10g/kg seeds and castor oil (T2 - 80%) while untreated control recorded lowest seed germination (49.00%). All the organic material tested recorded significantly higher percentage seed germination in considerable manner than untreated control. The germination was adversely affected in untreated control treatment due to infestation of *Trogoderma granarium* and gradually decreased with advancement in storage period and infestation of pest in case of untreated control

### 5. Effect of organic products on seed germination of wheat

Sr. No.	Treatment	Dose/kg seeds	Per cent seed weight loss at			
			30 DAT	60 DAT	90 DAT	120 DAT
T <sub>1</sub>	Mustard oil	10ml	2.25 (1.65)	3.17 (1.91)	6.72 (2.63)	10.21 (3.26)
T <sub>2</sub>	Castor oil	10ml	1.78 (1.58)	2.91 (1.84)	6.13 (2.57)	9.26 (3.11)
T <sub>3</sub>	Neem oil	10ml	0.87 (1.16)	1.22 (1.30)	2.62 (1.76)	5.25 (2.39)
T <sub>4</sub>	Coconut oil	10ml	1.99 (1.57)	4.76 (2.29)	5.48 (2.44)	7.29 (2.78)
T <sub>5</sub>	Karanj oil	10ml	1.24 (1.31)	2.63 (1.76)	3.92 (2.10)	7.24 (2.78)
T <sub>6</sub>	Black pepper powder	10g	2.74 (1.79)	4.86 (2.31)	6.74 (2.68)	9.24 (3.11)
T <sub>7</sub>	Vekhand powder	10g	2.33 (1.68)	2.62 (1.76)	6.00 (2.54)	7.19 (2.76)
T <sub>8</sub>	Control	-----	8.22 (2.94)	17.03 (4.18)	19.45 (4.46)	23.08 (4.85)
'F' test			Sig.	Sig.	Sig.	Sig.
SE (m) ±			0.039	0.047	0.068	0.08
CD at 5%			0.11	0.14	0.19	0.24

### Summary and conclusion

Khapra beetle, *Trogoderma granarium* (Coleoptera, Dermestidae) is one of the most important and destructive pest of stored cereals in general and wheat in particular being an important limiting factor in storage of cereals. The present study at Insectory field laboratory, College of Agriculture, Nagpur during 2016-17 carried out to evaluate the performance of seven commonly used organic products against khapra beetle infesting wheat under normal storage conditions. The results of the studies are summarized in this chapter. Seven organic products viz., neem oil, mustard oil, karanj oil, coconut oil and castor oil @ 10ml/kg seeds and two powders i.e. black pepper powder and vekhand powder @ 10g/kg seeds along with untreated control were evaluated by using Complete Randomized Design.

1. Effect of organic products on adult emergence: The observations on seed treatment of various organic products at 120 days after treatment indicated that the treatment neem oil (T3), coconut oil (T4), vekhand powder (T7), and karanj oil (T5) expressed similar effect on adult emergence to the extent of 27.33, 28.66, 29.33, 30.33 adults respectively as compared to 55 adults found in untreated control treatment.
2. Effect of organic products on adult emergence: The observations on seed treatment of various organic

products at 120 days after treatment indicated that the treatment neem oil (T3), coconut oil (T4), vekhand powder (T7), and karanj oil (T5) expressed similar effect on adult emergence to the extent of 27.33, 28.66, 29.33, 30.33 adults respectively as compared to 55 adults found in untreated control treatment

3. Effect of organic products on per cent grain damage caused by *Trogoderma granarium*. The grain damage observed at 120 days revealed that the seed treatment with neem oil (T3) @ 10 ml/kg seeds again recorded lowest seed damage i.e. 15.33 per cent but found at par with karanj oil (T5 - 18.66%).
4. Effect of organic products on per cent grain weight loss caused by *Trogoderma granarium*. Similar trend of observations on wheat grain weight loss were seen at 120 days after treatments. The treatment neem oil (T3) @ 10ml/kg seeds recorded 5.25 per cent grain weight loss and found statistically superior over all other treatment. The treatment vekhand powder (T7 - 7.19%), karanj oil (T5 - 7.24%) and coconut oil (T4 - 7.29%) were found to be on par with each other. The remaining treatments black pepper powder (T6 - 9.24%), castor oil (T2 - 9.26%) and mustard oil (T1 - 10.21%) were found on par with each other and better as compared to untreated control (23.08%).

5. Effect of organic products on seed germination of wheat seeds: The analysis of data of seed germination and interpretation of results at 120 days after treatment, concluded that the treatment neem oil (T3) @ 10 ml/kg seeds recorded i.e. 85.33 per cent, vekhand powder (T7), karanj oil (T5), castor oil (T2) with 84.33, 83.33 and 80.00 per cent seed germination respectively and found statistically on par with each other. The remaining treatment mustard oil (T1 - 76.66%), coconut oil(T4 - 75.33%), black pepper powder (T6 - 71.33%) were the next best organic treatments as compared to untreated control (49.00%), in registering germination percentage at 120 days after treatment.

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### Conclusion

Following conclusions are drawn on the basis of the results of the present investigation. Taking into consideration all the parameters like oviposition, adult emergence, seed damage, seed weight loss and per cent seed germination and ICBR, the treatment neem oil 10 ml/kg was found effective treatments against dermestids, *Trogoderma granarium*. Infesting wheat in storage with CB ratio 1: 1.59 (Ranked - 1) neem oil. The next best treatment was castor oil (Ranked 2 – 1:1.93 CB ratio) and mustard oil (Ranked 3 – 1:2.61). The findings of the present investigation indicated that organic derivatives might be useful for management of *Trogoderma granarium* besides safe food provisions. On the basis of interpretation of data it can be concluded that, without wheat seed treatment the insect species *Trogoderma granarium* causes maximum damage to the extent of Rs. 519.30 during the storage at 120 days as against the organic seed treatment neem oil @ 10 ml/kg seed incurred expenditure Rs. 194.71 towards seed protectant. And hence it is advised for seed treatments.

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