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Bioefficacy of different botanical oils against maize weevil, *Sitophilus zeamais* (M.) at medium altitude hills of Meghalaya

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ABSTRACT

The bioefficacy of various botanical oils were evaluated for the management of maize weevil, *Sitophilus zeamais* (M.) at the laboratory conditions of ICAR-RC for North Eastern Hill Region, Barapani, Meghalaya. Different vegetable oils *viz*., coconut, castor, mustard, soybean, sunflower and neem oil were tested for mortality, adult emergence and loss in terms of grain damage and loss in weight of kernels. Amongst them, neem oil was the most effective at both the doses (1ml and 3ml/kg grain). Cent per cent mortality was obtained in grains treated with oils of neem and mustard @ 3ml/kg grains. There was no weight loss and grain damage in treatment with neem oil @ 3ml/kg grain and adult emergence was found to be completely inhibited. Lowest weight loss was obtained in mustard oil treated maize grains followed by maize grains treated with soybean oil (0.75 %). Highest weight loss (2.27 %) was obtained in coconut oil treated maize grains. Highest grain damage (6.38 %) was obtained in maize grains treated with soybean oil and lowest damage (1.79 %) was observed in mustard oil treated grains. The treatment with oils had no negative impact on the germination of the grains.

1. Introduction

Maize follows wheat and rice in being the third most important cereal crop. Being popular globally it is grown in over 140 million hectares (Zaidi and Singh, 2005). Maize contributes 5 % of the total food grain production in the country. In India, maize is grown over an area of 9.2 mha area with a production of 28.75 mt (Rakshit *et al*., 2019). Around 35 % of the total maize produced in our country is used for consumption by humans, about 25 % as poultry feed and 15 % used by food processing industries (Singhal, 1999). Among cereals, it supplies highest amount of calorie (19.5%) for growth and development of the body followed by rice (16.5%) and wheat (15%) (FAO, 2019).

It is the second most important crop in Meghalaya (Patra *et al*., 2013) and is primarily grown in shifting cultivation. Area under maize in north east region is 182,000 ha, with 285,000 tonnes of production and productivity of 1660.7 kg/ha. Highest productivity is in Manipur with 2724 kg/ha and lowest in Tripura with 960 kg/ha during 2007-2008 (Map Atlas of India, New Delhi, 2009). The area under maize in the state of Meghalaya is 16,890 ha and the production is 24.42 MT and productivity is 1445 kg/ha (Directorate of Agriculture, Meghalaya, 2022).

Maize is infested by different insect pests at various growth stage of maize (Patra *et al*., 2021) in field as well as storage condition. Most of the farmers of our country belong to small and medium categories who have no adequate facilities for drying and storage. That is why stored grains become exposed and susceptible to attacked by insects, mites, rodents and pathogens causing huge loss in terms of quantity and quality. Postharvest losses are enormous in developing nations when compared to developed nations. In India, from the total production of cereal grains, 5-10 per cent are loss in storage in various ways, of stored insect pest account for a total loss of about 3.5 % (Girish *et al*., 1985). Biotic agents including insect damage accounts for 10 to 40% grain loss after harvest worldwide (Raja *et al*., 2001). Insect pests alone are responsible for causing storage losses inflicting a damage of up to 20–30 % to maize grains in tropical regions (Haque *et al*. 2000) due to congenial conditions for their development and poor storage conditions. More than 37 species of arthropod insects are reported to be associated with stored maize (Abraham, 1997).

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Controlling stored pests is a daunting task, although synthetic chemicals are apparently available for use. Application of synthetic insecticides can play an important role in reducing insect pests attack thereby reducing storage losses (Tapondjou *et al.*, 2001). However, the use of chemical insecticides for insect pests management of stored grains is limited due to development of resistance by the pest, environmental contamination, increased cost of application and concern of risks among consumers (Bekele *et al.*, 1996; Bekele, 2002). Because of the cons of using synthetic insecticides, the development of alternative chemicals such as botanical pesticides was required (Shaaya *et al.*, 1997). That is why as an alternative to chemicals, natural biopesticides like botanicals and plant derived essential oils for the management of biotic agents are gaining increased attention; they are easily accessible and less-toxic to the environment and human beings (Huang *et al.*, 2000; Lee *et al.*, 2001; Paranagama *et al.*, 2003; Ngamo *et al.*, 2007). Therefore, present experiment was conducted to develop botanical management practices against maize weevil.

2. Materials and methods

The present research work were done in Entomology laboratory, ICAR-RC for NEH region, Umiam, Barapani, Meghalaya. It is located at 25 ^{0}41' 21" N and 91 ^{0}55' 25"E and at an altitude of 1010 m above sea level. Maize weevil, *S. zeamais* (M.) was collected from the stock cultures maintained in the laboratory of Entomology section. The culture of test insect *S. zeamais* was maintained by rearing the insect on whole grains of maize (*Zea mays*) in plastic jars at 27 ± 1 ^{0}C temperature and 70 % relative humidity (RH). Newly emerged adults were separated from time to time for the present studies. The different vegetable oils *viz.*, coconut, castor, mustard, soybean, sunflower and neem oils were procured from the market and tested for their bioefficacy against maize weevil. Two concentrations of different oils @ 1ml/kg and 3ml/kg were mixed thoroughly in separate jars containing 100g of maize grains. Replication of the different treatments were done four times. In each replicate, 10 (ten) pairs of 0-24 hour old adult weevils were introduced. A control was maintained without any treatment. Mortality of adults were recorded at 1(one) day before giving treatment and at 1, 3,7,14 and 24 days after treating the grains. Longevity of adults in treated grains, adult emergence from the grains, per cent damage to grains, per cent insect survived was also noted for all the treatments. Per cent damage in all the treatments was also recorded by counting the number of seeds damaged and number of holes made by weevils.

The per cent loss in weight was calculated by using count and weigh method of Senguttuvan *et al.* (1995)

$$\text{Weight loss} = \frac{(U.Nd)-(D.Nu)}{U(Nd+Nu)} \text{ X } 100$$

Where, Nd = No. of damaged grains, Nu = No. of undamaged grains, U = weight of the undamaged grains and D = weight of damaged grainss.

All the data generated in this investigation were statistically analysed using Fisher's method of Analysis of Variance (ANOVA) in Completely Randomized Design (CRD). Significant and non-significant results of the variance due to treatments, was determined by calculating the respective 'F' values (Pansey and Sukhatme, 1985).

The standard error of the mean difference was calculated by using the following expression:

$$\text{S E M } (\pm) = \sqrt{\frac{2 \; X \; Error \; Mean \; Square}{Number \; of \; replication}}$$

The Critical Difference (C.D) was calculated to find out the significant or non-significant of mean of differences of treatments amongst treatments by using the following formula,

C.D = S. E(d). (±) x t

Where, t = tabulated value of 't' @ 5 per cent level of probability for appropriate degrees of freedom.

3. Results and discussion

The findings pertaining to the efficacy of the treated botanical oils in terms of insect mortality, per cent damage of seeds, per cent loss in weight of treated seeds and number of adult emerged or insect survival are presented as follows:

3.1 Mortality of adult weevils

There was no mortality of adults at 1DBT in all the oil treated treatments. The present investigations revealed that @ 1ml/kg grains the mortality ranged from 30.00 to 82.5 % at 14 DAT, no mortality were found at 24 DAT. Highest adult cumulative mortality of 82.5 % was found in maize grains treated with neem oil at 14 DAT. Lowest adult mortality of 30.00 % was found in safflower and coconut oil treated maize grains. There was no adult mortality observed in other oil treated maize grains at 14 DAT and 24 DAT (Table 1). The data presented at 24DAT represents the cumulative mortality and not the actual mortality on that particular day.

When the oils were applied @ 3ml/kg grains, mortality ranged from 50.00 to 100.00 %. 100 % mortality was obtained in neem and mustard oil treated grains at 7 DAT, the increase in mortality being 24.5 % and 12.5 %, respectively. The adult cumulative mortality in castor, soybean and safflower oil treated grains were statistically at par with was 70.00 %, 75.00 % and 67.5 % mortality, respectively. The lowest cumulative mortality of (42.50 %) was recorded in coconut oil treated grains at 7 days after treatment. High cumulative mortality of 80.00 %, 85.50 % and 85.50 % was recorded in grains treated with castor, soybean and safflower oils at 14 DAT and at 24 DAT no mortality was found (Table 2).

Neem oils at both the doses proved to be effective grain oil to be most effective, though grountnut, sesamum, soybean and mustard oils were also found to act as feeding and ovipositional deterrent and ovicidal agent against pulse beetle attacking cowpea. Khaire *et al.* (1992) reported neem oil treated grains prevented adult emergence at all doses up to 100 days. Similarly, complete adult emergence was restricted with castor oil treated grains at the 0.75 and 1% upto 66 days. Kumar *et al.* (2007) reported that *A. indica* oil treated grains resulted in reduce F_1 populations (3.33 adult) of *C. chinensis*, respectively. The oils act as ovipositional deterrant which cause reduction in fecundity thereby reducing the numbers of adults emerged.

3.2 Number of adults emerged

The present investigation revealed that in all the oil treatments few adults emerged but the best results were obtained in neem oil treatment. Lowest number of adults was found to emerge in neem oil treatment @ 1ml/kg grains. The highest number of adults emerged in soybean oil treated grains (9.75%), which was at par with mustard, castor and safflower treated grains. At the dose of 3ml/kg, there was no adult emergence in neem oil treated grains. Adult emergence in mustard treated grains was very low (1.75) at 3ml/kg followed by castor, soybean and safflower oils, respectively. Maize grains treated with coconut oil had the highest adult emergence (5.75). All the botanical oils resulted in reduced emergence of the progeny when compared with untreated grains (Fig. 1). Present findings are in congruent with Kumari *et al.* (1990), Khaire *et al.* (1992), Singh *et al.* (1994), Ahmed *et al.* (1999), Bhatnagar *et al.* (2001)**,** Uttam *et al.* (2002), Rahman *et al.* (2003) and Rahman and Talukdar (2006).

Singh *et al.* (2001) found that pea seeds treated with neem oil @ 1per cent reduced F_1 adult emergence of *C. chinensis* there by reducing damage damage when stored over a period of three months. Bhatnagar *et al.* (2001) found neem oil to be most effective, though grountnut, sesamum, soybean and mustard oils were also found to act as feeding and ovipositional deterrent and ovicidal agent against pulse beetle attacking cowpea. Khaire *et al.* (1992) reported neem oil treated grains prevented adult emergence at all doses up to 100 days. Similarly, complete adult emergence was restricted with castor oil treated grains at the 0.75 and 1% upto 66 days. Kumar *et al.* (2007) reported that *A. indica* oil treated grains resulted in reduce F_1 populations (3.33 adult) of *C. chinensis*, respectively. The oils act as ovipositional deterrant which cause reduction in fecundity thereby reducing the numbers of adults emerged.

3.3 Per cent grain damage

The damaged grain at the dose of 1ml/kg ranged from 5.00 to 9.60 %. The least damaged grains (5.00 %) were obtained in neem oil treated grains followed by safflower oil treatment (6.78 %). At the dose of 3ml/kg there was no grain damaged in neem oil treatment. Least damaged grains of 1.79 % were found in mustard oil treated grains followed by castor oil. Highest grain damage of 6.38 % was observed in coconut oil treated grains (Fig. 2). All these findings are similar with those of Kumari *et al.* (1990), Singal (1995), Ahmed *et al.* (1999), Singh *et al.* (2001) and Shaheen (2006).

Kumar *et al.* (2000) reported that grain damaged by *S. oryzae* was minimum in *Azadirachta indica* (neem) oil and maximum in *C. nucifera* (coconut) oil. Singh *et al.* (2001) reported minimum damage of 2.06 and 2.66 per cent by insect pests in grain treated with oils and leaf powders of neem compared to control (69.63 %), respectively. Similar results were also obtained by Singh and Singh (2005) who observed reduced damaged grains of 2.80, 4.47 and 6.85 per cent in neem oil, neem kernel powder and neem cake treated grains, respectively. Low percentage damage of grains can be attributed to high mortality of the adult weevils and also due to antifeedant and repellent properties of the oils.

3.4 Per cent weight loss

The lowest loss in weight of maize grains was recorded on neem oil (0.98 %) treated maize grains @ 1ml/kg grains followed by mustard oil (1.25 %). At the dose of 3ml/kg grains, there was no reduction in weight of oil treated grains. Lowest weight loss of 0.22 % was recorded in grains treated with castor oil. Reduction in grain weight upto 0.90, 0.66 and 0.75 per cent was obtained in maize grains treated with mustard, soybean and safflower, respectively. Coconut oil @1ml/kg was not at all effective at all in preventing the loss in weight of treated grains. (Fig.3). These results are in agreement with *Ahmed et al.* (1999), Rani *et al.* (2000) and Bhatnagar *et al.* (2001).

Singh and Singh (2005) found that the neem oil and kernel powder resulted in minimum damage by *Rhizopertha dominica* and thus reduced loss in weight in wheat grains (1.15 and 2.08 %, respectively). Kumar *et al.* (2007) reported that the loss in weight by *S. oryzae* was less (1.95 %) in wheat grains treated with neem oil.

Singh *et al.* (2001) reported that the loss in weight due to *Callosobruchus chinensis* was minimised to 0.63 % and 1.10 % in pulses applied with neem oil and castor oil when compared with untreated control which was very high (47.40 %), respectively. Khalequzzaman *et al.* (2007) reported that average percentage weight loss in grain of pigeon pea at different dosage ranged from 0.6-6.9 % after 33 days of treatment as against 14.0 % in control. The above findings are in conformity with the the present findings.

3.5 Per cent germination

The treatment with different oils appeared to be very safe as present investigations revealed that there was no reduction in germination after the treatment of grains with oils after 60 days. Khaire *et al.* (1992) reported that the germination of seeds was not affected when pigeonpea grains were given treatment with various botanical oils (Fig. 4). Rahman and Talukder (2006) also reported that oil treated grains even up to three months had no effect on seed germination capability. Similar findings were also reported by Khalequzzaman *et al.* (2007) who found that oil treated seeds did not affect the germination of seeds. These reports were in conformity with the present findings that oil treated grains did not have any harmful effect on seed germination.

4. Conclusion

From this study, it can be concluded that all botanical oils were effective in management of maize weevil. Neem oil at 1ml/kg dose gave highest adult mortality 14 DAT. The least damaged grains were obtained in grains treated with neem oil followed by safflower oil treatment. At the dose of 3ml/kg there was no grain damaged in neem oil treatment. The lowest weight loss was recorded on maize grains treated with @ 1ml/kg grains followed by mustard oil. No loss in weight of grains was found in neem oil treated grains @ 3ml/kg grains. There was no reduction in germination after the treatment of grains with oils after 60 days. Therefore, it is concluded that neem oil @3ml/kg of grain may be effective treatment as grain protectant against maize weevil under storage condition.

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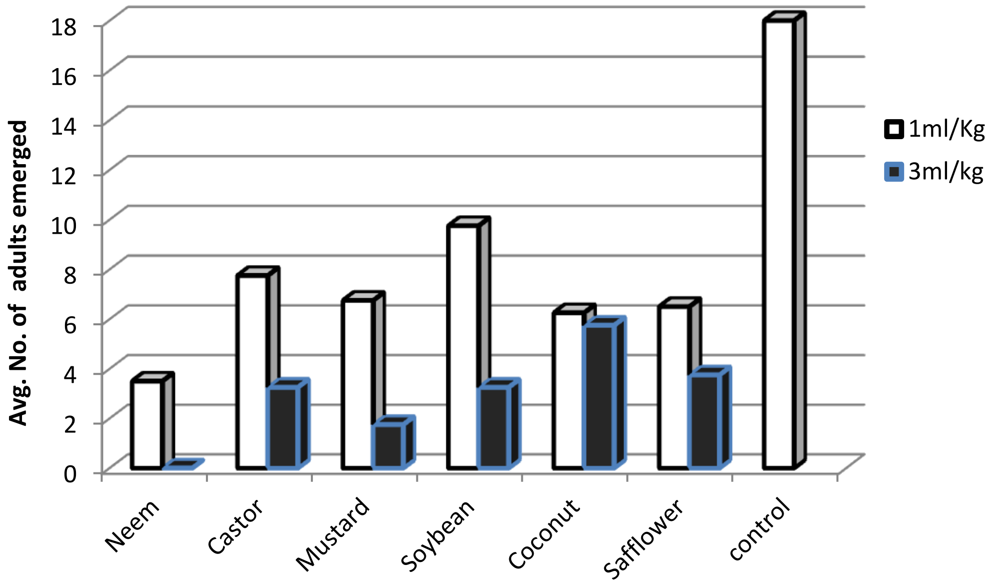

Figure 1. Bioefficacy of different botanical oils on number of adults emerged @ 1 and 3ml/kg grain

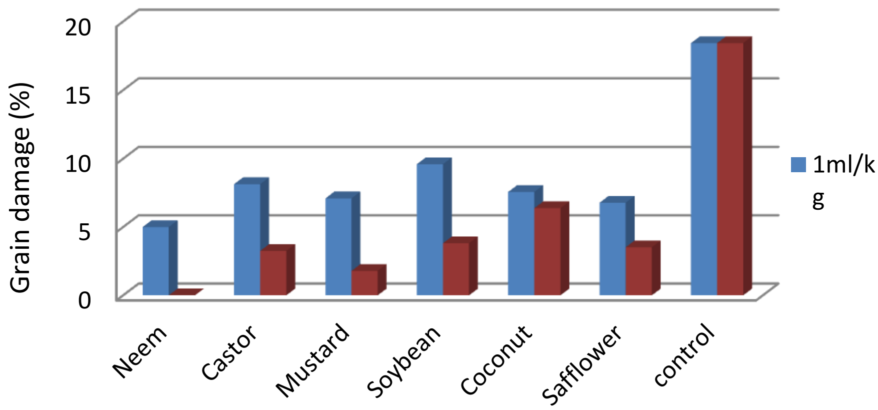

Figure 2. Bioefficacy of different botanical oils on Per cent grain damage @ 1 and 3ml/kg

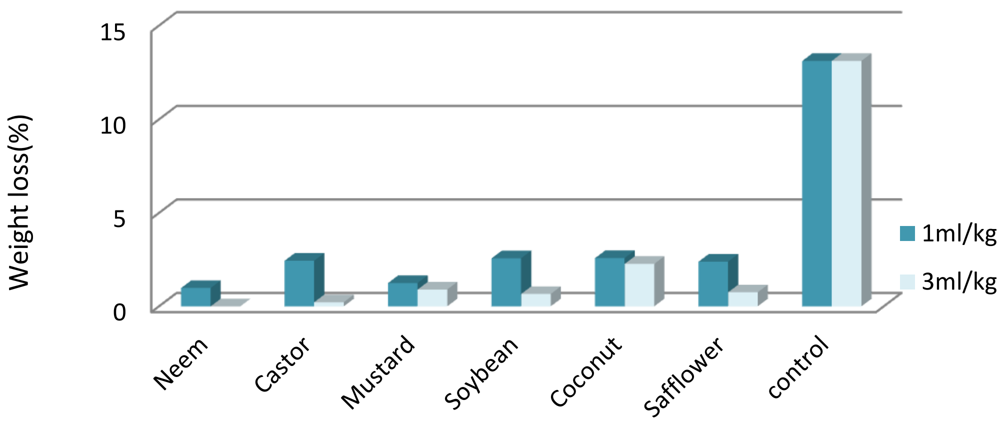

Figure 3. Bioefficacy of different botanical oils on weight loss@1 and 3ml/kg grain

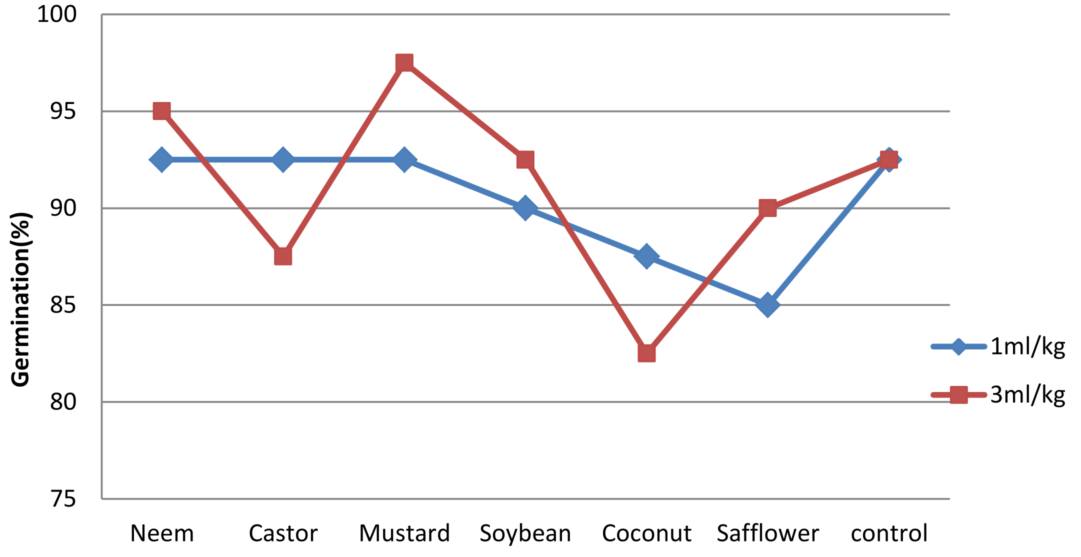

Figure 4. Bioefficacy of different botanical oils on germination of maize grains @1ml and 3ml/kg

Table 1. Bioefficacy of botanical oils on *S. zeamais* (M.) @ 1ml/kg grain

Treatments	Adult cumulative mortality (%)					
	1 DBT	1 DAT	3 DAT	7 DAT	14 DAT	24 DAT
Neem	0.00	12.5[a]	45.0[a]	75.0[a]	82.5[a]	82.50[a]
Castor	0.00	12.5[a]	27.5[b]	45.0[b]	45.0[b]	45.0[b]
Mustard	0.00	5.00[a]	27.50[b]	37.5[b]	37.5[b]	37.5[b]
Soybean	0.00	7.5[a]	22.5[b]	37.5[b]	37.5[b]	37.5[b]
Coconut	0.00	7.5[a]	20.0[b]	30.0[b]	30.0[b]	30.0[b]
Safflower	0.00	10.0[a]	22.5[b]	30.0[b]	30.0[b]	30.0[b]
Control	0.00	0.00	0.00	0.00	0.00	0.00
SE m(±)	-	2.18	3.45	5.28	5.26	5.26
CD at 5%	-	6.41	10.14	15.55	15.47	15.47

NB: Means followed by a common letter are not significantly different at 5% level

Table 2. Bioefficacy of botanical oils on *S. zeamais* (M.) @ 3ml/kg grain

Treatments (Botanical oils)	Adult cumulative mortality (%)					
	1 DBT	1 DAT	3 DAT	7 DAT	14 DAT	24 DAT
Neem	0.00	20.0[a]	72.5[a]	100[a]	100[a]	100[a]
Castor	0.00	17.5[a]	40.0[c]	70.0[b]	80.0[b]	80.0[b]
Mustard	0.00	30.0[a]	87.5[a]	100[a]	100[a]	100[a]
Soybean	0.00	15.0[a]	52.5[c]	75.0[b]	85.0[a]	85.0[a]
Coconut	0.00	10.0[a]	25.0[d]	42.50[c]	50.0[c]	50.0[c]
Safflower	0.00	15.0[a]	42.5[c]	67.5[b]	85.0[a]	85.0[a]
Control	0.00	0.00	0.00	0.00	0.00	0.00
SE m(±)	-	3.23	5.97	4.69	4.36	4.36
CD at 5%	-	9.49	17.57	13.80	12.83	12.83

NB : Means followed by a common letter are not significantly different at 5% level