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ECOFRIENDLY MANAGEMENT OF MAJOR INSECT PESTS OF STORED MAIZE

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ABSTRACT

The laboratory experiments were conducted during 2017-2018 and 2018-2019 to study the efficacy of seed protectants namely fly ash, paddy husk and it's ash, turmeric powder, silica gel, neem leaves and oil, eucalyptus leaves and oil, canola oil and boric acid against rice weevil *Sitophilus oryzae* (L.) and lesser grain borer *Rhyzopertha dominica* (F.) and khapra beetle *Trogoderma granarium* Everts on stored maize (genotype HQPM 1). The results revealed that neem oil was the most ecofriendly treatment against *S. oryzae* with 94.76% adult mortality, 12.54x population growth after 6 months and 0% grain damage (pooled data). In case of *R. dominica*, maximum mortality (91.90%) and 0% grain damage was observed in neem oil but minimum growth (12.44-) value was observed for canola oil. The neem oil was also found effective against *T. granarium* (92.83% mortality; 0% grain damage), and the least (60.04 larval growth was observed with canola oil. Neem oil showed maximum (80%, 80% and 86.67%) repellency against *S. oryzae, R. dominica* and *T. granarium*, respectively which was followed by eucalyptus oil. The neem oil showed 86% germination which was followed by eucalyptus oil (84%). The boric acid showed adverse effects on germination of maize seeds.

Key words: *Sitophilus oryzae*, *Rhyzopertha dominica, Trogoderma granarium*, maize, seed protectants, neem oil, canola oil, eucalyptus oil, damage, growth rate, repellency, germination

The maize *Zea mays* (L.) belong to family Poaceae, is the third most important cereal crop cultivated in 192.13 million ha with yield of 5.62 mt (Anonymous, 2018), and India ranks with 2% (Tripathi et al., 2011). During storage maize is attacked by insect pests, mites and rodents with significant loss. Amongst these, insect pests cause maximum losses, and this amounts to 20 to 40% in many African countries with significant decrease in agricultural production (Abass et al*.,* 2014). Mason and MC Donough (2012) reported that rice weevil (*Sitophilus oryzae* L.), lesser grain borer (*Rhyzopertha dominica* F.) and khapra beetle (*Trogoderma granarium*) are the major insect pests of stored maize. The insecticides chiefly fumigants like phosphine, methyl bromide, cyanogen's, sulfuryl fluoride are being used extensively against these. But, resistance to phosphine and malathion had been reported in India (Leelaja et al*.,* 2007; Rajashekar et al, 2006; Arnaud and Haubruge, 2002). Though these insecticides are very effective, residual effect has negative impact on environment, food commodity and human health (Kumar et al., 2007; Dubey et al., 2007). These problems can be solved by developing cheapest and effective ecofriendly management practices, and the present study evaluates some oils against three major pests viz., *S. oryzae*, *R. dominica* and *T. granarium* in stored maize.

MATERIALS AND METHODS

The stock culture of *R. dominica* and *T. granarium* were obtained from the Department of Entomology, GBPUA&T, Pantnagar, Uttarakhand, while that of *S oryzae* was from the Department of Entomology, CCSHAU, Hisar, Haryana. These cultures were maintained separately in BOD incubator (28±2°C, 70%RH) in the Department of Entomology, on wheat grains, which were sterilized at 50°C for 4 hr. These grains were brought to room temperature before inoculation of test insects, and culture was observed at regular intervals for observing contamination by other insect species as well as pathogens. The male and females were identified in each insect from pure culture and used for various experiments. The evaluation of oils was carried out on maize variety HQPM 1 in three replications in completely randomized design (CRD). The protectants evaluated include- fly ash @ 10g/ kg seed, paddy husk @ 5g/ kg seed, paddy husk ash @ 5g/ kg seed, turmeric powder @ 5g/ kg, silica gel @ 20g/ kg, neem leaves @ 20g/ kg, eucalyptus leaves @ 20g/ kg, neem oil @ 15 ml/ kg, eucalyptus oil @ 20 ml/ kg, canola oil@ 20 ml/ kg and boric acid @ 20g/ kg. In each50 g of maize seeds were inoculated with 5 pairs of freshly emerged adults in each container covered with muslin cloth fastened with rubber band.

The adult mortality was estimated by counting number of dead insects in each at intervals of 1, 3 and 7 days after treatment. The number of dead were converted in terms of % mortality. These data were subjected to Abbott's correction (Abbott, 1925). For estimation of growth, the test insects were discarded after 7 days from each container manually by spreading them on white chart paper. The observations on number of adults (live+ dead) of *S. oryzae* and *R. dominica* as well as grubs of *T. granarium* in each were made made three and six months after storage.

For estimation of grain damage, samples of 100 grains from above were selected randomly at intervals of 30, 60 and 90 days after storage, and % damage was calculated. The % repellency was evaluated for an oil formulation using Whatman's No 1 filter paper, with filter paper divided in two equal parts and rejoined by using cellotape. This rejoined paper was placed in glass petri plate, and the treatments were applied to a half filter paper disc as uniformly as possible and another half was treated as control. In case of solid treatments, 2 g of seeds were treated and placed on half of petri plate whereas other half has untreated seeds (McDonald et al., 1970). The % repellence of each extract was calculated and assigned to repellence classes from 0 to V: Class 0 (PR ≤ 0.1 %)- Non repellent, Class I (PR = 0.1–20 %)- Very low repellent, Class II (PR = 20.1–40 %)- low repellent, Class III (40.1–60 %)- Moderately repellent, Class IV (60.1–80 %)- Repellent and Class V (80.1–100 %)- Highly repellent. Maize seeds treated with seed protectants were stored under laboratory conditions, from which 50 seeds were selected randomly for germination test conducted by using "between paper" method at 20°C in germinator. The data was recorded after 7 day (final count day), and counts of normal and abnormal seedlings made. And, 10 normal seedlings were randomly selected for root and shoot length measurements (in cm). The germination % and seed vigour index was calculated after Abdul-Baki and Anderson (1973). The data obtained were subjected to statistical analysis with OPSTAT software (with CD, p=0.05) after suitable transformations like angular (% data) and square root (count data) (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

The ecofriendly treatments evaluated against *S. oryzae*, *R. dominica* and *T. granarium* (2017 and 2018) with pooled data revealed that all treatments are effective (Table 1); against *S. oryzae*, neem oil was found to be the best with the maximum mortality and at par with eucalyptus oil, while fly ash was the least. Against *R. dominica*, maximum mortality was again with neem oil; similar was the case with *T. granarium*. These results are in accordance with those of Shanmugapriyan and Kingly (2001) and Dayal et al. (2003) on neem oil with *S. oryzae.* Similarly, Jakhar (2004) areported that neem oil at 1% was effective against *T. granarium* with prolonging developmental period, reducing adult emergence, fecundity and longevity. Negahban and Moharramipour (2007) reported that *Eucalyptus* oil was toxic to *S. oryzae.* Hameed et al. (2012) revealed that neem oil showed 45% mortality in major storage insects. The growth rate evaluated up to six months after treatments, revealed that neem, eucalyptus and canola oils were effective against all the three pests (Table 1); *S. oryzae* showed the least growth rate; and with *R. dominica*, minimum growth was in canola oil at par with neem and eucalyptus oils; in *T. granarium*, canola oil led to the least growth. These results agree with those of Jood et al. (1993) on neem oil against *T. granarium;* Sarup (1993) found neem oil highly effective in against *S. oryzae* in stored maize. Sharma (1999) also reported that Nimbecidine @ 2% (neem oil) was effective for 6 months progeny against *S. oryzae, R. dominica* and *T. granarium* in maize. Ketkar (1986) revealed that neem kernel powder at 0.5 and 1.0-2.0 % (w/w) was effective against *S. oryzae* and *R. dominica*. In terms of damage by *S. oryzae*, *R. dominica* and *T. granarium,* the damage was zero with neem, eucalyptus and canola oils. (Table 1). Jakhar and Jat (2010) observed only 9.36% damage by *T. granarium* when wheat grains were treated with neem oil and seeds were viability for up to 270 DAT. Singh et al. (2016) found neem and eucalyptus oil at 0.20% as highly effective against *R. dominica* in stored wheat.

The repellency action reveal that neem and eucalyptus oils with s. oryzae cane be a class 4 repellant; canola oil was found to be the best but with low repellency (class 1); with *R. dominica*, neem and eucalyptus oils revealed best repellency and canola oil was less effective (class 2); and with *T. granarium*, neem oil was the best. The fly ash, paddy husk, paddy husk ash and turmeric powder did not reveal any repellency. Similar observations were made by Mishra et al. (2012) with oil of *Eucalyptus globulus* with *S. oryzae*. Adarkwah et al. (2010) and Akter et al., (2015) observed repellency with neem oil for *Tribolium castaneum* and *S. oryzae.* Kumar and Gupta (2013) observed with eucalyptus oil for *T. granarium*. The maximum germination was observed with eucalyptus

Table 1. Effect of seed protectants on insect pests in stored maize (pooled data- 2017-18, 2018-19)

Treatments with dose in g or ml/ kg seed	Adult mortality**			Growth rate#			Grain damage**		
	S. oryzae	*R. dominica*	*T. granarium*	*S. oryzae*	*R. dominica*	*T. granarium*	*S. oryzae*	*R. dominica*	*T. granarium*
Fly ash 10	3.36 (10.38)	3.86 (11.32)	14.58 (22.44)	59.33 (7.76)	52.00 (7.21)	643.59 (25.37)	17.33 (24.60)	15.33 (23.05)	20.78 (27.11)
Paddy husk 5	15.96 (23.54)	12.91 (21.05)	14.21 (22.13)	59.75 (7.79)	38.00 (6.15)	699.26 (26.44)	17.70 (24.88)	13.28 (21.36)	24.11 (29.40)
Paddy husk ash 5	7.73 (16.13)	9.54 (17.98)	15.52 (23.19)	56.00 (7.54)	39.33 (6.25)	623.34 (24.96)	17.06 (23.38)	12.89 (21.03)	20.61 (26.99)
Tumeric powder 5	36.56 (37.19)	34.94 (36.22)	25.02 (30.00)	61.17 (7.88)	36.58 (5.99)	501.50 (20.65)	15.69 (23.32)	14.17 (22.10)	24.28 (29.51)
Silica gel 20	21.64 (27.71)	23.97 (29.30)	17.05 (24.38)	51.00 (7.20)	73.50 (8.57)	427.08 (17.00)	15.33 (23.01)	17.00 (24.33)	21.28 (27.46)
Neem leaves 20	81.60 (64.57)	82.45 (65.21)	80.63 (63.87)	40.67 (6.45)	45.17 (6.72)	289.17 (16.35)	10.63 (19.05)	12.11 (20.34)	14.06 (22.00)
Eucalyptus leaves 20	80.81 (64.00)	85.29 (67.42)	81.27 (64.34)	56.67 (7.58)	38.92 (6.23)	269.75 (22.39)	13.61 (21.64)	10.89 (19.25)	17.06 (24.36)
Neem oil 15	94.76 (70.11)	91.90 (73.45)	92.83 (74.47)	12.54 (3.54)	13.31 (3.65)	77.57 (8.81)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Eucalyptus oil 20	89.77 (71.33)	89.16 (70.76)	89.01 (70.63)	12.94 (3.60)	13.94 (3.74)	76.78 (8.76)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Canola oil 20	77.10 (61.39)	81.21 (64.29)	81.79 (64.71)	13.91 (3.73)	12.44 (3.53)	60.04 (7.75)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Boric acid 20	33.60 (35.41)	18.12 (25.18)	24.70 (29.79)	44.67 (6.75)	62.58 (7.91)	427.08 (20.65)	13.44 (21.50)	13.06 (21.71)	15.67 (23.30)
Control	1.78 (7.67)	0.53 (4.17)	2.08 (8.30)	102.00 (8.11)	114.08 (10.68)	825.31 (28.72)	30.94 (33.79)	27.39 (31.53)	33.89 (35.59)
C D (p=0.05)	(0.54)	(0.62)	(1.02)	(0.52)	(0.70)	(3.45)	(1.25)	(1.42)	(1.43)
SE(m) ±	(0.18)	(0.21)	(0.35)	(0.17)	(0.17)	(1.15)	(0.41)	(0.47)	(0.73)

*Mean of three replications; **figure in parentheses angular transformed; #square root transformed

leaves followed by fly ash and turmeric powder, and the oil formulations did not have any adverse effect, with boric acid showing nil values (Table 2). The seedling vigour index was minimum for boric acid and maximum for eucalyptus oil; and viability was maximum with eucalyptus leaves followed by fly ash and control. Similar results were obtained by Dakshinamurthy and Goel (1992) with neem leaf powder (0.5 %); Yadav and Tiwari (2018) also gave similar results with neem leaves in wheat. Nukenine et al. (2011) also gave similar results with Neem Azal in maize. Thus, the seed protectants such as neem, eucalyptus and canola oils are effective against *S oryzae, R. dominica and T. granarium*, and these can be used as ecofriendly approaches.

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Table 2. Repellence activity/ effect on germination/ seedling vigour due to seed protectants on insect pests in stored maize

Treatments with dose in g or ml/ kg seed	Mean repellency (%)	Class repellency	Category	Mean repellency (%)	Class repellency	Category	Mean repellency (%)	Class repellency	Category	Germination (%)	Shoot length (cm)	Root length (cm)	Vigour index (%)	Signifi-cance of viability
		S. oryzae			*R. dominica*			*T. granarium*						
Fly ash 10	-6.67	0	Non repellent	0.00	0	Non repellent	-40.00	0	Non repellent	19.00	3091.2	1.000	19.00	3091.2
Paddy husk 5	-6.67	0	Non repellent	-40.00	0	Non repellent	-53.33	0	Non repellent	20.00	3192.00	0.913	20.00	3192.00
Paddy husk ash 5	0.00	0	Non repellent	-20.00	0	Non repellent	6.67	0	Non repellent	18.85	2724.00	0.870	18.85	2724.00
Tumeric powder 5	-13.33	0	Non repellent	-33.33	0	Non repellent	-13.33	0	Non repellent	19.00	3168.00	0.978	19.00	3168.00
Silica gel 20	-13.33	0	Non repellent	-20.00	0	Non repellent	-20.00	0	Non repellent	19.00	3001.00	0.935	19.00	3001.00
Neem leaves 20	13.33	1	Very low repellence	20.00	1	Very low repellence	46.67	3	Moderately repellent	17.80	2996.40	0.957	17.80	2996.40
Eucalyptus leaves 20	6.67	1	Very low repellence\	-33.33	0	Non repellent	-40.00	0	Non repellent	18.50	3292.80	1.043	18.50	3292.80
Neem oil 15	80.00	4	Repellent	80.00	4	Repellent	86.67	4	Repellent	18.60	3096.00	0.935	18.60	3096.00
Eucalyptus oil 20	73.33	4	Repellent	73.32	4	Repellent	73.33	4	Repellent	20.80	3318.00	0.913	20.80	3318.00
Canola oil 20	13.33	1	Very low repellence	26.67	2	Low repellence	13.33	1	Very low repellence	17.35	2295.48	0.804	17.35	2295.48
Boric acid 20	-40.00	0	Non repellent	6.67	1	Very low repellence	-6.67	0	Non repellent	0.00	0.00	0.000	0.00	0.00
Control										19.90	3266.00	1.000	19.90	3266.00
C D (p=0.05)														
SE(m) ±														

+ ve value = Repellence, –ve value = attraction

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