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Evaluation of different botanicals as seed protectant against *Trogoderma granarium* everts infesting stored wheat

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Abstract
An experiment was carried out to evaluate different botanicals as seed protectant against *Trogoderma granarium* Everts infesting stored wheat seeds at Junagadh in laboratory condition. The results revealed that based on per cent adult mortality of *T. granarium*, azadirachtin 10000 ppm (1.5 ml/kg seed) was found the most effective treatment which exhibited highest average adult mortality (69.09%) which was at par with neem seed kernel powder (5 g/kg seed). The treatment of neem oil (5 ml/kg seed) was next effective against this pest. The treatment of karanj oil (43.68%) was found the least effective treatments which was at par with mint leaf powder which in turn on par with custard apple seed powder. Among all the treatments, azadirachtin was found most effective one.

Keywords: Seed protectant, botanicals, *T. granarium*, wheat seeds

Introduction
Wheat (*Triticum aestivum* L.) of Gramineae, is a staple food in the world and said to be originated from south western Asia. The global wheat production was estimated to be 758 million tones. In India, it has occupied an area of 29.8 million hectares with an annual production of 98 million tones (Anon., 2017) [2]. Several hundred insect species have been reported to be associated with stored grains and milled cereals. The *T. granarium* Everts is one of the world's most damaging pests of whole and ground cereals, oilseeds, dry fruits and other stored products. 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) [10]. The insect first of all eats away the germ portion resulting in reduced viability as well as nutritive value of the grain. They can feed on dried products with as little as 2% moisture contents (GISD, 2015 and Lindgren *et al*., 1955) [7, 11]. In India it is a serious pest of wheat (Rahman, 1942) [15]. The larval stage is generally responsible for damage and adults do not normally feed on whole grains (Hadaway, 1956) [8]. They can cause weight loss between 5-30% and may be extent up to 70% in severe cases (GISD, 2015) [7]. As per the Indian Minimum Seed Certification Standards (IMSCS), if seed damage due to storage pests is found more than 0.5%, seed become unfit for further use of sowing. Hence, seed damaged by insect pests during storage is not acceptable at any level. Therefore, pre storage management practices are today's prime need to take care of insect pests during storage with the aim of improving the shelf life of seed.
Mixing of botanicals is easy, cheap and safe method to protect grains like wheat stored particularly for domestic consumption and it is a traditional Indian practice in rural and urban area. During the present course of study attempt was made to evaluate the efficacy of botanicals against *T. granarium* infesting wheat seeds.

Materials and Methods
Eight different botanicals were evaluated for their seed protectant efficacy against *T. granarium* based on periodical mortality at Department of Entomology, Junagadh Agricultural University, Junagadh during 2019-20. The laboratory experiment was conducted with Completely Randomized Design with 3 repetitions on GW-496 variety of wheat. The oils and azadirachtin (10000 ppm) commercial formulation were purchased from the local market of Junagadh, while powder of botanicals used in the experiment were prepared in the laboratory from sun dried parts of respective plants**.** Each botanical material were mixed or smeared to 1.0 kg previously sterilized wheat seeds.

An untreated and sterilized bulk of 1.0 kg wheat seeds was kept under control treatment. All the nine bulks (each of 1.0 kg) of wheat seeds were stored in airtight plastic jar at room temperature and utilized for further experimentation.

Evaluation based on adult mortality

To evaluate the efficacy of botanicals against *T. granarium* based on periodical mortality of adults, a series of experiments were carried out during 2019-20 in laboratory conditions. Each experiment was carried out at a 15days interval, three samples of treated wheat grains, each of 50g (one sample for one repetition) was drawn from each bulk of treatment. The samples were filled in plastic tube (Diameter: 7.00 cm and Height: 8.00 cm) individually. Ten pairs (five to ten days old) of *T. granarium* obtained from laboratory culture were released into each of the plastic tubes and each plastic tube was covered with a piece of two-fold muslin cloth, which is held in position with a rubber band. The observations on the number of total adults were recorded after 7 days of adult release and per cent adult mortality was worked out. Insects showing the movement of legs or antennae were considered as alive. This experiment was conducted for a period of 7 months. The periodical data on per cent mortality was corrected by using Abbott's formula (Abbott, 1925) mentioned below.

$$P = \frac{T - C}{100 - C} X\ 100$$

Where
P = Corrected per cent mortality
T = Observed per cent mortality in treatment
C = Observed per cent mortality in control

Results and Discussion

Nine different treatments including various botanicals were evaluated for their seed protectant efficacy against *T. granarium* in laboratory experiments on wheat seeds. The seed protectant value of various botanicals ware evaluated based on periodical adult mortality.

Evaluation based on adult mortality

The data on corrected per cent adult mortality of *T. granarium* obtained during each experiment carried out at 15 day interval during storage period are presented in (Table 1).

The periodical data further revealed that neem seed kernel powder, neem oil, castor oil and azadirachtin maintained the adult mortality 90.00 per cent up to 45 DOS, while mint leaf powder, custard apple seed powder and karanj oil found effective up to 30 DOS. In case of karanj oil, the mortality falls below 70.00 per cent after 60 DOS. Azadirachtin and neem seed kernel powder could maintain the adult mortality above 50.00 per cent up to 165 DOS, while neem oil and castor oil could do so up to 135 DOS and 120 DOS, respectively. Neem dry leaf powder could maintain upto 105 DOS, while custard apple seed powder and mint leaf powder could able to maintain the mortality above 50.00 per cent up to 90 DOS. Karanj oil could do so up to 75 DOS. Overall, the per cent adult mortality decreased as storage period increased in case of all the botanicals but the rate of decrease in mortality percentage was comparative slower in case of azadirachtin and neem seed kernel powder as can be seen from.

The pooled data on per cent adult mortality of *T. granarium* over different storage periods revealed that there was significant difference in adult mortality due to various botanicals. The period, one of the sources of ANOVA was significant which indicated that there was significant difference in the mean adult mortalities (averaged over treatments) obtained at different storage period. As the period of storage increased, the mean adult mortality decreased significantly. It was 96.54 per cent after 15 DOS, which decreased to 23.88 per cent after 210 DOS. The interaction, treatment x period was not significant indicating consistency of various treatment over periods. The order of botanicals with per cent adult mortality averaged over periods (given in bracket after each treatment) was azadirachtin (69.09%) > neem seed kernel powder (68.59%) > neem oil (64.97%) > castor oil (60.85%) > neem dry leaf powder (58.54%) > custard apple seed powder (51.97%) > mint leaf powder (45.18%) > karanj oil (43.68%). Azadirachtin was found the most effective treatment exhibiting highest average adult mortality (69.09%) which was at par with neem seed kernel powder (68.59%), neem oil (64.97%) and castor oil (60.85%). All these four treatments were significantly more effective than rest of the treatments. The treatments of neem oil were statistically at par with castor oil on one side and azadirachtin & neem seed kernel powder on another side of chronological order. The treatment of karanj oil was found the least effective treatment which was at par with mint leaf powder.

Various workers have evaluated the botanicals at various doses for their insecticidal values against different store grain pests based on adult mortality. Neem oil @ 10 ml/kg, found effective treatments against *T. granarium* infesting wheat in storage (Masolkar *et al.* 2018) [12].

The use of neem (*Azadirachta indica*) essential oil has proved to be the most promising plant extract in controlling *T. granarium*. They act as suffocating agents and kill the insect by blockage of their spiracles (Arivudainambi and Singh, 2003; Odeyemi and Ashamo, 2005 and Egwurube *et al*., 2010) [3, 14, 6]. The repellence and toxicity of a plant species *Plethora* against *T. granarium* have been proved by different workers at various research stations (Rao *et al.*, 2005; Cis *et al*., 2006; Jakhar and Jat, 2010; Nenaah, 2011 and Derbalah, 2012) [16, 4, 9, 13, 5].

Table 1: Mortality of *T. garanarium* in stored wheat seeds due to botanicals

Treat.	Corrected (%) adult mortality of *T. granarium* at fortnightly interval														
	15	**30**	**45**	**60**	**75**	**90**	**105**	**120**	**135**	**150**	**165**	**180**	**195**	**210**	**Pooled**
T_1	90.00 (100.00)*	90.00 (100.00)	90.00 (100.00)	70.91 (89.33)	66.84 (84.00)	64.20 (80.66)	56.91 (70.00)	55.18 (67.33)	48.63 (56.33)	45.94 (51.66)	44.98 (50.00)	40.36 (42.00)	37.60 (37.33)	34.17 (31.66)	59.69 (68.59)
T_2	90.00 (100.00)	85.68 (98.33)	74.48 (92.66)	66.40 (84.00)	55.52 (68.00)	52.14 (62.33)	45.55 (51.00)	42.88 (46.33)	41.34 (43.66)	39.57 (40.66)	38.01 (38.00)	36.44 (35.33)	35.04 (33.00)	30.78 (26.33)	52.41 (58.54)
T_3	73.76 (91.66)	71.34 (81.33)	60.37 (75.33)	56.75 (69.66)	49.59 (58.00)	46.91 (53.33)	38.42 (38.66)	34.78 (32.66)	32.04 (28.33)	29.06 (23.66)	28.01 (22.33)	27.15 (21.00)	26.94 (20.66)	23.39 (16.00)	42.75 (45.18)
T_4	90.00	74.89	66.50	59.36	51.53	50.17	42.30	40.94	38.01	33.72	33.05	30.36	27.93	27.15	47.56

	(100.00)	(93.00)	(84.00)	(74.00)	(61.33)	(59.00)	(45.33)	(43.00)	(38.00)	(31.33)	(30.00)	(25.66)	(22.00)	(21.00)	(51.97)
T_5	75.78 (91.00)	90.00 (100.00)	90.00 (100.00)	74.79 (93.00)	62.80 (79.00)	60.21 (75.33)	54.52 (66.33)	51.92 (62.00)	45.55 (51.00)	42.87 (46.33)	39.40 (40.33)	39.01 (39.66)	31.99 (28.66)	37.42 (37.00)	56.87 (64.97)
T_6	90.00 (100.00)	90.00 (100.00)	90.00 (100.00)	73.06 (91.33)	60.44 (75.66)	56.58 (69.66)	50.56 (59.66)	48.05 (55.33)	41.34 (43.66)	39.01 (39.66)	38.60 (39.00)	31.63 (27.66)	30.78 (26.00)	29.51 (24.33)	54.96 (60.85)
T_7	74.72 (89.66)	69.20 (87.33)	60.67 (75.66)	56.77 (70.00)	48.62 (56.33)	43.83 (48.00)	37.42 (37.00)	34.78 (32.66)	29.06 (24.00)	28.39 (22.66)	27.15 (21.33)	26.94 (20.66)	22.90 (15.66)	18.61 (10.66)	41.36 (43.68)
T_8	90.00 (100.00)	90.00 (100.00)	90.00 (100.00)	74.79 (93.00)	65.16 (82.33)	62.46 (78.66)	56.79 (70.00)	53.91 (65.33)	49.01 (57.00)	48.85 (56.66)	47.66 (54.66)	39.24 (40.33)	36.35 (39.33)	33.05 (30.00)	59.68 (69.09)
Mean	84.28 (96.54)	82.64 (95.99)	77.75 (90.95)	66.60 (83.04)	57.56 (70.58)	54.56 (65.87)	47.81 (54.75)	45.31 (50.54)	40.62 (42.38)	38.43 (38.63)	37.11 (36.40)	33.89 (30.09)	31.19 (26.82)	29.26 (23.88)	51.91 (61.94)
S.Em. ±	4.00	2.08	1.89	1.77	1.79	1.83	1.53	1.56	1.67	1.66	2.18	2.83	2.64	2.25	1.64
Treat. (T)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.56
Period (P)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.24
TXP															
C.D. at 5%	12.09	6.30	5.71	5.37	5.43	5.54	4.63	4.73	5.07	5.03	6.61	8.57	7.99	6.80	4.76
T	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.68
P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NS
TxP C.V.%	8.22	4.37	4.21	4.61	5.40	5.82	5.55	6.03	7.53	7.76	10.33	13.83	13.55	13.31	16.68

Notes: Means in parentheses are retransformed values, those outside are arc sin transformed values

T_1: Neem seed kernel powder, T_2: Neem dry leaf powder, T_3: Mint leaf powder and T_4: Custard apple seed powder @ 5.0 g/kg seed; T_5: Neem oil, T_6: Castor oil and T_7: Karanj oil @ 5.0 ml/kg seed; T_8: Azadirachtin 10000ppm @ 1.5 ml/kg seed.

Conclusion

The results revealed that based on per cent adult mortality of *T. granarium*, azadirachtin 10000 ppm (1.5 ml/kg seed) was found the most effective treatment which exhibited highest average adult mortality (69.09%) which was at par with neem seed kernel powder (5 g/kg seed). The treatment of neem oil (5 ml/kg seed) was next effective against this pest.

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