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Eco friendly management of red flour beetle, *Tribolium castaneum* (Hbst.) (Coleoptera: Tenebrionidae) on stored sesame

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Abstract
The present investigation is aimed to assess the efficacy of different botanicals for the management of red flour beetle, *Tribolium castaneum* in sesame. The study lasted for six months and comprised of ten treatments, namely Sweet flag rhizome powder, Nirgundi leaf powder, Datura leaf powder, Lantana leaf powder, Turmeric leaf powder, Castor leaf powder, Eucalyptus leaf powder, Neem leaf powder, Neem seed kernel extract and Untreated control. Data was recorded three times with 60 days interval between data recordings to assess the parameters *viz.,* per cent seed damage, per cent weight loss, No. of adults emerged and germination percentage. The storage studies revealed that the treatment sweet flag rhizome powder @ 10 g/kg seed recorded the lowest number of adult emerging (2.31adults), the lowest percentage of seed damage (11.71%), percentage of seed weight loss (2.97%) and the highest percentage germination (74.73%) after six months of storage. Furthermore, none of the botanicals had any effect on sesame seed germination.

Keywords: *Tribolium castaneum*, sweet flag rhizome powder, sesame, botanicals, storage

Introduction
Sesame seed is one of the known oldest oilseed crop, domesticated well over 3000 years ago. Sesame is drought-tolerant and can grow where other crops fail. Sesame has the highest oil contents (50%), protein (25%) and carbohydrate (15%). In India, sesame crop occupies an area of 16.20 lakh ha with production of 7.49 lakh tonnes and productivity of 463 kg/ha. The state of Madhya Pradesh contributes an area of 315 ha with a production of 126 tones and productivity of 400 kg/ha (Anon, 2019) [2]. It occupies an important position within the world as the fourth leading oilseeds producing countries lacking behind solely the USA, China, and Brazil.

In India sesame seed bug (*Elasmolomus sordidus*), rice moth (*C. cephalonica*) and red flour beetle (*T. castaneum*) are the major post-harvest seed storage pests of sesame. Among them *C. cephalonica* and *T. castaneum* are most dominant, particularly in small scale storage. According to Kumar (2012), C. *cephalonica* causes up to 94% damage in sesame seed. *Tribolium* is a serious pest that feeds on broken grains, germ portion and milled products due to heavy infestation cause a stinking odour in flour and adversely affect dough quality. Management of agricultural pests has been largely dependent on the use of synthetic chemicals and pesticides and fumigants for post - harvest protection of crops (Isman, 2006) [7]. Overuse of chemicals leads to development of resistance, environmental pollution effects on natural enemies. The present investigations aim to evaluate the efficacy of various botanicals against red flour beetle on sesame to promote non insectidal pest management and safe production.

Material and methods
The experiment was conducted in the division of entomology ICAR-IIOR, Hyderabad during 2019-2020. Consists of ten treatments were arranged in a Completely Randomized Design with three replications. The treatments were Sweet flag rhizome powder, Nirgundi leaf powder, Datura leaf powder, Lantana leaf powder, Turmeric leaf powder, Castor leaf powder, Eucalyptus leaf powder, Neem leaf powder, Neem seed kernel extract and Untreated control. Each treatment of 10 g was treated to one kg of swetha seed of sesame and 50 adult beetles of *Tribolium* were release in to the cloth bag.

Preparation of leaf powder

Fresh leaves are collected, washed thoroughly, and then dried under shade for ten days. The dried leaves were ground to a fine powder with the help of a grinding machine. The powder was then sieved and preserved for experiment purposes.

Measuring seed damage and weight loss

Grain damage is qualitative nature and is usually reported as a percentage of grains damaged in a sample (Boxall, 2002) [3]. Grain weight loss was determined using the count and weight method of Gwinner *et al*. (1996) [6].

$$\text{Weight loss (\%)} = \frac{(\text{Wu x Nd}) - (\text{Wd x Nu})}{\text{Wu x (Nd + Nu)}} \text{x100}$$

Where:
Wu = Weight of undamaged grain
Nu = Number of undamaged grain
Wd = Weight of damaged grain
Nd = Number of damaged grain

Seed germination percentage

Standard germination tests were carried out and the Petri dishes were incubated in walk in germinator for 7 days and the percentage of germination was calculated by using the formula

$$\text{Seed gemination (\%)} = \frac{\text{No of germinated seeds}}{\text{Total number of seed}} \text{x100}$$

Results and Discussions

Per cent seed damage

After 2 months of treatment, sweet flag rhizome powder (4.38%) was found most effective and significantly superior to other treatments followed by nirgundi leaf powder (4.52%), and eucalyptus leaf powder (5.25%). While untreated control recorded (11.03%) highest seed damage followed by lantana leaf powder (9.37%), and datura leaf powder (7.6%).

After 4 months of treatment, sweet flag rhizome powder (7.19%) was found effective, followed by nirgundi leaf powder (7.30%), and eucalyptus leaf powder (7.35%). The untreated control (15.50%) found maximum seed damage followed by lantana leaf powder (12.75%) and datura leaf powder (11.92%).

After 6 months of treatment, sweet flag rhizome powder (11.71%) recorded the lowest seed damage followed by nirgundi leaf powder (12.78%), and eucalyptus leaf powder (13.24%) was at par with each other. Significantly, the highest per cent seed damage was observed in the untreated control (19.17%), lantana leaf powder (16.27%) which were significantly deferred with datura leaf powder (15.91%) and castor leaf powder (15.48%). These findings are in agreement with the results of a study conducted by Yevoor (2003) [9] who reported sweet flag rhizome powder rhizome powder @ 2% caused zero per cent seed damage and Dipak *et al*. (2021) reported the lowest per cent damage of seed (4.0%) with sweet flag rhizome powder.

Per cent seed weight loss

After 2 months of treatment, sweet flag rhizome powder (0.80%), nirgundi leaf powder (0.84%), eucalyptus leaf powder (1.08%), neem leaf powder (1.09%) were found on par with each other. Whereas maximum weight loss was observed in untreated control (5.74%) followed by lantana leaf powder (4.17%), and datura leaf powder (3.27%).

After 4 months of treatment, higher seed weight loss was observed in untreated control (6.03%) followed by lantana leaf powder (4.79%), and datura leaf powder (3.85%) which were at par with each other. The minimum per cent seed damage was recorded in sweet flag rhizome powder (1.96%) followed by nirgundi leaf powder (2.40%) and eucalyptus leaf powder (4.72%).

After 6 months of treatment, significant minimum weight loss was observed in the sweet flag rhizome powder (2.97%) followed by nirgundi leaf powder (3.90%), and eucalyptus leaf powder (4.72%). Whereas untreated control (9.52%) was registered as minimum per cent weight loss, followed by lantana leaf powder (7.09%), and datura leaf powder (6.42%). The findings with respect of sweet flag rhizome powder are in conformity with Gawade *et al.* (2009) [5] who reported that Sweet flag rhizome powder @ 2 .5 g/kg was significantly effective in reducing the per cent weight loss of treated cowpea seed. Similarly, Dipak *et al*. (2021) [4] reported the lowest per cent weight loss (3.32%) was observed in wheat treated with sweet flag rhizome powder.

Number of adult emergence

After 2 months of treatment, sweet flag rhizome powder (1.38 adults) showed minimum number of adult emergence followed by nirgundi leaf powder (2.00 adults), eucalyptus leaf powder (2.00 adults). Whereas the untreated control (10.85 adults) noticed maximum number of adult emergence followed by lantana leaf powder (8.22 adults), and datura leaf powder (4.93 adults) are deferred with each other.

After 4 months of treatment, minimum number of adult emergence noticed in sweet flag rhizome powder (2.25 adults) followed by nirgundi leaf powder (2.67 adults), and eucalyptus leaf powder (5.13 adults) on par with each other. Significantly, the maximum number of adult emergence was observed in untreated control (40.79 adults) followed by lantana leaf powder (32.50 adults), and datura leaf powder (21.13 adults) were significantly differed from each other.

After 6 months of treatment, among different botanical sweet flag rhizome powder was recorded least number of adult emergence (2.31 adults), and nirgundi leaf powder (9.51 adults) were the rest of the significant treatments. While the untreated control (59.33 adults) was found the maximum number of adult emergence followed by lantana leaf powder (54.95 adults), and castor leaf powder (22.00 adults). The findings are corroborated with the results of Siva Srinivasu (2001) who reported the lowest emergence of *S. oryzae* in sorghum grains, treated with 1.00 per cent sweet flag rhizome powder. Similarly, Abhijit *et al.* (2018) [1] who recorded that sweet flag rhizome powder storage caused low adult emergence of *C. ferrugineus and L. serricorne* at different concentrations.

Per cent seed germination

After 2 months of treatment, among the different botanical evaluated sweet flag rhizome powder, and nirgundi leaf powder recorded highest germination (91.50%) followed by eucalyptus leaf powder (89.00%) and neem leaf powder (83.50%). While minimum germination was recorded in untreated control (68.08%) followed by lantana leaf powder (70.50%), and datura leaf powder (72.50%).

After 4 months of treatment, germination was maximum with sweet flag rhizome powder (92.27%) followed by eucalyptus leaf powder (86.78%) nirgundi leaf powder (79.90%) and

neem leaf powder (73.86%). While significantly minimum germination was noticed in untreated control (63.00%) followed by lantana leaf powder (66.57%), datura leaf powder (68.16%) and castor leaf powder (68.80%).

After 6 months of treatment, maximum seed germination was observed in the sweet flag rhizome powder (74.43%) followed by nirgundi leaf powder (71.50%), and eucalyptus leaf powder (66.48%). While minimum viability was recorded in the untreated control (52.33%) followed by lantana leaf powder (57.53%), and datura leaf powder (58.96%). The similar findings are reported by Dipak *et al*. (2021) [4] that the highest germination (89%) was observed in seeds treated with sweet flag rhizome powder up to 90 days after treatment.

Table 15: Efficacy of botanicals against *T. castaneum* in sesame during storage

Treatments	Dose/kg seed	% Seed damage*			% Seed weight loss*			No of adults emerged#			% Seed germination*		
		Months after treatment											
		2	4	6	2	4	6	2	4	6	2	4	6
Sweet flag rhizome powder	10 g	4.38 (12.07)	7.19 (15.55)	11.71 (19.99)	0.80 (5.13)	1.96 (8.06)	2.97 (9.93)	1.38 (1.16)	2.25 (1.46)	2.31 (1.48)	91.50 (73.16)	92.27 (73.98)	74.73 (59.84)
Nirgundi leaf powder	10 g	4.52 (12.27)	7.30 (15.67)	12.78 (20.95)	0.84 (5.27)	2.40 (8.91)	3.90 (11.38)	2.00 (1.41)	2.67 (1.61)	9.51 (3.08)	91.50 (73.10)	79.90 (63.39)	71.50 (57.74)
Datura leaf powder	10 g	7.16 (15.49)	11.92 (20.20)	15.91 (23.49)	3.27 (10.42)	3.85 (11.31)	6.42 (14.67)	4.93 (2.22)	21.13 (4.60)	21.53 (4.64)	72.50 (58.40)	68.16 (55.66)	58.96 (50.19)
Lantana leaf powder	10 g	9.37 (17.81)	12.75 (20.91)	16.27 (23.78)	4.17 (11.78)	4.79 (12.64)	7.09 (15.44)	8.22 (2.87)	32.50 (5.70)	54.95 (7.41)	70.50 (57.13)	66.57 (54.71)	57.53 (49.36)
Turmeric leaf powder	10 g	5.53 (13.60)	8.39 (16.83)	14.07 (22.03)	1.22 (6.34)	3.41 (10.65)	5.86 (13.99)	2.23 (1.48)	10.03 (3.17)	16.70 (4.08)	81.00 (64.25)	71.53 (57.77)	64.42 (53.41)
Castor leaf powder	10 g	6.41 (14.66)	10.63 (19.03)	15.48 (23.16)	2.80 (9.64)	3.64 (11.00)	5.97 (14.14)	4.12 (2.03)	18.08 (4.25)	22.00 (4.69)	72.50 (58.40)	68.80 (56.13)	60.03 (50.79)
Eucalyptus leaf powder	10 g	5.25 (13.24)	7.35 (15.73)	13.24 (21.33)	1.08 (5.96)	2.64 (9.35)	4.72 (12.55)	2.00 (1.41)	5.13 (2.26)	15.19 (3.89)	89.00 (70.70)	86.78 (68.71)	66.48 (54.68)
Neem leaf powder	10 g	5.43 (13.47)	8.16 (16.60)	13.72 (21.73)	1.09 (5.98)	2.82 (9.67)	5.10 (13.05)	2.69 (1.62)	5.73 (2.38)	15.50 (3.94)	83.50 (66.09)	73.86 (59.28)	65.25 (53.89)
NSKP	10 g	5.62 (13.71)	10.15 (18.58)	14.31 (22.22)	2.30 (8.71)	3.52 (10.81)	5.92 (14.08)	2.62 (1.62)	10.29 (3.21)	18.12 (4.25)	79.00 (62.73)	69.50 (56.49)	62.15 (52.04)
Untreated control	-	11.03 (19.39)	15.50 (23.16)	19.17 (25.96)	5.74 (13.86)	6.03 (14.20)	9.52 (17.96)	10.85 (3.29)	40.17 (6.34)	59.33 (7.70)	68.08 (55.62)	63.00 (52.56)	52.33 (46.34)
S.Em±	-	0.39	0.34	0.48	0.15	0.21	0.28	0.10	0.12	0.14	1.26	1.48	1.62
C.D(5%)	-	1.16	1.00	1.41	0.45	0.63	0.81	0.32	0.38	0.40	3.73	4.38	4.80
C.V	-	4.66	3.23	3.68	3.21	3.48	3.48	9.90	6.40	5.27	3.42	4.29	5.34
*Figures in the parentheses are arc sine transformed values and # square root transformed values MAT-months after treatment													

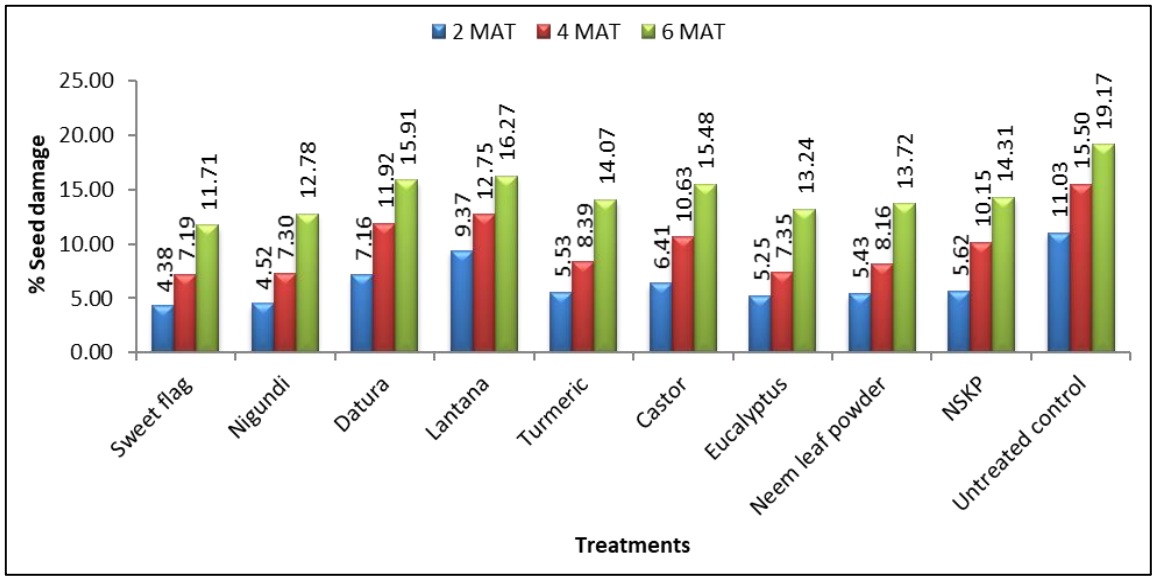


Fig 1: Efficacy of botanicals on % Seed damage against *T. castaneum* during storage

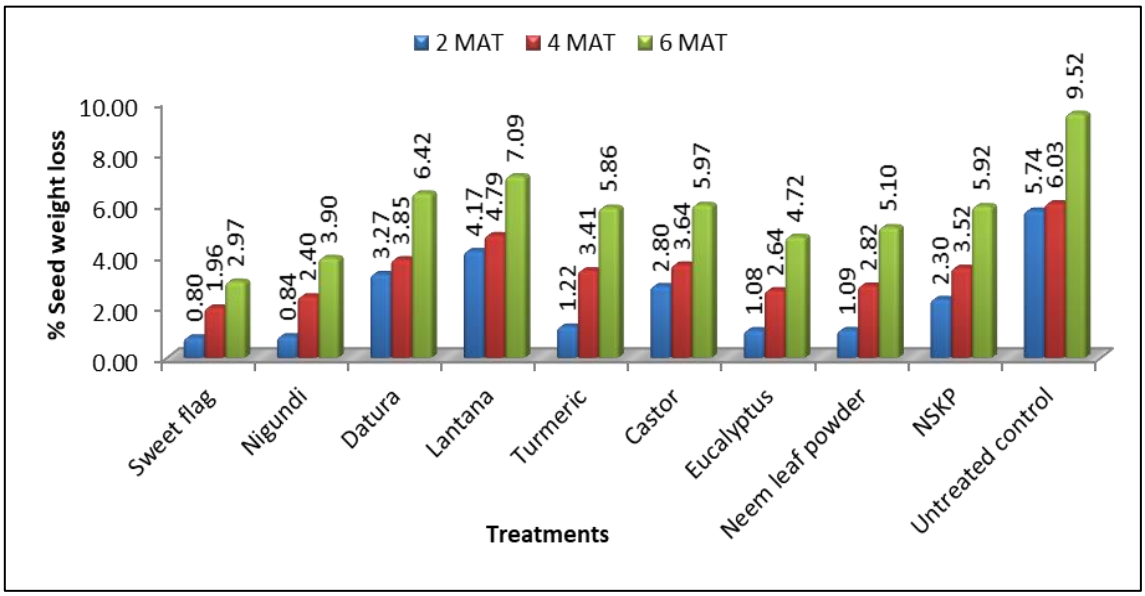


Fig 2: Efficacy of botanicals on % Seed weight loss against *T. castaneum* during storage

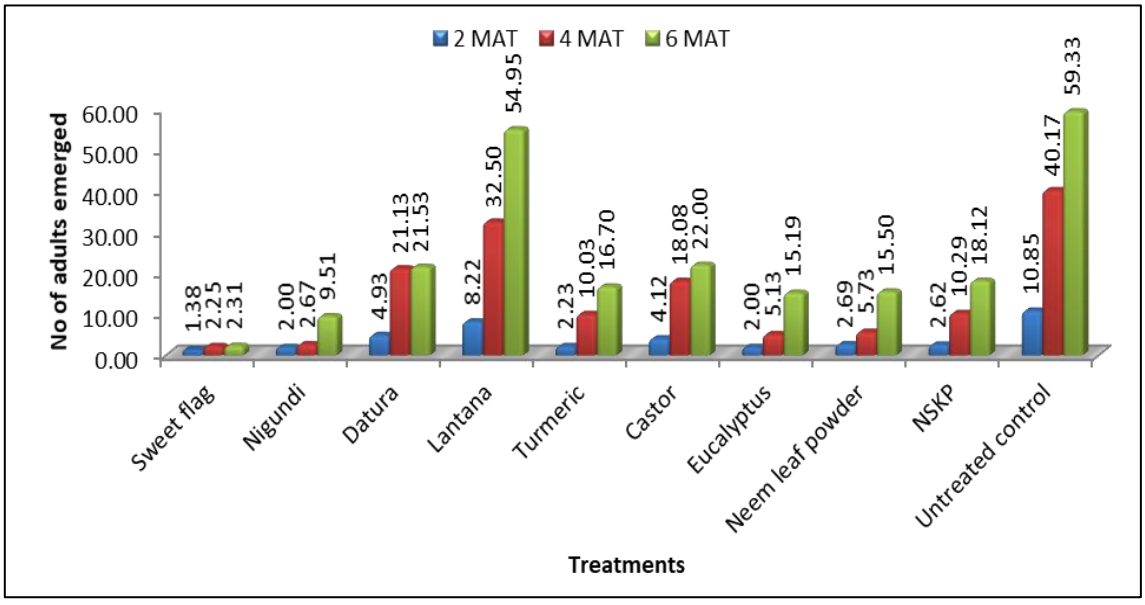


Fig 3: Efficacy of botanicals on No. of adult emergence against *T. castaneum* during storage

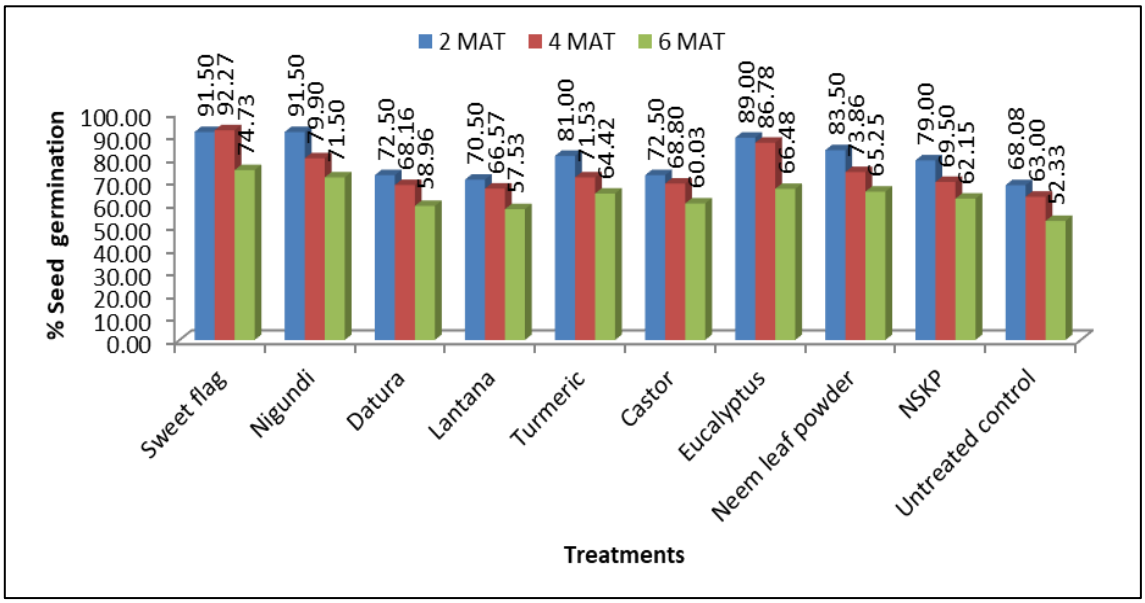
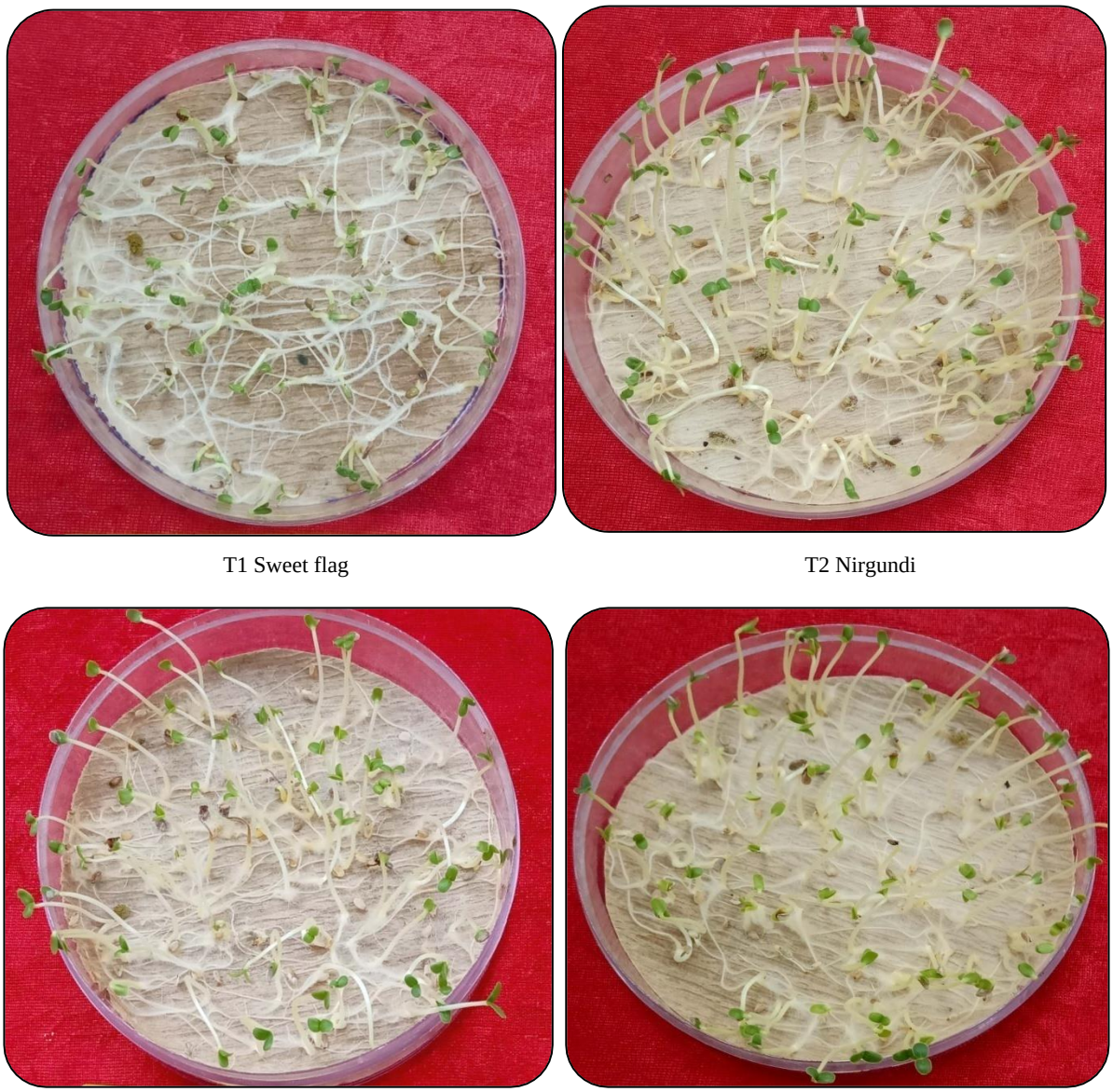


Fig 4: Efficacy of botanicals on % Seed germination against *T. castaneum* during storage



T1 Sweet flag T2 Nirgundi

T4 Lantana T10 Control

Plate 1: Effect of germination with different botanicals by Petri dish method

Conclusion

The result of the study exhibited that all used botanicals can play an important role in stored food product protection. The botanical sweet flag rhizome powder showed satisfactory activity and proved to be promising against *T. castaneum*. Therefore botanical can become an interesting alternative to conventional chemical control strategies. Further studies are required for identification of active compounds of Sweet flag rhizome powder.

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