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Effect of different packaging materials on the efficacy of sweet flag rhizome powder (*Acorus calamus L.)* treated sorghum against *Sitophilus oryzae*

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Abstract: An experiment was conducted to know the effect of different packaging materials and sweet flag rhizome on seed quality of sorghum. The graded seeds were packed in six containers *viz.,* polythene cover, mud container, cloth bag, gunny bag, glass container and steel container and seeds were treated with two percent of sweet flag rhizome powder before storage. The different observations *viz.,* number of live adults, seed damage (%) by *Sitophilus oryzae* and germination (%) of seeds were recorded. The results revealed that the sweet flag rhizome treated seeds packed in steel container, recorded lowest seed damage percentage (32.00%), number of live adults (5.11) and highest seed germination (76.00%) after nine months of treatment. Hence seeds treated with sweet flag rhizome stored in steel containers reduces the insect infestation and steel containers can be effectively used for maintaining seed quality of sorghum during storage.

Keywords: Containers, Seed quality, Sitophilus oryzae, Sorghum, Sweet flag rhizome

INTRODUCTION

Sorghum (*Sorghum bicolor* (L.) Moench) is a premier crop of the semi arid tropics which ranks fourth after rice, wheat and maize and is a major staple food in several parts of the world. Food grains play an important role in the country's economy, as nearly 18-20 percent of gross domestic product (GDP) is obtained from agriculture. Food grain losses due to insect infestation during storage are a serious problem, particularly in the developing countries (Talukder *et al.*, 2004; Dubey *et al.*, 2008). The quantitative and qualitative damage to stored grains and grain product from the insect pests may amount to 20–30% in the tropical zone and 5–10% in the temperate zone (Talukder, 2006; Rajendran and Sriranjini, 2008). Food grain production in India has reached 250 million tonnes in the year 2010-2011, in which nearly 20–25% food grains are damaged by stored grain insect pests (Rajashekar *et al.*, 2010; Rajashekar and Shivanandappa, 2010). The efficient control and removal of stored grain pests from food commodities has long been the goal of entomologists throughout the world.

Since the 1950s, synthetic insecticides have been used extensively in grain facilities to control stored product insect pests. Fumigants such as methyl bromide, phosphine, cyanogens, ethyl formate, or sulfuryl fluoride rapidly kill all life stages of stored product insects in a commodity or in a storage structure. Fumigation is still one of the most effective methods for the prevention of stored product losses from insect pests. But pests develop resistance, not stored products were showing a slow upsurge in fumigation resistance (Donahaye, 2010). Resistance to phosphine is so high in Australia and India, it may cause control failures (Leelaja *et al.*, 2007; Rajashekar *et al.*, 2006). Although chemical insecticides are effective, their repeated use has led to residual toxicity, environmental pollution and an adverse effect on food besides side effect on humans (Dubey *et al.*, 2007; Kumar *et al.*, 2007). Their uninterrupted and indiscriminate use not only has led to the development of resistant strains but also accumulation of toxic residues on food grains used for human consumption that has led to the health hazards (Sharma and Meshram, 2006).

To avert these problems, there is need to develop alternative strategies like use of botanicals. They must be pest specific, nonphytotoxic, nontoxic to mammals, ecofriendly, less prone to pesticide resistance, relatively less expensive, and locally available (Hermawan *et al.*, 1997). This has led to re-examination of the century-old practices of protecting stored products using plant-derivatives, which have been known to resist insect attack (Talukder, 2006; Lale, 1992; Sahayaraj, 2008). Plant derived materials are more readily biodegradable, less likely to contaminate the environment and nay be less toxic to mammals. Of the several plant origin materials, use of sweet flag, *Acorus calamus* (L.) is widely spread in Asia, North America and Europe. The essential oil obtained from rhizome (by steam distillation of *A. calamus*) showed pronounced insecticidal properties. There is an extensive literature

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covering the whole spectrum of the insecticidal property of *A. calamus* rhizomes. It possesses insecticidal property against many stored grain pests as reported by Khan and Agharwal (1972), Pawar (1980) and Kittur (1990). Keeping above in view the efforts were made to know the efficacy of sweet flag rhizome under different packaging materials.

MATERIALS AND METHODS

Studies on the effect of packaging materials on the efficacy of sweet flag rhizome treated sorghum against *Sitophilus oryzae* was carried out during 2012-13 and 2013-14 in the Department of Agricultural Entomology, College of Agriculture, Raichur, Karnataka state.

Preparation of sweet flag rhizome powder : Rhizomes of sweet flag when procured from ayurvedic medical store and made into bits and shade dried for a week (Nandi, 2007). Later it was grounded in to powder and sieved in 60 micron sieve and used for further studies.

One kg of freshly harvested certified seed with very high percentage of germination and low moisture content (<10%) were taken and fumigated prior to use, to ensure complete eradication of field infestation if any. For each treatment one kg seed was used. Prepared sweet flag rhizome powder, malathion were treated to the seeds. After shade drying the packaging materials, redgram seeds were filled in bags and kept in laboratry under ambient condition. The treatments imposed in the experiment were as follows in Table 1.

Packing materials: P1: Polythene cover; P2: Mud container; P3: Cloth bag; P4: Gunny bag; P5: Glass container ; P6: Steel container

The experiment was initiated with three treatments and six packing materials by adopting Factorial completely randomized design (FCRD) with three replications.

Observations: Mortality/ survival rate of *S. oryzae* was recorded in all treatment to know the effectiveness of botanical and malathion. Following observations were recorded at trimonthly interval up to 9 months or loss of germination below Minimum Seed Certification Standard (MSCS) on the following parameters like, adult emergence, percent seed damage and germination percent. Damaged seeds were counted for each treatment by drawing a sample of 100 seeds at random. Adults that emerged from 100 g were obtained by deep freezing for about five minutes and sieved.

Adult emergence in representative sample: Adults that emerged were counted in all the treatments by taking 100 g of sorghum seeds.

Percent damage (insect infestation): Four hundred seeds were randomly drawn from each treatment and replication, Number of damaged seeds were counted and expressed as per cent seed damage.

Percent seed infestation=100 × (Number of seed damaged/Total number of seeds in sample)

Table 1. Details of seed treatment.

Treatments	Treatment details	Concentration
T1	Sweet flag rhizome powder	2%
T2	Malathion	1%
T3	Untreated control	-

Germination of seeds: The germination test was conducted by between paper (BP) methods as prescribed by the International Seed Testing Association (ISTA). A total of 100 sorghum seeds of each replication in each of the treatment were selected and uniformly placed on a germination paper and the rolled towels were placed vertically in the germination cabinet maintained at 25° C, with 90 per cent relative humidity. Germination counts were taken on sixth day after incubation and per cent germination was worked out.

RESULTS AND DISCUSSION

The data on the number of live adults was presented in the table 2. It was observed that the number of adults varies with the packaging materials and treatments during the storage period. Number of adults was more in cloth bag and less in steel, glass and polythene cover. This may be due to congenial condition for insects in the cloth bag. Significant difference were recorded between the treatments and packaging materials and interaction effect at three, six and nine months after storage At six months after storage, with respect to packaging material the lowest (1.61 adults/100 g seeds) was recorded in polythene cover, steel and glass container, whereas highest was in cloth bag (3.56 adults/100 g seeds). Among treatments malathion and sweet flag rhizome were on par with each other. At nine months significantly least number of adults was observed in malathion (4.97 adults/100 g seeds) followed by sweet flag (5.67 adults/100 g seeds) and highest in untreated control. With respect to packaging material the lowest in polythene cover, steel and glass containers and highest was in cloth bag. This is in agreement with Mishra *et al*. (2008) who revealed that gunny bag impregnated with deltamethrin (0.0125 per cent) afforded complete protection up to 6 months. Sia and Rejesus (1989) reported the gunny bag impregnation with spinosad, cypermethrin and peremethrin at 1 per cent were safe and protected against insect damage for four months. Narayanaswamy (2013) also reported the highest number of adults of *Sitophilus oryzae* was recorded in the cloth bag. Vidyashree (2013) studied the effect of different packaging materials against pulse beetle in chickpea and reported cloth bag was worst affected and HDPE porus bag shows promising.

It was observed that the sorghum seeds stored in different packaging materials and treated with sweet flag and chemicals varied significantly in respect of per cent seed damage. There is a significant difference among the interaction also. The seeds stored in polythene cover, steel containers and glass containers (32.00) recorded lowest seed damage per cent compared to cloth bag (45.22%) at 9 months after storage. Seeds treated with malathion showed less percent seed

Table 2. Influence of packaging materials on the efficacy of sweet flag rhizome powder on the adults of *S. oryzae.*

Treatments	No. of live *S. oryzae* adults during storage																				
	3 months after treatment							6 months after treatment							9 months after treatment						
	P1	P2	P3	P4	P5	P6	Mean	P1	P2	P3	P4	P5	P6	Mean	P1	P2	P3	P4	P5	P6	Mean
T_1 (Sweet flag rhizome)	0.00 (0.71)*	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)b	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)b	4.50 (2.24)	6.67 (2.68)	8.33 (2.97)	5.67 (2.48)	4.50 (2.24)	4.50 (2.24)	5.69 (2.49)b
T_2 (Malathion)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)b	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)b	3.33 (1.96)	5.50 (2.45)	7.67 (2.86)	6.67 (2.68)	3.33 (1.96)	3.33 (1.96)	4.97 (2.34)c
T_3 (Untreated control)	0.00 (0.71)	0.83 (1.15)	1.83 (1.53)	1.17 (1.29)	0.00 (0.71)	0.00 (0.71)	0.64 (1.07)a	4.83 (2.31)	6.83 (2.71)	10.17 (3.27)	8.00 (2.92)	4.83 (2.31)	5.83 (2.31)	7.06 (2.75)a	7.50 (2.83)	9.50 (3.16)	14.67 (3.89)	11.50 (3.46)	7.50 (2.83)	7.50 (2.83)	9.69 (3.19)a
Mean	0.00 (0.71)d	0.28 (0.88)c	0.61 (1.05)a	0.39 (0.94)b	0.00 (0.71)d	0.00 (0.71)d		1.61 (1.45)d	2.23 (1.67)c	3.56 (1.97)a	2.67 (1.78)b	1.61 (1.45)d	1.61 (1.45)d		5.11 (2.37)d	7.22 (2.78)c	10.22 (3.27)a	7.94 (2.91)b	5.11 (2.37)d	5.11 (2.37)d	
	S.Em±				CD at P=0.01			S.Em±				CD at P=0.01			S.Em±				CD at P=0.01		
Treatments (T)	0.030				0.085			0.007				0.020			0.011				0.032		
Packing materials (P)	0.042				0.121			0.010				0.028			0.016				0.078		
T x P	0.073				0.209			0.017				0.049									

*Figures in the parentheses are $\sqrt{x + 0.50}$ transformed values; NS: Non significant; P1: Polythene cover, P2: Mud container, P3: Cloth bag, P4: Gunny bag, P5: Glass container and P6: Steel container; Figures in the column followed by same letters are not-significant at P = 0.01 by DMRT

damage followed by sweet flag rhizome powder (Table 3). This is in corroboration with Basavegowda *et al.,* (2013), who recorded highest seed damage of *Callasobruchus analis* in chickpea in cloth bag. Ghelani and Helal (2009) studied the efficacy of emamectin benzoate on harvested pearl millet hybrid seed (GHB-558) was taken and reported that cloth bag impregnated with emamectin benzoate recorded the highest seed damage. Vidyashree (2013) studied the effect of various packaging materials treated with insecticides against pulse beetle and reported that porous HDPE bag shows effective. Narayanaswamy (2013) also reported cloth bag treated with insecticide recorded highest seed damage caused by *S. oryzae* in maize and lowest was in porous HDPE bag. Further, the seeds stored in steel container, glass container and polythene cover recorded highest germination per centage (76.00%) at 9 months after treatment. With respect to interaction effect, after 9 months of storage, the seeds treated with malathion and stored in steel, glass container and polythene cover recorded highest germination percentage (Table 4).

There was gradual reduction in germination percentage during storage in all the packaging materials and treatments but reduction process was relatively slower in steel, glass container and polythene cover compared to cloth bag. This might be due to storage environmental conditions. Longevity of stored seeds considerably depends upon the storage conditions, primarily in terms of temperature and moisture content (Relative humidity) and also aeration. The probable reason for slow rate of reduction in germination is due to reduced rate of respiration and metabolic changes occurring in seeds as reported by Das *et al*. (1998). The results of this investigation regarding the use of different packaging materials, steel container, glass container and polythene cover showed its superiority in confirmation with the Vasudevan *et al*. (2014), they have studied the effect of different packaging materials against different parameters, among them one is germination percentage and reported that groundnut kernals stored in 700 gauge polyethylene bag maintained better quality in terms of germination and vigour up to ten months of storage. Narayanaswamy (2013), studied the effect of different packaging materials treated with insecticides on the germination of maize at 3, 6 and 9 months and recorded highest germination in porous HDPE bag and Lowest germination percentage in cloth bag at 3, 6 and even at 9 months. Similar findings was also reported by Vidyashree (2013) reported that lowest germination percentage chickpea was observed in cloth bag.

Conclusion

The results of the present study clearly indicated that the seeds treated with malathion reduces egg laying, seed damage and number of adults of *S. oryzae* followed by sweet flag rhizome treated seeds. Among the packaging materials treated seeds stored in steel, glass

Table 3. Influence of packaging materials on the efficacy of sweet flag rhizome powder on seed damage by *S. oryzae*.

Treatments	Seed damage (%) during storage																				
	3 months after treatment							6 months after treatment							9 months after treatment						
	P1	P2	P3	P4	P5	P6	Mean	P1	P2	P3	P4	P5	P6	Mean	P1	P2	P3	P4	P5	P6	Mean
T_1- Sweet flag rhizome	1.50 (7.03) *	1.83 (7.78)	3.67 (11.04)	2.50 (9.10)	1.50 (7.03)	1.50 (7.03)	2.08 (8.30)b	4.67 (12.48)	8.00 (16.43)	16.67 (24.09)	12.67 (20.85)	4.67 (12.48)	4.67 (12.48)	8.56 (17.01)b	28.67 (32.37)	33.17 (35.16)	43.50 (41.27)	36.67 (37.27)	28.67 (32.37)	28.67 (32.37)	33.08 (35.11)b
T_2 - Malathion	1.17 (6.20)	1.50 (7.03)	2.50 (9.10)	1.83 (7.78)	1.17 (6.20)	1.17 (6.20)	1.56 (7.16)c	4.17 (11.78)	4.67 (12.48)	12.67 (20.85)	8.00 (16.43)	4.17 (11.78)	4.17 (11.78)	6.33 (14.54)c	23.17 (28.77)	28.67 (32.37)	36.67 (37.27)	33.17 (35.16)	22.00 (27.97)	22.00 (27.97)	27.61 (31.70)c
T_3 - Untreated control	3.33 (10.52)	3.83 (11.29)	4.67 (12.48)	4.17 (11.78)	3.33 (10.52)	3.33 (10.52)	3.78 (11.21)a	20.50 (26.92)	23.17 (28.77)	33.17 (35.16)	28.67 (3237)	20.50 (26.92)	20.50 (26.92)	24.42 (29.61)a	47.33 (43.47)	50.33 (45.19)	55.50 (48.16)	54.50 (47.58)	47.33 (43.47)	45.83 (43.47)	50.14 (45.08)a
Mean	2.00 (8.13)	2.39 (8.89)	3.61 (10.95)	2.83 (9.69)	2.00 (8.13)	2.00 (8.13)		9.78 (18.22)d	11.94 (20.22)c	20.83 (27.16)a	16.44 (23.92)b	9.78 (18.22)d	9.78 (18.22)d		33.06 (35.10)d	37.39 (37.70)c	45.22 (42.26)a	41.44 (40.07)b	32.56 (34.79)d	32.00 (34.79)d	

	3 months S.Em±	3 months CD at P=0.01	6 months S.Em±	6 months CD at P=0.01	9 months S.Em±	9 months CD at P=0.01
Treatments (T)	0.331	0.952	0.066	0.191	0.094	0.269
Packing materials (P)	0.468	1.346	0.094	0.270	0.132	0.380
T x P	0.811	NS	0.163	0.467	0.229	0.659

*Figures in the parentheses are $\sqrt{x + 0.50}$ transformed values; NS: Non significant; P1: Polythene cover, P2: Mud container, P3: Cloth bag, P4: Gunny bag, P5: Glass container and P6: Steel container; Figures in the column followed by same letters are not-significant at P = 0.01 by DMRT

Table 4. Influence of packaging materials on the efficacy of sweet flag rhizome powder on the germination of sorghum seeds.

Treatments	Germination percentage during storage																				
	3 months after treatment							6 months after treatment							9 months after treatment						
	P1	P2	P3	P4	P5	P6	Mean	P1	P2	P3	P4	P5	P6	Mean	P1	P2	P3	P4	P5	P6	Mean
T_1- Sweet flag rhizome	91.50 (73.05)*	88.50 (70.18)	84.50 (66.82)	86.50 (68.44)	91.50 (73.05)	91.50 (73.05)	89.00 (70.63)b	88.67 (70.33)	87.50 (69.30)	80.67 (63.92)	83.50 (66.03)	88.67 (70.33)	88.67 (70.33)	86.28 (68.26)b	86.50 (68.44)	85.00 (67.21)	78.83 (62.61)	80.50 (63.79)	86.50 (68.44)	86.50 (68.44)	83.97 (66.40)b
T_2 - Malathion	92.50 (74.11)	90.33 (71.89)	86.83 (68.72)	88.67 (70.33)	92.50 (74.11)	92.50 (74.11)	90.56 (72.10)a	90.50 (72.05)	88.50 (70.18)	82.50 (65.27)	84.50 (66.82)	90.50 (72.05)	90.67 (72.05)	87.83 (69.59)a	87.50 (69.30)	85.17 (67.35)	79.83 (63.32)	83.00 (65.65)	87.50 (69.30)	87.50 (69.30)	85.08 (67.28)a
T_3 - Untreated control	83.67 (66.16)	82.33 (65.15)	80.67 (63.92)	81.67 (64.65)	83.50 (66.03)	83.50 (66.03)	82.56 (65.31)c	78.67 (62.49)	74.50 (59.67)	72.50 (58.37)	73.50 (59.02)	78.67 (62.49)	78.67 (62.49)	76.08 (60.72)c	54.00 (47.29)	50.67 (45.38)	46.83 (43.18)	49.00 (44.43)	54.00 (47.29)	54.00 (47.29)	51.42 (45.81)c
Mean	89.22 (70.83)a	87.06 (68.91)b	84.00 (66.42)d	85.61 (67.71)c	89.17 (70.78)a	89.17 (70.78)a		85.94 (67.98)a	83.50 (66.03)b	78.56 (62.41)d	80.50 (63.79)c	85.94 (67.98)a	85.94 (67.98)a		76.00 (60.67)a	73.61 (59.09)b	68.50 (55.86)d	70.83 (57.31)c	76.00 (60.67)a	76.00 (60.67)a	

	3 months S.Em±	3 months CD at P=0.01	6 months S.Em±	6 months CD at P=0.01	9 months S.Em±	9 months CD at P=0.01
Treatments (T)	0.039	0.112	0.034	0.098	0.057	0.163
Packing materials (P)	0.055	0.159	0.048	0.138	0.080	0.230
T x P	0.096	0.275	0.083	0.239	0.139	0.399

*Figures in the parentheses are $\sqrt{x + 0.50}$ transformed values; NS: Non significant; P1: Polythene cover, P2: Mud container, P3: Cloth bag, P4: Gunny bag, P5: Glass container and P6: Steel container; Figures in the column followed by same letters are not-significant at P = 0.01 by DMRT container and polythene cover found better in reducing insect infestation and maintaining the seed germination percentage compared to cloth bag, mud container and gunny bag.

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