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EFFECT OF SWEET FLAG RHIZOME, *ACORUS CALAMUS* L. FORMULATIONS AGAINST *SITOPHILUS ORYZAE* IN SORGHUM

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ABSTRACT
Investigation were conducted to test the insecticidal activity of sweet flag rhizome (*Acorus calamus* L.) formulations against *Sitophilus oryzae* on sorghum in storage during 2012-13 and 2013-14 at the Department of Agricultural Entomology, College of Agriculture, Raichur, Karnataka state. The results revealed that the sweet flag rhizome powder with talc as a carrier at two per cent concentration reduced the seed damage to 35.67 per cent as against 98.67 per cent in untreated check after 120 days of treatment (DAT), among the different carriers in the experiment the best carrier with reduced seed damage was observed in talc (4.00%) at 30 DAT and the efficacy continued even upto 120 DAT (40.33%) during 2012-13 while the least performance was noticed when wood ash was used as carrier at 30 DAT (20.33%) and also at 120 DAT (86.00%). The trend remained same in the subsequent year of the experimentation.With respect to weight loss, seeds treated with sweet flag rhizome powder along with talc as carrier at two percent as it recorded 2.50 per cent seed weight loss after 120 days and highest weight loss was recorded in the seeds treated with wood ash (27.05) at 120 DAT during 2012-13 and 2013-14 pooled. The number of adults emerged per 100g of seeds after 120 days of treatment was minimum (59.17 adults/100 g of seeds) in seeds treated with sweet flag rhizome powder with talc as a carrier at two per cent concentration. Overall the study concludes that use of sweet flag rhizome powder is effective in reducing the damage with talc as the effective carrier.

INTRODUCTION

Farmers retain about 60-70 per cent of their produce for seed purpose, home consumption and for sale (Reddy and Pushpamma., 1980). Though, food grain production of 265 million tonnes was achieved during 2013-14, it is believed that nearly 15 per cent of the grains stored after each harvest will be lost due to ravages by rats, insects, non insect pests, microbial agents and spillage (Walter, 1971). Among these, insects cause loss to the tune of 6.58 per cent. A survey conducted by Mookerjee *et al.* (1998) revealed that the annual loss of grains due to insects is estimated to 5.90 million tones, reflecting the intensity of insect pest problem in store.

The most common method of store pest control followed at present is the application of malathion, fumigation with aluminium phosphide or other volatile substances. Though, these chemicals offer efficient in protection against pests but,cause certain undesirable effects like residual toxicity, application hazards, environmental pollution, etc. Consumers are afraid to use such food grains with toxic effects and residual chemicals. Further, organic seed is a crucial link in the chain from research to organic seed production and ultimate supply of high quality seed at reasonable price to the commercial seed producing farmers for promotion of organic seed production. Hence, the safe and feasible approach is the treatment of seeds with organics which are safe, ecofriendly, economical and easily.

Many plant extracts have been used for their insecticidal and fungicidal properties (Obeng-Ofori *et al.*, 1998). Black pepper, also known as "King of Indian spices" has also been in use forthis purpose (Lale and Alaga, 1998; Pessu and Williams, 1998). Similarly, cinnamon has also been studied (Ho *et al.*, 1997) for its insect repellent properties. Every house holder will testify to the fact that several insects infest the stored grains of rice, wheat, pulses etc., and render them unfit for human consumption.

To avert these problems, there is need to develop control measures which are most effective, cheap and easier to adopt. In this context, use of indigenous technologies of botanicals, having efficient insecticidal properties was followed by age old Indian farmers, most of which exist today as indigenous practices which are being realized as safe tool in the stored pest management. Paddy seeds treated with beejamruta @50 per cent recorded higher germination percentage (85.37%), seedling vigour index (2805), dehydrogenase enzyme activity (0.300 OD value) (Shakuntala *et al.,* 2012). cinnamon bark and black pepper corn extracts are more effective in controlling the insects at lower concentrations in pulses (Shobha Mishra and Nigam, 2011) effective in controlling the insects at lower concentrations.

Many plant materials have been assessed for their effects on fecundity, per cent damage and adult emergence of pulse beetle by Donpedro (1985), Das (1986) and Raj Pakse (1996). Of the several plants originated materials, use of Sweet flag, *Acorus calamus* (L.) (Araceae), is widely spread in Asia, North America and Europe. The essential oil obtained from rhizome (by steam distillation of *Acorus calamus*) showed pronounced insecticidal properties. There is an extensive literature covering the whole spectrum of the insecticidal property of *A. calamus* rhizomes.

Keeping this in view, the present study scientifically analyzed to evaluate effect of sweet flag rhizome formulations alone and in combinations with different carriers to reduce the damage caused by *Sitophilus oryzae* on sorghum was tested.

MATERIALS AND METHODS

Studies on the evaluation of sweet flag rhizome formulations against *Sitophilus oryzae* on sorghum in storage 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. Later it was grounded in to powder and used for further studies. For preparing two per cent sweet flag rhizome powder, two gram of sweet flag rhizome powder was mixed with 98 g of talc and finally volume was made up to 100 g to get two per cent. Talc powder was purchased from the Raichur local market and used for treating the seeds as a carrier along with sweet flag formulation.

Preparation of sweet flag rhizome extract

Sweet flag rhizome powder prepared in the previous studies was taken and mixed with water in equal proportion to get sufficient quantity and soaked overnight for almost eight hours and later it was squeezed using fine muslin cloth and extract was obtained. This served as pure extract and from this desired concentration were prepared as like in two per cent concentration two ml of pure extract was mixed with 98 ml of water with little quantity of soap powder (Punamkumar *et al.,* 1999; Hampanna., 2004).

Maintenance of stock culture of *Sitophilus oryzae*

Adults of *S. oryzae* from the infested sorghum seeds were collected from the central store of Main Agricultural Research Station, Raichur and the culture was further maintained in plastic jars of one litre capacity containing sorghum seeds. The mouth of the container was covered with muslin cloth and fastened tightly with the help of rubber band. Fresh disinfested seeds were provided regularly and exposed separately for the multiplication of insects at room condition. The insects emerged from this culture were reared throughout the period of experimentation and used in the experiment.

Experimental procedure

Healthy seeds of 200 g of sorghum were sun dried and kept in hot air oven for two hours at 50ºC to sterilize. Seeds were then thoroughly mixed with different treatments using malathion as standard check and were kept in 1000 ml plastic jars. Fifteen mating pairs of weevils were collected from stock culture and introduced into each jar. Before collecting weevils from main culture the beetles were kept in deep freeze for few minutes to inactivate which helped in easy count and release. Such jars were replicated thrice under normal room temperature (Biradar., 2000; Ahmad, 2000).

Observations were made on per cent seed damage, population build up and weight loss of the seeds at monthly interval up to 120 days. Damaged seeds were counted in treatment by drawing a sample of 100 seeds at random, three times from each jar and adults from 100g obtained by deep freezing for about five minutes and sieved. The collected insects were transformed to big vials and counted. Seed weight loss was computed by the following formula as suggested by Harris and Limblad (1978).

$$\text{Per cent weight loss} = \frac{\text{O.W.} - \text{C.W.}}{\text{O.W.}} \times 100$$

Where,

O.W. = Original weight on dry weight basis

C.W. = Current weight on dry weight basis

RESULTS AND DISCUSSION

Pooled results computed in table 1 clearly indicated that the malathion, sweet flag rhizome alone and sweet flag rhizome powder + talc at two percent concentration were found to be superior over the other formulations of sweet flag rhizome. The seed damage was highest in untreated check which recorded 98.67 per cent followed by wood ash alone (85.50%) and cow dung ash alone (78.17%). There was no seed damage in malathion and sweet flag rhizome powder alone followed by least seed damage in sweet flag rhizome + talc at two per cent concentration which recorded 35.67 per cent seed damage followed by sweet flag rhizome powder + cow dung ash and sweet flag rhizome powder + wood ash at two per cent concentration with 53.33 and 58.67 per cent seed damage respectively (Table 1). The present findings are supported by the findings of Nandi (2007) who reported that the sweet flag rhizome powder + talc was found to be effective in reducing the seed damage up to 120 days. Further the findings are contradictory to the findings of Sunilkumar (2003) who reported that the sweet flag rhizome powder alone at one per cent afforded maximum protection to the seeds up to 60 days of storage. The present findings are supported by the findings of Hampanna (2004) who reported that the sweet flag rhizome powder at two per cent afforded complete protection without damage to chickpea (Bengal gram).

Similarly sweet flag, *Acorus calamus* on the larval and adult forms of *Triboliumcastaneum*was reported after oral administration through food for a prolonged period. Periodical observation over 125 days revealed a definite phagodeterrent activity of the botanical insecticide, as reported by Chandel *et al.* (2001).

The pooled data on seed weight loss revealed that there was no seed weight loss in malathion and sweet flag rhizome powder alone. The per cent seed weight loss 120 days of treatment was least in seeds treated with sweet flag rhizome powder + talc at two per cent concentration with 2.50 per cent weight loss after 120 DAS, which was next to the malathion and sweet flag rhizome powder alone where there was no seed weight loss (Table 2). These findings are in corroboration with the findings of Paneru *et al.* (1997), Jilani and Saxena (1984), Khan and Borle (1985) and Tiwari (1993) who reported that *A. calamus* as a good protectant with long residual activity on mung which was also confirmity with the reports of Biradar (2000) and Sunil Kumar (2003). These findings are also supported by Kalasagonda (1998) who reported no weight loss in wheat grains at 0.8 per cent concentration of sweet flag

Table 1: Effect of different carriers in enhancing the efficacy of sweet flag rhizome powder on seed damage by *S. oryzae*

Treatment details	Dosage (%)	Seed damage (%)											
		2012-13				2013-14				Pooled data			
		30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT
T_1: SFRP + talc	2.00	4 (11.37)e*	17.67 (24.85)c	20.67 (27.03)g	40.33 (39.28)f	4.33 (11.99)f	18.33 (25.35)f	20.67 (27.03)h	31 (33.83)h	4.5 (12.20)f	18 (25.10)f	20.67 (27.04)h	35.67 (36.60)f
T_2: SFRP + cowdung ash	2.00	11.67 (19.94)d	28.67 (32.36)d	46.33 (42.89)f	57.33 (49.35)e	11.33 (19.66)e	29 (32.58)e	45.33 (42.32)g	49.33 (44.61)g	11.5 (19.81)e	28.83 (32.47)e	45.83 (42.61)g	53.33 (46.93)e
T_3: SFRP + woodash	2.00	14 (21.96)c	38 (38.05)c	54 (47.29)e	59.33 (50.38)e	13.33 (21.41)d	38.33 (38.25)d	53.67 (47.10)f	58 (49.60)f	13.5 (21.56)d	38.17 (38.15)d	53.83 (47.20)f	58.67 (49.99)e
T_4: SFR extract	2.00	14.33 (22.24)c	41.33 (40.00)b	60 (50.76)d	62.33 (52.14)e	13.67 (21.69)d	41.67 (40.20)c	59.33 (50.37)e	62.67 (52.33)e	14 (21.97)d	41.5 (40.11)c	59.67 (50.57)e	62.5 (52.24)de
T_5: Talc alone	2.00	15.33 (23.05)c	41.33 (40.00)b	67.67 (55.34)c	69 (57.68)d	14.67 (22.47)d	41.67 (40.20)c	67.67 (55.34)d	70 (56.79)d	14.75 (22.58)d	41.5 (40.11)c	67.67 (55.35)d	72.33 (58.31)cd
T_6: Cowdung ash alone	2.00	16.67 (24.08)c	43.67 (41.36)b	70.33 (56.99)b	74.67 (59.95)c	17.67 (24.85)c	44.33 (41.74)b	70.33 (56.99)c	85 (67.22)c	17 (24.35)c	44.33 (41.75)b	70.33 (57.00)c	78.17 (63.02)bc
T_7: Wood ash alone	2.00	20.33 (26.80)b	44.67 (41.93)b	72 (58.05)b	86 (68.08)b	20.33 (26.80)b	45 (42.13)b	72.33 (58.26)b	87.33 (69.15)b	20.5 (26.92)b	44.5 (41.84)b	72.17 (58.16)b	85.5 (67.63)b
T_8: SFRP alone	2.00	0.00 (0.00)f	0.00 (0.00)f	0.00 (0.00)h	0.00 (0.00)g	0.00 (0.00)g	0.00 (0.00)g	0.00 (0.00)i	0.00 (0.00)i	0.00 (0.00)g	0.00 (0.00)g	0.00 (0.00)i	0.00 (0.00)g
T_9: Malathion	1	0.00 (0.00)f	0.00 (0.00)f	0.00 (0.00)h	0.00 (0.00)g	0.00 (0.00)g	0.00 (0.00)g	0.00 (0.00)i	0.00 (0.00)i	0.00 (0.00)g	0.00 (0.00)g	0.00 (0.00)i	0.00 (0.00)g
T_{10}: Untreated check	-	23.67 (29.10)a	51 (45.57)a	80.67 (63.92)a	98.67 (83.46)a	25 (29.99)a	50.67 (45.38)a	80 (63.43)a	98.67 (83.46)a	23.75 (29.17)a	50.83 (45.48)a	80.33 (63.68)a	98.67 (83.40)a
S.Em ±		0.67	0.39	0.27	0.7	0.47	0.24	0.23	0.37	0.339	0.261	0.199	2.348
CD @1%		1.78	1.61	1.15	2	1.96	1.01	0.96	1.55	1.365	1.049	0.8	9.448

DAT – Days after treatment, SFRP – Sweet flag rhizome powder; Figures in the parentheses are angular transformed values; *Figures in the column followed by same letters are not-significant at p = 0.01 by DMRT

Table 3: Effect of different carriers in enhancing the efficacy of sweet flag rhizome powder on population build up by *S. oryzae*

Treatment details	Dosage (%)	Number of adults/100 g of seeds											
		2012-13				2013-14				Pooled data			
		30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT
T_1: SFRP + talc	2.00	32.67 (5.75)f*	50 (7.10)g	51.67 (7.22)f	59.33 (7.73)f	31 (5.61)g	49.33 (7.05)g	51.67 (7.22)h	59 (7.71)g	31.83 (5.69)g	49.67 (7.08)d	51.67 (7.22)h	59.17 (7.72)g
T_2: SFRP + cowdung ash	2.00	32.67 (5.75)f	62 (7.90)f	77.67 (8.84)e	98 (9.92)e	32 (5.70)g	52 -6.85	74.67 (8.67)g	98 (9.92)f	32.33 (5.73)g	61.67 (7.83)c	76.17 (8.76)g	98.17 (9.93)f
T_3: SFRP + woodash	2.00	35 (5.95)e	64.67 (8.07)e	81 (9.02)d	99 (9.97)de	34.67 (5.93)f	61.67 (7.88)f	80 (8.97)f	98.33 (9.94)ef	34.83 (5.94)f	61.83 (7.90)c	80.5 (9.00)f	98.5 (9.95)ef
T_4: SFR extract	2.00	40.67 (6.41)d	70 (8.39)d	82 (9.08)d	100.33 (10.23)c	40.33 (6.39)e	65 (8.09)e	83.33 (9.15)e	99.67 (10.00)de	40.5 (6.40)e	64.83 (8.08)c	82.67 (9.12)e	100 (10.02)de
T_5: Talc alone	2.00	44 (6.67)c	71.33 (8.47)d	90 (9.51)c	100.67 (10.05)d	45.33 (6.77)d	69 (8.33)d	89.33 (9.47)d	100.33 (10.04)d	44.67 (6.72)d	69.5 (8.37)c	89.67 (9.50)d	100.5 (10.05)d
T_6: Cowdung ash alone	2.00	51.33 (7.19)b	84.67 (9.22)c	91 (9.56)c	104.33 (10.23)c	50.33 (7.13)c	84.67 (9.22)b	92.33 (9.63)c	104.67 (10.25)c	50.83 (7.16)c	84.67 (9.23)b	91.67 (9.60)c	104.5 (10.25)c
T_7: Wood ash alone	2.00	52.67 (7.29)b	87 (9.35)b	99.33 (9.99)b	111 (10.55)b	52.33 (7.26)b	86 (9.30)b	98.67 (9.95)b	110 (10.51)b	52.5 (7.28)b	86.5 (9.33)b	99 (9.97)b	110.5 (10.54)b
T_8: SFRP alone	2.00	0.00 (0.70)g	0.00 (0.70)h	0.00 (0.70)g	0.00 (0.70)g	0.00 (0.70)h	0.00 (0.70)h	0.00 (0.70)i	0.00 (0.70)h	0.00 (0.71)h	0.00 (0.71)e	0.00 (0.71)i	0.00 (0.71)h
T_9: Malathion	1	0.00 (0.70)g	0.00 (0.70)h	0.00 (0.70)g	0.00 (0.70)g	0.00 (0.70)h	0.00 (0.70)h	0.00 (0.70)i	0.00 (0.70)h	0.00 (0.71)h	0.00 (0.71)e	0.00 (0.71)i	0.00 (0.71)h
T_{10}: Untreated check	-	60 (7.77)a	133.33 (11.56)a	197.67 (14.07)a	230 (15.18)a	59.67 (7.75)a	134.67 (11.62)a	197.33 (14.06)a	229 (15.14)a	59.83 (7.77)a	134 (11.60)a	197.5 (14.07)a	229.5 (15.17)a
S.Em ±		0.05	0.039	0.048	0.042	0.026	0.55	0.024	0.021	0.03	0.215	0.028	0.027
CD @1%		0.209	0.16	0.199	0.175	0.11	2.275	0.1	0.087	0.122	0.864	0.113	0.109

DAT – Days after treatment, SFRP – Sweet flag rhizome powder; Figures in the parentheses are angular transformed values; *Figures in the column followed by same letters are not-significant at p = 0.01 by DMRT

Table 2: Effect of different carriers in enhancing the efficacy of sweet flag rhizome powder on seed weight loss by *S. oryzae*

Treatment details	Dosage (%)	Seed weight loss (%)											
		2012-13				2013-14				Pooled data			
		30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT
T_1: SFRP + talc	2.00	1.4 (6.79)f*	1.57 (7.14)f	2.43 (8.96)e	2.43 (8.97)f	1.5 (7..03)g	1.73 (7.56)f	2.33 (8.78)e	2.6 (9.21)f	1.45 (6.92)f	1.65 (7.37)f	2.38 (8.88)e	2.5 (9.10)f
T_2: SFRP + cowdung ash	2.00	2.03 (8.19)e	8.07 (16.50)e	11.1 (19.45)d	17.33 (24.60)e	2 (8.13)f	8 (16.43)e	11.17 (19.52)d	17.4 (24.57)e	2.02 (8.16)e	8.03 (16.47)e	11.13 (19.49)d	17.32 (24.59)e
T_3: SFRP + woodash	2.00	2.53 (9.15)d	9.2 (17.65)d	11.87 (20.14)c	17.6 (24.80)bc	2.6 (9.27)e	9.17 (17.62)d	11.77 (20.06)c	17.7 (24.57)e	2.57 (9.22)d	9.18 (17.64)d	11.82 (20.11)c	17.55 (24.77)e
T_4: SFR extract	2.00	2.9 (9.80)c	9.27 (17.72)d	12 (20.26)c	24.5 (29.66)d	2.87 (9.74)d	9.17 (17.62)d	11.83 (20.12)c	24.8 (29.84)d	2.88 (9.78)c	9.22 (17.67)d	11.92 (20.19)c	24.63 (29.76)d
T_5: Talc alone	2.00	2.93 (9.86)c	10.13 (18.56)c	12.03 (20.29)c	26.43 (30.93)c	2.87 (9.74)d	10.17 (18.59)c	11.93 (20.20)c	26 (30.76)c	2.9 (9.80)c	10.15 (18.58)c	11.98 (20.25)c	26.3 (30.85)c
T_6: Cowdung ash alone	2.00	3.13 (10.19)b	14.23 (22.16)b	14.57 (22.43)b	26.8 (31.17)bc	3 (9.97)c	14.17 (22.11)b	14.53 (22.41)b	26 (31.00)bc	3.08 (10.11)b	14.2 (22.14)b	14.55 (22.42)b	26.67 (31.09)bc
T_7: Wood ash alone	2.00	3.17 (10.25)b	14.3 (22.21)b	14.87 (22.67)b	27.17 (31.41)b	3.23 (10.35)b	14.23 (22.16)b	14.87 (22.67)b	27 (31.26)b	3.18 (10.28)b	14.27 (22.19)b	14.87 (22.68)b	27.05 (31.34)b
T_8: SFRP alone	2.00	0.00 (0.00)g	0.00 (0.00)g	0.00 (0.00)f	0.00 (0.00)g	0.00 (0.00)h	0.00 (0.00)g	0.00 (0.00)f	0.00 (0.00)g	0.00 (0.00)g	0.00 (0.00)g	0.00 (0.00)f	0.00 (0.00)g
T_9: Malathion 1		0.00 (0.00)g	0.00 (0.00)g	0.00 (0.00)f	0.00 (0.00)g	0.00 (0.00)h	0.00 (0.00)g	0.00 (0.00)f	0.00 (0.00)g	0.00 (0.00)g	0.00 (0.00)g	0.00 (0.00)f	0.00 (0.00)g
T_{10}: Untreated check	-	3.53 (10.83)a	27.57 (31.67)a	38.2 (38.17)a	60.47 (51.04)a	3.5 (10.78)a	27.5 (31.62)a	37.33 (37.66)a	60.2 (50.80)a	3.52 (10.81)a	27.53 (31.65)a	37.77 (37.92)a	60.27 (50.92)a
S.Em ±		0.111	0.21	0.16	0.124	0.07	0.105	0.126	0.089	0.075	0.108	0.141	0.088
CD @1%		0.46	0.88	0.66	0.515	0.29	0.433	0.52	0.367	0.302	0.435	0.569	0.356

DAT – Days after treatment, SFRP – Sweet flag rhizome powder; Figures in the parentheses are angular transformed values; *Figures in the column followed by same letters are not-significant at p = 0.01 by DMRT

rhizome powder. This may be due to strong ovicidal property of sweet flag as reported by Kittur (1990) and Shivanna (1994), who noticed, no weight loss in red gram against *C. chinensis* at one per cent concentration. Similar reports to confirm the present studies have been made earlier by Jilani and Saxena (1984), Umareddy and Shobhareddy (1987) and Kalasagonda (1998) on different stored grain pests.

The pooled data on population build up was 59.17 adults/ 100g of seed sample after 120 DAT in the seeds treated with sweet flag rhizome powder + talc at two per cent compared to adult population in untreated control, which recorded 229.50 adults/ 100 g of seeds after 120 days (Table 3). The present findings are in agreement with the observations of Khan and Borle (1985) and Sunil Kumar (2003), who recorded adult population on 30th day after treatment in gram and sorghum. The sweet flag powder was known to suppress adults to the maximum extent up to 240 days in wheat was reported by Kalasagond (1998). Though, all the treatments reduced the pest population as compared to untreated control the sweet flag rhizome + talc at two per cent concentration showed significantly superior over other treatements.

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