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Sheetal Bhopinder Singh Juneja
Department of Zoology, Dhote Bandhu Science College, Gondia, Maharashtra, India

Corresponding Author:
Sheetal Bhopinder Singh Juneja
Department of Zoology, Dhote Bandhu Science College, Gondia, Maharashtra, India

Efficacy comparasion of chemical and botanical fumigants against rice weevil *Sitophilus oryzae* in *Triticum* cultivars

Sheetal Bhopinder Singh Juneja

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Abstract
Commercially available chemical fumigants have been found to be the most common and effective in stored grain pest management as they show optimum effect with even low doses. The present paper aims to compare efficacy of two commonly used chemical fumigants such as Parad and Grain Phos with plant leaves like *Aegle mermelos, Azadirachta indica, Cymbopogon citrates, Ocimum sanctum, O. basilicum* and *Murraya koenigii* aginst Rice Weevil, *S. oryzae.* The fumigants Parad and Grainphos were selected for the study and were found to be effective even at lower concentration in both the Triticum cultivars Lokwan and Sharbati. In the lower concentration of Parad, weight loss recorded was 0.23 and 0.22% respectively, it was no loss recorded at higher concentration in both varieties. While in case of Grainphos, at lower concentration 0.21% and 0.19% weight loss were recorded in Lokwan and Sharbati respectively whereas in higher concentration there was no loss in both the cultivars. The effects of these chemical fumigants were compared with the effects of Azadirichta indica and other five plant leaves and it was found to be at par in both Lokwan and Sharbati cultivars respectively.

Keywords: Stored grain pest management, chemical fumigants, *A. indica*

Introduction

India has recovered from chronic food deficit to surplus food production, of around 250 million tonnes. However, one of the major problems with agriculture is the rate of food production is still lower than the demand of food due to increase in population. Post-harvest losses are also recognized as a major constraints in preserving (restoring) the quality and quantity of the stored grains. In the developing countries, the detoritation in the stored food commodity is mainly caused by triple agencies *viz* insects, fungi and rodents. Food grain losses due to insect infestation during storage are also one of the serious problems. It is estimated that more than 20,000 species of field and store grain pests destroy approximately one third of the total World's food production, valued annually at more than $100 billion among which the highest losses (43%) occurr in the developing world. The rice weevil, S. oryzae is a major insect pest causing substantial loss to cereal grains during storage. The monetary value of these losses amounts to more than Rs 50,000 crores per year (Singh, 2010) [11].

Botanical insecticides have long been touted as to synthetic chemical insecticides for pest management. Chemicals being harmful to the environment, human beings and animals have created many complex environmental problems). Due to tremendous environmental hazards and residual effects of chemicals, an urgent need of searching alternative in plant and plant products has been emphasized (KD Singh, *et al*., 2021) [7]. The present paper aims to compare efficacy of two commonly used chemical fumigants such as Parad and Grain Phos with plant leaves like *Aegle mermelos*, *Azadirachta indica*, *Cymbopogon citrates*, *Ocimum sanctum* and *Murraya koenigii* aginst Rice Weevil, *S. oryzae*.

Methodology

Dosage preparation

Insecticides: Commercially available pesticides, Grainphos and Parad (Zandu) were purchased from the local market to conduct bioassay studies. Different dosages of grainphos *viz*., 0.6µl, 1.2µl, 2.5µl and 5µl were mixed with 50g of wheat grains. Parad tablets were used in the dose of 1, ½, ¼ and 1/8 for 50gm of wheat grains weighing 0.78g, 0.39g, 0.195g and 0.097g respectively.

Leaf powder

The leaves were taken from the plants, cleaned, and shade dried in a visible laboratory before being ground into a very fine powder with an electric blender. The powder was then further separated using 1 mm^2 holes. Prior to usage, the powder was kept at 4 ºC in a refrigerator. For the treatment of Lokwan and Sharbati, the following plant leaf powder dosages 0.3 g, 0.6 g, 1.2 g, and 1.8 g were made in 100 ml clear plastic containers. No plant powders were present in the seeds used as controls.

Application

Plastic jars with a size of 100ml were used to evaluate the effects of plant products. 50 g of T. aestivum, sterilised wheat, was placed inside the jars after they had been meticulously cleaned. Using four different concentrations of dry leaf powder 0.3g, 0.6g, 1.2g, and 1.8g for every 50g of seeds, the seeds of both Lokwan and Sharbati were treated. To ensure the treatment powders and wheat seeds were thoroughly mixed, the containers were gently shook. There were three independent replications of each treatment and the control.

Five pairs of newly emerged, two-day-old S. oryzae male and female adults were released in each jar after being retrieved from the culture. The jars were sealed with a perforated lid and maintained in an incubator at 25°C (+2°C) and 70% (+5%) relative humidity.

The jars were capped with perforated lid and kept in incubator at 25ºc (± 2ºc) and 70% (± 5%) relative humidity. The females were allowed to oviposit on the seeds. Thereafter, adults were removed from the jars after one week.

Mortality

Mortality was recorded by counting the number of dead weevils 7 days after treatment (DAT) based on the behavioural response after stimulation

Estimation of weight loss

For loss estimation, 50gm of seed were taken in to container of 100gm capacity, 10 pairs of adult were release in to the container, and open top of the container was cover with muslin cloth and fastened with rubber band. Each treatment was replicated thrice. Observation on seed damage and weight loss was recorded.

Weight loss was work out by using the formula

$$\text{Percent of weight loss} = \frac{(UND)-(DNU)}{U\ (ND+NU)} \times 100$$

Where,

U – Weight of un- infested grains

NU- number of uninfested grains

D - Weight of infested grains

ND - number of infested grains

Grain Damage

Grain damage percent was obtained by counting total number of grains and grains bored by the *S. oryzae*, then the percentage of infestation was calculated using the following formula

Total number of grains

Grain damage (%) Number of grains with exit holes 100

Results and Discussion

The rice weevil, *S. oryzae* is a serious pest of stored grain and the use of chemical insecticides being most and hazardous to human health. In the present study, the attempt has been made towards development of a non-toxic and effective control measures for the management of important store grain pest.

In many parts of world, locally available plants are currently in used to protect stored products against damage caused by insect infestation (Tripathi *et al*., 2009; Khater, 2012) [12, 8]. Numerous studies have documented the use of indigenous local herbs and plant materials used worldwide (Rauha *et al*., 2000; Ahmad and Beg, 2001; Penna *et al*., 2001) [10, 1, 9]. Many of these plants are widely used by local communities in traditional medicine for the treatment of several ailments. Leaves, twigs and flowers have been admixed as protectant in different parts of world, particularly India, China and Africa (Golob *et al*., 1999) [4]. The practical advantage of using locally available material to protect stored products destined for household and small scale use remains compelling (Weaver and Subramanyam, 2000) [13].

Among the different plant species used, *A. indica* (Neem), *A. mermelos* (Bael), *C. citrates* (Lemon grass), *M. koenigii* (Curry-patta), *O. sanctum* (Ram-tulsi), *O. basilicum* (Shyam-tulsi) were assessed in the present studies. Behavioural response of the *S. oryzae* to the commonly used insecticides such as Grainphos and Parad have also been used to study.

Mortality

When leaf powder of *C. citrates*, *A. indica* and *A. mermelos* mixed with wheat grain, in Lokwan mortality was 90% with the dose of 0.3g /50g grains treated with *A. indica*, which reached 100% with 0.6gm / 50g grains, whereas in Sharbati a dose of 1.2g/50 grains of *A. indica* was effective. *A. marmelos* was not effective *and* the mortality was around 23% in Lokwan with 0.6g as compared to 83% in Sharbati.

Mortality with *C. citrates* reached above 50% in both Sharbati and Lokwan varieties with 1.2g leaf powder and similar was even with 1.8gm (Table 1a, b; Graph Ia - d).

The dry leaf powder of *M. koenigii* and *O. sanctum* gave 100% mortality with 1.2g in Sharbati and as, in Lokwan mortality was 96.6%. When *O. sanctum* and *O. basilicum* used, mortality reached 100% in both Sharbati and Lokwan with 1.8gm powder (Table 1a, b; Graph I a - d).

Chemical fumigants such as Parad and Grainphos are commercially used.

Parad when 1/8 th part(0.097g) used, resulted 100% mortality of *S. oryzae* in both Lokwan and Sharbati, whereas Grain phos produced 100% mortality in both Sharbati and Lokwan with the dose of 2.5 µl/50 gram (Table1d, Graph I).

Table 1a: Effect of plant leaf powders on S. oryzae during storage

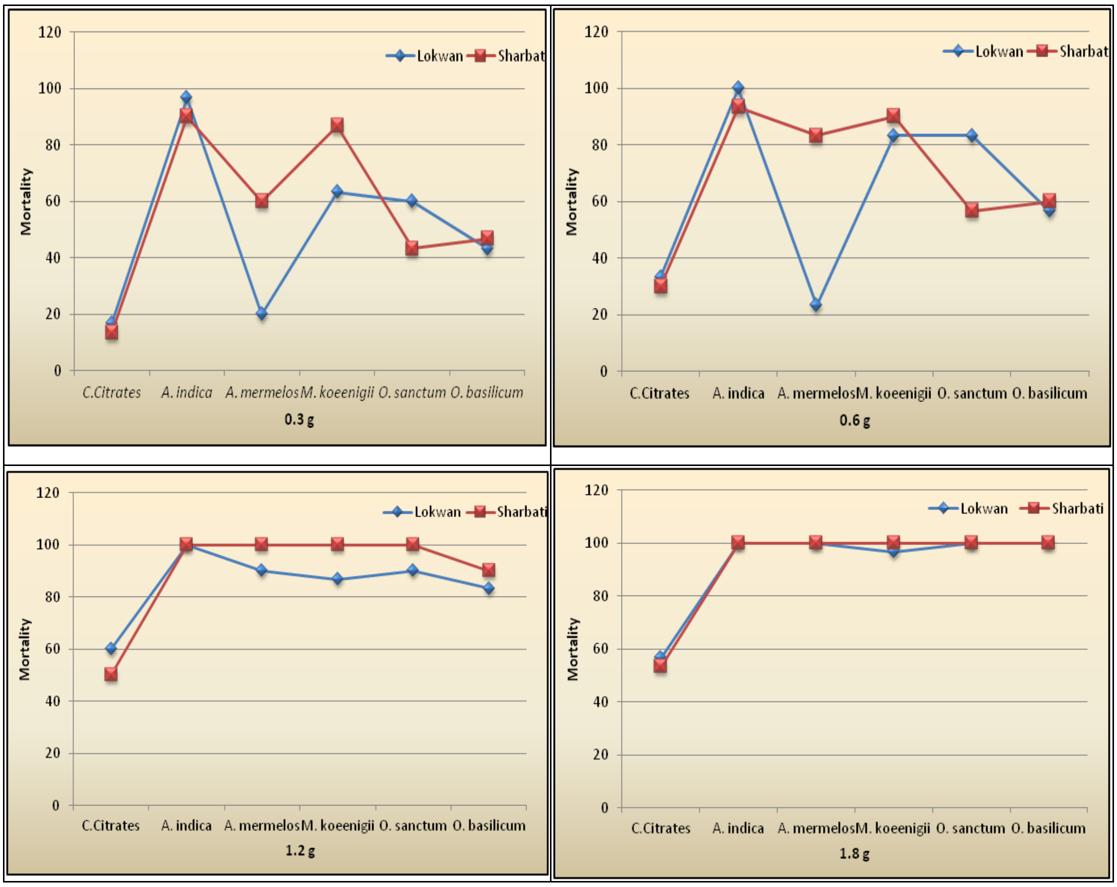
Quantity	Mortality (%)					
	C. Citrates		*A. Indica*		*A. Mermelos*	
	Sharbati	**Lokwan**	**Sharbati**	**Lokwan**	**Sharbati**	**Lokwan**
0.3	13.33± 0.10	16.60± 0.21	90.00±0.0	96.6± 0.10	60.0 ± 0.13	20.00 ± 0.00
0.6	30.0± 0.18	33.33± 0.28	93.33± 0.10	100± 0.00	83.33± 0.25	23.33± 0.11
1.2	50.00± 0.48	60.00± 0.65	100± 0.00	100± 0.00	100 ± 0.00	90.00± 0.00
1.8	53.33± 0.76	56.66± 0.73	100± 0.00	100± 0.00	100 ± 0.00	100 ± 0.00

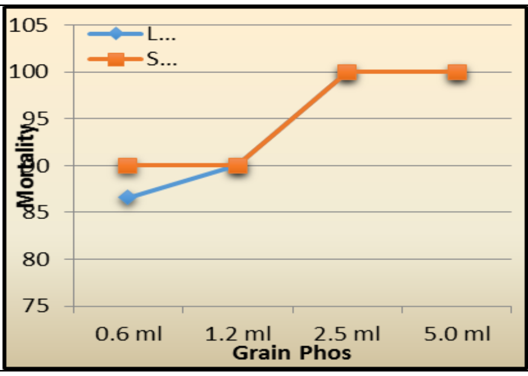
Table 1b: Effect of plant leaf powders on S. oryzae during storage

Quantiy (g)	*M. koenigii*		*O. Sanctum*		*O. Basilicum*	
	Sharbati	**Lokwan**	**Sharbati**	**Lokwan**	**Sharbati**	**Lokwan**
0.3	86.66±0.10	63.33±0.21	43.33±0.10	60.00±0.00	46.66±0.10	43.33±0.10
0.6	90±0.00	83.33±0.21	56.66±0.10	83.33± 0.25	60.00±0.00	56.66±0.10
1.2	100±0.00	86.66±0.10	100± 0.00	90.00±0.00	90.00±0.00	83.33± 0.25
1.8	100±0.00	96.66±0.10	100± 0.00	100± 0.00	100 ± 0.00	100 ± 0.00

Table 1c: Mortality of *Sitophilus oryzae* after 7 days when treated with chemical fumigants during storage.

Fumigant	Dose	Sharbati	Lokwan
Parad	0.097g	100±0.00	100±0.00
	0.195g	100±0.00	100±0.00
	0.39g	100±0.00	100±0.00
	0.78g	100±0.00	100±0.00
Grainphos	0.6µl	90.0±0.0	86.6±0.6
	1.2µl	90.0±0.0	90.0±0.0
	2.5µl	100±0.00	100±0.00
	5.0µl	100±0.00	100±0.00





Graph 1: Showing effect of different concentrations of plant powders on mortality by *S. oryzae*

Grain damage

Oryzae infested grains were treated with various leaf powders. The results of both Sharbati and Lokwan variety treated with leaf powder of *A. marmelos, A. indica, C. citrates, O. sanctum and O. basilicum* per 50g grain resulted no infestation (Table 2 a, b). The overall loss of significant reduction in grain damage and loss due to damage of grain reduced in all the treated groups as compared to that of control on damage was by about 12.5% in Lokwan and 11.36% in Sharbati (Table 2 a,b; Table 3 a,b; Graphs II a-d).

Table 2a: Effect of leaf powders on damage of Triticum (Lokwan Cultivar) by the weevils, S. oryzae

Treatments	Dose / 50 g of grain.(g)	Total No of Grains/50 g	Av. no of infested grains	Grain damage (%)
Control	-	1248 ± 5.78	156 ± 0.50	12.5 ± 0.55
A. marmelos	0.3	1254 ± 4.47	5.0 ± 0.66	0.24± 0.03
	0.6	1201 ± 5.80	4.0± 0.55	0.15± 0.08
	1.2	1157± 2.2	0.0± 0.00	0.00± 0.00
	1.8	1187± 1.5	0.0± 0.00	0.00± 0.00
A. indica	0.3	1202± 5.00	2.00± 0.33	0.24± 0.01
	0.6	1230± 2.96	3.00± 0.20	0.16± 0.02
	1.2	1180± 1.20	0.00± 0.00	0.00± 0.00
	1.8	1211± 0.88	0.00± 0.00	0.00± 0.00
M. koenigii	0.3	1245± 3.21	5.00± 0.32	0.4± 0.01
	0.6	1232± 1.20	5.00± 0.00	0.2± 0.00
	1.2	1248± 4.37	4.00± 1.04	0.16± 0.02
	1.8 g	1245± 2.65	1.00± 0.20	0.08± 0.01
C. citrates	0.3 g	1202 ± 1.00	1.00± 0.00	0.083± 0.02
	0.6 g	1236± 8.45	1.00± 0.57	0.80± 0.01
	1.2 g	1208± 2.65	2.00± 0.66	0.16± 0.01
	1.8 g	1192± 2.96	13± 2.50	1.05± 0.08
O. sanctum	0.3 g	1167± 2.96	5.00± 2.50	0.42± 0.01
	0.6 g	1114± 11.20	4.00± 0.57	0.35± 0.06
	1.2 g	1186± 3.46	4.00± 0.00	0.12± 0.02
	1.8 g	1225± 11.20	1.00± 0.66	0.08± 0.01
O. basilicum	0.3 g	1198± 3.46	3.00± 0.66	0.25± 0.02
	0.6 g	1192± 8.45	2.00± 0.33	0.25± 0.02
	1.2 g	1236± 6.00	0.00± 0.00	0.00± 0.00
	1.8 g	1225± 5.45	0.00± 0.00	0.00± 0.00

Table 2b: Effect of leaf powders on damage of Triticum (Sharbati Cutivar) by the weevils, S. oryzae

Treatments	Conc. / 50 G of Grain(g)	Av. Total no. of grains / 50 g	Av. No of Infested grains	Grain damage (%)
Control	-	1197± 3.46	136 ± 0.31	11.36 ± 0.18
A. mermelos	0.3 g	1116 ± 2.3	8.00 ± 0.52	0.71 ± 0.06
	0.6 g	1134 ± 0.88	4.00 ± 0.30	0.35 ± 0.02
	1.2 g	1113 ± 1.20	0.00 ± 0.00	0.00 ± 0.01
	1.8 g	1200 ± 2.96	0.00 ± 0.00	0.00 ± 0.00
A. indica	0.3 g	1174.3 ± 3.12	1.50 ± 0.20	0.139 ± 0.04
	0.6 g	1197 ± 1.20	0.10 ± 0.30	0.008 ± 0.03
	1.2 g	1136 ± 2.65	0.00 ± 0.00	0.00 ± 0.00
	1.8 g	1201 ± 2.4	0.00 ± 0.00	0.00 ± 0.00
M. koenigii	0.3 g	1210 ± 2.96	0.7 ± 2.22	0.56 ± 0.04
	0.6 g	1115 ± 1.5	2.0 ± 0.57	0.17 ± 0.02
	1.2 g	1153 ± 5.4	1.0 ± 0.20	0.086 ± 0.001
	1.8 g	1187 ± 3.46	1.0 ± 0.51	0.008 ± 0.001
C. citrates	0.3 g	1119 ± 5.00	2.0 ± 0.00	0.17 ± 0.002
	0.6 g	1196 ± 8.45	5.0 ± 1.20	0.41 ± 0.001

	1.2 g	1176 ± 2.20	23 ± 8.45	2.13 ± 0.5
	1.8 g	1195 ± 1.20	22 ± 6.00	2.00 ± 0.3
O. sanctum	0.3 g	1197 ± 9.00	23.0 ± 3.7	1.92 ± 0.8
	0.6 g	1105 ± 6.4	20.0 ± 1.47	1.80 ± 0.5
	1.2 g	1108 ± 2.96	20.2 ± 5.75	1.80 ± 0.2
	1.8 g	1187 ± 2.30	8.0 ± 2.20	0.767 ± 0.03
O. basilicum	0.3 g	1201 ± 4.37	15.0 ± 1.20	1.24 ± 0.3
	0.6 g	1198 ± 5.80	15.0 ± 0.8	1.08 ± 0.01
	1.2g	1166 ± 1.20	12.0 ± 1.15	1.029 ± 0.01
	1.8 g	1200 ± 2.96	0.00 ± 0.00	0.00 ± 0.00

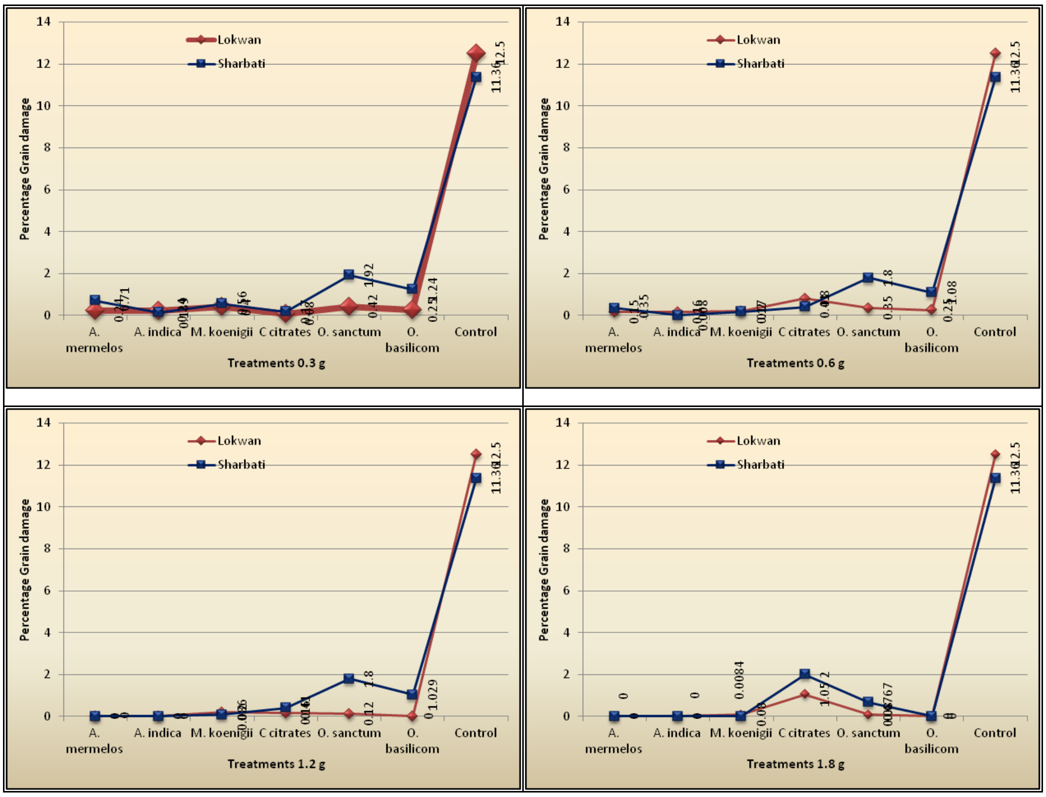
Table 2c: Effect of fumigants on Grain-damage of Triticum cultivars by S. oryzae, after six months storage

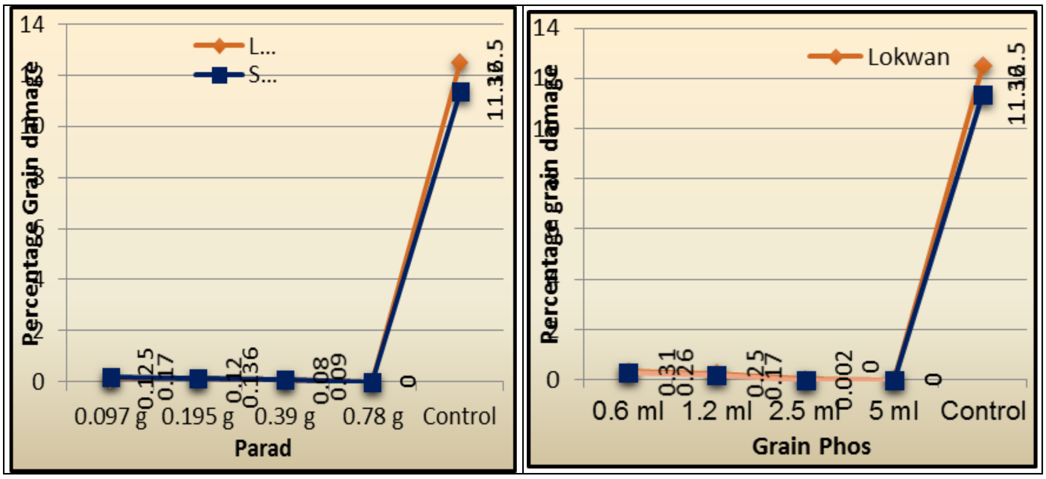
Lokwan

Treatments	Conc/50 gm of grains	No of grains/50 g	No of Infested Grains	Grain damage (%)
Control	-	1248 ± 5.78	156 ± 0.50	12.5 ± 0.55
Parad	0.0975g	1197 ± 11.60	1.5± 0.083	0.125± 0.001
	0.195g	1244± 13.96	1.5± 0.60	0.12± 0.0013
	0.39g	1237.5± 3.33	1.0 ± 0.30	0.080± 0.001
	0.78g	1225± 2.8	0.0± 0.00	0.00± 0.01%
Grain Phos	0.6 µl	1125± 3.7	3.5± 0.30	0.31± 0.001
	1.2 µl	1187± 4.3	03± 0.33	0.25± 0.002
	2.5 µl	1183± 5.08	03 ± 0.00	0.002± 0.00
	5 µl	1187± 4.2	0.00± 0.00	0.00± 0.00

Sharbati

Treatments	Conc/50 gm of grains	Av. total no. of grains/50 g	Av. No of Infested grains	Grain damage (%)
Control	-	1197 ± 3.46	136 ± 0.3	11.36 ± 0.18
Parad	0.0975g	1112 ± 22.0	0.2± 0.5	0.17± 0.001
	0.195g	1100± 18.27	1.5± 0.3	0.136± 0.002
	0.39g	1100± 7.8	1± 0.08	0.090± 0.000
	0.78g	1101± 5.6	0.0± 0.00	0.00± 0.00
Grain Phos	0.6 µl	1145± 6.48	03± 0.3	0.26± 0.001
	1.2 µl	1120± 11.23	02± 0.21	0.170± 0.001
	2.5 µl	1052± 9.2	20.0 ± 0.00	0.0 ± 0.00
	5 µl	1152± 7.3	0.00± 0.00	0.00 ± 0.00





Graph 2: Showing effect of different concentrations of plant powders and chemical fumigants on grain damage by *S.oryzae*

Weight loss

The weight loss was 7.97%, in Lokwan and 4.65% in Sharbati (Table 15a, b; Graph III a-d). At low concentration (0.3g) of *O. sanctum* and *A. marmelos*, the damage was 1.65 g, 1.45g and 1.29g respectively in Sharbati cultivar. The loss of weight in wheat treated with higher concentration was less as compared to those with lower concentration. The weight loss was maximum in Lokwan with 0.3gm powder of *A. marmelos* (Table IIIa, Graph III a-d).

The fumigants Parad and Grainphos were also effective at lower concentration in both the cultivars *Lokwan and Sharbati.* In the lower concentration of Parad, weight loss recorded was 0.23 and 0.22% in Lokwan and Sharbati respectively, there was no loss recorded at higher concentration. Grainphos, at lower concentration resulted 0.21% and 0.19% weight loss in Lokwan and Sharbati respectively and the similar result obtained at higher concentration as with Parad. (Table 3a, b & table 4 Graph III a, b).

Table 3a: Effect of leaf powder impregnation on Triticum sps. (Lokwan cultivar) by the weevils, S. oryzae

Treatment	Dose / 50 g of grain(g)	Initial wt. of the sample(g)	Final Wt. of The Sample (g)	Wt. Loss (g)	Wt. loss (%)
Control	-	50	46.0113±0.00	3.989±0.05	7.978±0.03
A. mermelos	0.3	50	48.33±0.20	1.67±0.10	3.34±0.012
	0.6	50	49.026±0.12	0.974±0.50	1.94±0.15
	1.2	50	50.00±0.00	0.00±0.00	0.00±0.00
	1.8	50	50.00±0.00	0.00±0.00	0.00±0.00
A. indica	0.3	50	49.885±0.5	0.115±0.12	0.23±0.01
	0.6	50	49.841±0.3	0.119±0.13	0.238±0.01
	1.2	50	50.00±0.00	0.00±0.00	0.00±0.00
	1.8	50	50.00±0.00	0.00±0.00	0.00±0.00
M. koenigii	0.3	50	49.89±0.12	0.110±0.01	0.220±0.01
	0.6	50	49.903±0.25	0.097±0.001	0.194±0.00
	1.2	50	49.909±0.3	3.091±0.00	0.182±0.001
	1.8	50	49.959±0.5	0.041±0.001	0.082±0.00
C. citrates	0.3	50	50.00±0.00	0.00±0.00	0.00±0.00
	0.6	50	50.00±0.00	0.00±0.00	0.00±0.00
	1.2	50	49.892±0.00	0.108±0.001	0.816±0.12
	1.8	50	49.196±0.00	0.804±0.01	1.608±0.001
O. sanctum	0.3	50	49.815±0.33	0.185±0.01	0.37±0.001
	0.6	50	49.82±0.15	0.180±0.12	0.36±0.12
	1.2	50	49.87±0.23	0.130±0.5	0.76±0.51
	1.8	50	49.95±0.16	0.045±0.02	0.09±0.001
O. basilicum	0.3	50	49.828±0.12	0.712±0.01	0.34±0.12
	0.6	50	49.83±0.5	0.169±0.12	0.338±0.15
	1.2	50	50.00±0.00	0.00±0.00	0.00±0.00
	1.8	50	50.00±0.00	0.00±0.00	0.00±0.00

Table 3b**: Effect of leaf powder impregnation on Triticum sps. (Sharbati cultivar) by the weevils, S. oryzae**

Treatment	Dose / 50 g of grain	Initial wt. of the sample(g)	Final wt. of the Sample (g)	Wt. Loss (g)	Wt. loss (%)
Control	-	50	47.0712±0.12	2.328 ±0.18	4.656±0.08
A. mermelos	0.3	50	49.355±0.28	0.645±0.040	1.29±0.02
	0.6	50	49981±0.14	0.019±0.001	0.038±0.00
	1.2	50	50.00±0.00	0.00±0.00	0.00±0.00
	1.8	50	50.00±0.00	0.00±0.00	0.00±0.00
	0.3	50	49.895±0.33	0.105±0.003	0.21±0.01

A. indica	0.6	50	49.95±0.50	0.045±0.00	0.09±0.001
	1.2	50	50.00±0.00	0.00±0.00	0.00±0.00
	1.8	50	50.00±0.00	0.00±0.00	0.00±0.00
M. koenigii	0.3	50	49.878±0.12	0.122±02	0.24±0.00
	0.6	50	49.916±0.28	0.084±0.03	0.168±0.01
	1.2	50	49.955±0.14	0.045±0.0.06	0.09±0.00
	1.8	50	49.958±0.26	0.042±0.000	0.084±0.02
C. citrates	0.3	50	49.96±0.1	0.04±0.00	0.08±0.001
	0.6	50	49.98±0.12	0.02±0.01	0.04±0.01
	1.2	50	48.8±0.14	1.20±0.05	2.40±0.50
	1.8	50	48.56±0.26	1.44±0.22	2.88±0.33
O. sanctum	0.3	50	49.175±0.1	0.825±0.01	1.65±0.72
	0.6	50	49.271±0.28	0.729±0.002	1.45±0.91
	1.2	50	49.363±0.32	0.637±0.05	1.274±0.50
	1.8	50	49.764±0.24	0.236±0.001	0.472±0.2
O. basilicum	0.3	50	49.614±0.5	0.386±0.02	0.772±0.1
	0.6	50	49.828±0.3	0.172±0.5	0.344±0.8
	1.2	50	49.89±0.24	0.11±0.001	0.22±0.00
	1.8	50	50.00±0.00	0.00±0.00	0.00±0.00

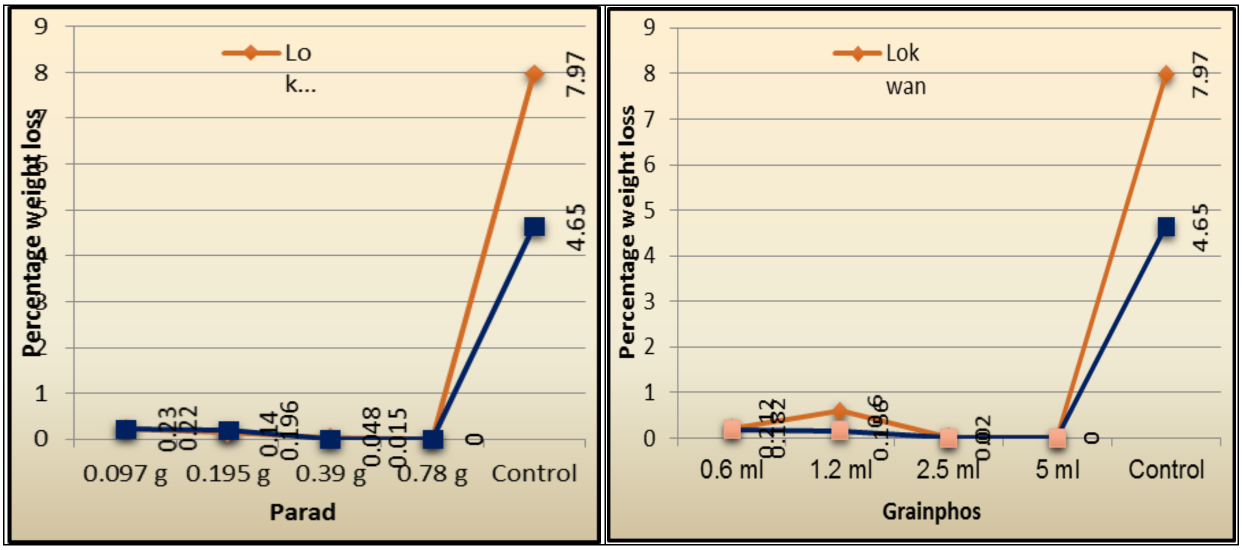
Table 4: Effect of fumigants on *Triticum sps* by the weevils, *S. oryzae*.

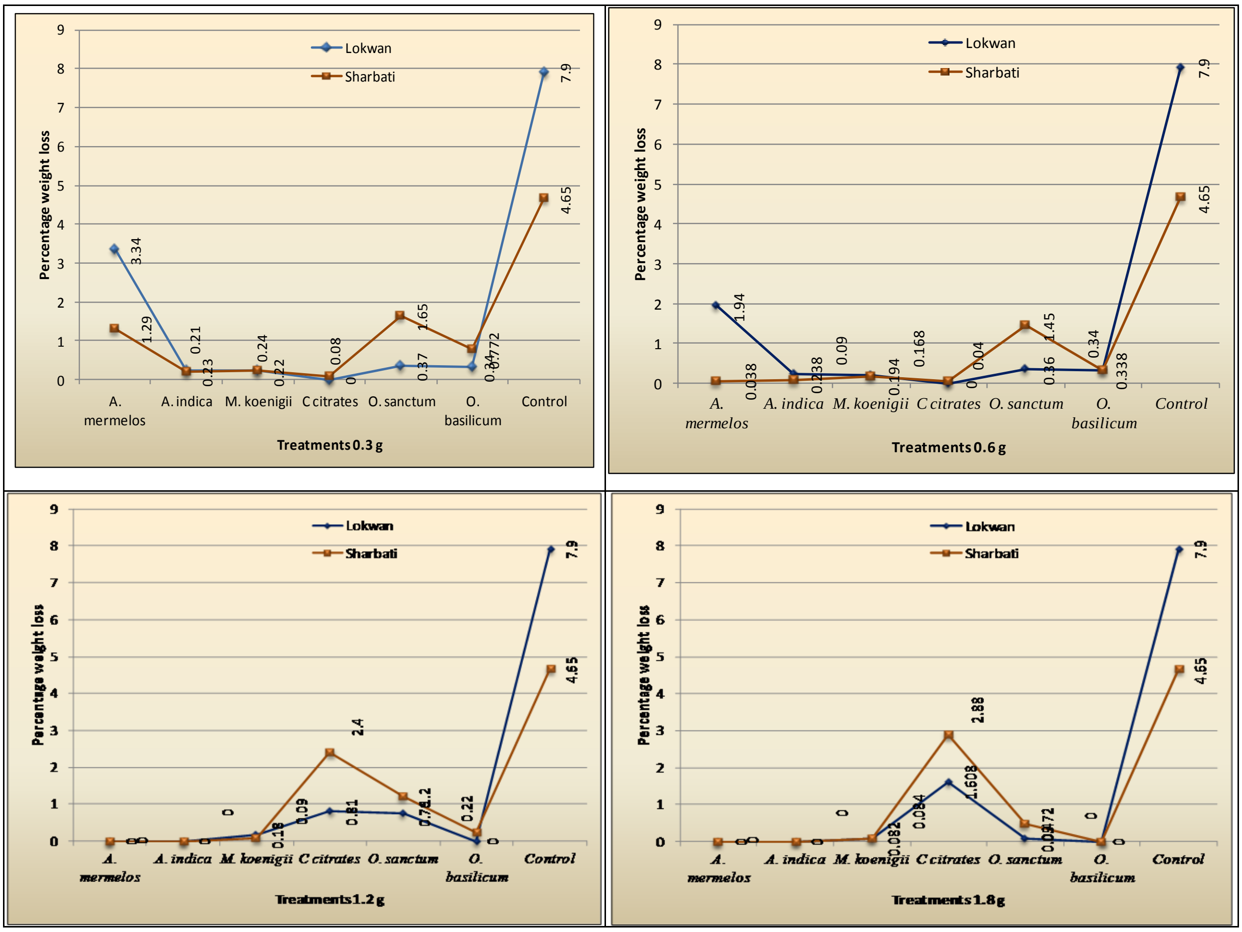
Lokwan

Treatment	Conc. / 50 Gm Of Grain	Initial Wt. Of The Sample(G)	Final Wt. of the Sample(G)	Wt. Loss(g)	Wt. loss (%)
Control	-	50.00 ± 0.00	46.01 ± 0.03	3.98 ± 0.05	7.97 ± 0.03
Parad	0.0975g	50.00 ± 0.00	49.88 ± 0.02	0.12 ± 0.00	0.23 ± 0.00
	0.195g	50.00 ± 0.00	49.93 ± 0.00	0.070 ± 0.002	0.14 ± 0.00
	0.39g	50.00 ± 0.00	49.97 ± 0.03	0.024 ± 0.00	0.04 ± 0.00
	0.78g	50.00 ± 0.00	50.00± 0.023	0.00 ± 0.014	0.00
Grain Phos	0.6 µl	50.00 ± 0.00	49.89 ± 0.05	0.106 ± 0.012	0.212
	1.2 µl	50.00 ± 0.00	50.00 ± 0.00	0.10 ± 0.00	0.60
	2.5 µl	50.00 ± 0.00	50.00 ± 0.00	0.09 g± 0.00	0.02
	5µl	50.00 ± 0.00	50.00 ± 0.00	0.00±0.00	0.00

Sharbati

Treatment	Conc. / 50 Gm Of Grain	Initial Wt. of the Sample (G)	Final wt. of the Sample (g)	Wt. Loss(g)	Wt. loss (%)
Control	-	50.00 ± 0.00	47.07 ± 0.12	2.32 ± 0.18	4.67±0.08
Parad	0.0975g	50.00 ± 0.00	49.89 ± 0.13	0.110 ± 0.02	0.22±0.00
	0.195g	50.00 ± 0.00	49.902 ± 0.00	0.098 ± 0.03	0.20±0.00
	0.39g	50.00 ± 0.00	49.925 ± 0.05	0.075 ± 0.02	0.015±0.00
	0.78g	50.00 ± 0.00	50.000 ± 0.00	0.00 ± 0.00	0.00±0.00
Grain Phos	0.6 µl	50.00 ± 0.00	49.91 ± 0.50	0.091 ± 0.01	0.19±0.00
	1.2 µl	50.00 ± 0.00	49.92 ± 0.20	0.078 ± 0.05	0.18±0.00
	2.5 µl	50.00 ± 0.00	50.00 ± 0.00	0.00 ± 0.00	0. 00±0.00
	5 µl	50.00 ± 0.00	50.00 ± 0.00	0.00 ± 0.00	0.00±0.00





Graph 3a-b: Showing effect of different concentrations of plant powders on weight loss by *S. oryzae*

Conclusion

The present study states that application of these botanical insecticide treatments are generally easy to prepare, inexpensive and has been found to be effective giving good control of existing insect infestation as par as commercially available chemical fumigants such as Parad and GrainPhos. The ethano botanical use of these botanicals in ample quantities along with few selected chemical insecticides in small quantities when utmost required will help the farmers to save the grains.

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