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Efficacy of Botanicals against Maize Weevil (*Sitophilus zeamais*) on Wheat grain during storage (*Triticum aestivum*)

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Abstract
The objective of this study was to evaluate efficacy of different botanical against Sitophilus zeamais during storage of wheat grain. The study was conducted at laboratory condition of Lamjung campus, Lamjung at room temperature from January to April 2019. *Azadiracta indica*, *Allium sativum*, *Curcuma longa*, *Acorus calamus*, *Ginger officinale*, *Piper nigrum*, *Artemisia vulgaris*, *Brassica juncea* and untreated control was applied as treatments with three replications in completely randomized design. Wheat samples were infested with S. zeamais at a rate of 8 pair adults/40gram and botanicals were applied on 2 percentage (w/w) basis, and stored for 80 days. At 20 days intervals, samples of wheat were sieved followed by weighting for calculation of weight loss. While, infected seed and weevil mortality were recorded by visionary basis. And, germination test was done before and after experimentation. The results of the study revealed that all botanical showed significant effect on weevil mortality and controlling weight loss of wheat than unchecked control at ($p<0.05$) but, hinder the germination except in sweet flag (95%) and black pepper (95%). Among the botanicals, black pepper was found very effective in the study by securing 100% weevil mortality within 20days, and less infected seed (6.33) and least weight loss (0.323g) at the end of experiment without deterring the germination percentage. However, further research are needed to be carried out to ensure the long term effect in large stores of farmer's condition.

Keywords: botanicals, maize weevil, mortality, wheat

Introduction
Wheat is one of the most important cereal crops in Nepal which contributes the nation's 18% total cereal production [1]. It has covered 20% of total cultivated area and contributed 18% in the total cereal production in Nepal [1]. It can be used to make various human consumable products like a biscuit, noodles, bakery products, etc. And, wheat grain has also good in nutritive basis with nutritive compositions are moisture (13.3%), protein (12.7%), total ash (1.4%), crude fiber (2.4%), fatty acid (20.5 mg) and gluten (8%) [2].

The preservation of wheat in post-harvest has been equally challenging and important like wheat production in developing countries. The post-harvest loss of wheat in today's agriculture in developing countries is 46% of its total post-harvest loss [3]. Many organisms like rats, birds, insects and many more deteriorate the wheat quality and quantity in its post-harvest. Within insects, all species of *Sitophilus* can infect wheat causing great extent of loss during storage [4]; of these, *Sitophilus zeamais* showed great host preferences on wheat as compared to barley, buckwheat and milled rice [5]. It has a high caliber of reproducing into a large population in a short time which can cause great damage to the stored grain [6].

The use of synthetic pesticides may be a possible solution to the post-harvest loss of wheat faced by the farmers; however, chemical pesticides have shown many drawbacks in its use. Types of research show that chemical pesticides have a toxic effect on human health due to its residue effect and, its use may not be economical for the farmers; its broad-spectrum nature might not address the specific pest in the post-harvest. Furthermore, sometimes it will be so expensive that it may out of the reach for the poor farmer. Thus, an alternative method which is safer, economical and eco-friendly is needed to short out these problems.

Botanical will be a suitable alternative to control the weevil population in wheat storage. They are the plant materials which have many insecticidal properties within it. Again, these botanical have biodegradable properties which do not result in pesticide residue effect on

human health and its pervasiveness in the local area may not cost a fortune for the farmer.

Some commonly available plant species used by Nepalese farmers to control storage insect pests are sweet flag, neem, garlic, black pepper, ginger, brown mustard, turmeric and mugwort. Kind of research also has proved that these plant materials have effective in controlling various pests with its extract. Thus, this research focused on the relative efficacy of these plant materials to check the weevil population so that farmer can prioritize various plants within their reach to control the Maize weevil population. It uses a powder extract of these botanical to ensure the cheap and safe control practice to *Sitophilus zeamais* in wheat storage.

Materials and Methods

Insect cultures

Sitophilus zeamais was purely cultured at entomology department, Nepal Agriculture Research Council (NARC). The weevil were cultured at 26 ± 2 °C and 70 ± 5% Relative Humidity.

Botanicals Collection and Preparation

The tested botanical in the experiment was neem (*Azadiracta indica*) leaves, garlic (*Allium sativum)* cloves, ginger (*Ginger officinale)* rhizome, black pepper (*Piper nigrum)* seeds, brown mustard *(Brassica juncea)* seeds, mugwort (*Artemesia vulgaris)* leaves, sweet flag (*Acorus calamus*) rhizome and turmeric (*Curcuma longa)* rhizome. Garlic, ginger, black pepper, brown mustard and turmeric were purchased from the local market.

Garlic, ginger and turmeric were cleaned then cut longitudinally 2-3 pieces from one rhizome or clove; after that left for sun dried and finally powdered with the help of mortar and pestle. While black pepper and brown mustard seeds were cleaned first then left in sun for 4 days and finally powdered with the help of mortar and pestle.

From the periphery of Lamjung campus, Sweet flag, mugwort and neem were collected then cleaned and left for shade dry and at last powdered with the help of mortar and pestle.

Research Design

The research was conducted in completely randomized design with 3 replications and 9 treatments.

Treatments Details

List of Botanicals

Treatment 1- Neem (*Azadiracta indica*)
Treatment 2- Garlic (*Allium sativum*)
Treatment 3- Turmeric (*Curcuma longa*)
Treatment 4- Sweetflag (*Acorus calamus*)
Treatment 5- Ginger (*Ginger officinale*)
Treatment 6- Black pepper (*Piper nigrum*)
Treatment 7- Mugwort (*Artemisia vulgaris*)
Treatment 8- Brown mustard (*Brassica juncea*)
Treatment 9- Control

Experimental Procedure

The wheat seeds, obtained from NARC, were dried in sun for 4 days to remove excess moisture and possible insect infestation. Then, 20 grams of wheat seeds were measured and separately, treated with the powder form of neem, garlic, ginger, turmeric, brown mustard, bojho (Sweet flag), black pepper and mugwort (Titepati) respectively, at the concentration of 2% (w/w) basis. The treated seeds were kept in 40 ml of plastic jar and each jar was infested with 8 pairs of unsex maize weevil. After that, muslin clothes covered the jar. The untreated wheat seeds with infestation served as a control in the experiment. Data was taken 4 times at 20 days interval. The observed parameters were weevil mortality, infected seeds, weight loss of seeds and change in the germination of seeds. With the assistance of weighing balance, loss in wheat weight was calculated while infected seeds and weevil mortality were found out by sieving followed by a visionary basis.

Germination test of wheat was carried out two times; before and after experimentation period. Before experiment, randomly selected 100 wheat seeds from the whole mass were subjected for germination test. And after experiment, 20 wheat seeds from each treatment was randomly selected for germination test. In the both germination test, the randomly selected wheat seeds were kept in petri dish covered with wet blotting paper for 72 hours in germinator. In twelve hours interval, the wheat seed inside germinator was watered just only to wet the paper.

Germination percentage can be calculated by, the number of seeds germinated to the number of seeds subjected to the germination process then multiply by a hundred [7].

Analysis of data

Analysis of the obtain data was done by MS-Excel and R-stat at 5% level of significance.

Results

Weight loss of wheat seeds in percentage at different days after treatment

Table 1: Weight loss of wheat seeds

S.N.	Treatment	20DAT	40DAT	60DAT	80DAT
1	Neem	0.61 c	0.4033 d	0.16000 e	0.0000 g
2	Garlic	0.5866 c	0.37667 d	0.34667 c	0.39667 c
3	Turmeric	0.58 c	0.34 e	0.35667 c	0.31333 d
4	Sweet flag	0.3833 of	0.05 f	0.0000 f	0.0000 g
5	Ginger	0.48667 d	0.4633 c	0.51333 b	0.51333 b
6	Black pepper	0.323 f	0.0000 f	0.0000 f	0.0000 g
7	Mugwort	0.6766 b	0.5033 b	0.21667 d	0.2633 e
8	Brown mustard	0.406 e	0.32667 e	0.22333 d	0.15000 f
9	control	0.7733 a	0.5833 a	0.51333 a	0.7100 a
F-Test		1.42e-10 ***	<2e-16 ***	<2e-16 ***	<2e-16 ***
Mean		0.5362963	0.338518	0.2555556	0.2607407
CV(%)		6.874583	5.482481	5.533879	6.175303
LSD		0.06324344	0.0318364	0.02425936	0.02762049

In the experiment, control showed maximum weight loss while the black pepper treated sample demonstrated the least loss in weight among treatment (table1). After black pepper, the least loss in weight was seen in Sweet flag treated sample (table1). Furthermore, among botanical treated samples, the ginger treated sample was seen a great loss in weight (table1).

Number of infected seeds at different days after treatment

Table 2: Number of infected wheat seeds

S.N.	Treatment	20DAT	40DAT	60DAT	80DAT
1	Neem	11.66667c	7.666667d	3.333333e	**0.00000f**
2	Garlic	11.33333c	7.333333d	6.666667c	7.666667c
3	Turmeric	11.33333c	6.333333e	6.333333c	6.333333d
4	Sweetflag	7.66667e	1.333333f	0.00000 f	0.00000f
5	Ginger	9.66667d	8.666667c	9.333333b	10.0000b
6	Black pepper	6.33333f	0.0000 g	0.00000 f	0.00000f
7	Mugwort	13.66667b	10.33333b	4.00000de	5.666667d
8	Brown mustard	8.33333e	6.333333e	4.333333d	2.666667e
9	control	15.66667a	11.66667a	10.3333a	14.66667a
	F-Test	1.98e-12 ***	7.97e-15 ***	1.5e-15 ***	<2e-16 ***
	Mean	10.62963	6.62963	4.925926	5.222222
	CV(%)	5.431518	9.666667	9.569866	8.24039
	LSD	0.9903841	0.9337431	0.8086453	0.7381888

In the end of experiment, control showed a maximum number of infected seeds while black pepper treated sample showed a minimum number of infected seeds among the botanical treated samples (table 2). After the black pepper, Sweet flag treated sample showed a minimum number of infected seeds at the end of the experiment (table 1). Among the botanical treated samples, the ginger treated sample showed maximum number of infected seeds in the experiment (Table 2).

Effect of different treatments on weevil mortality (%) at days after treatment

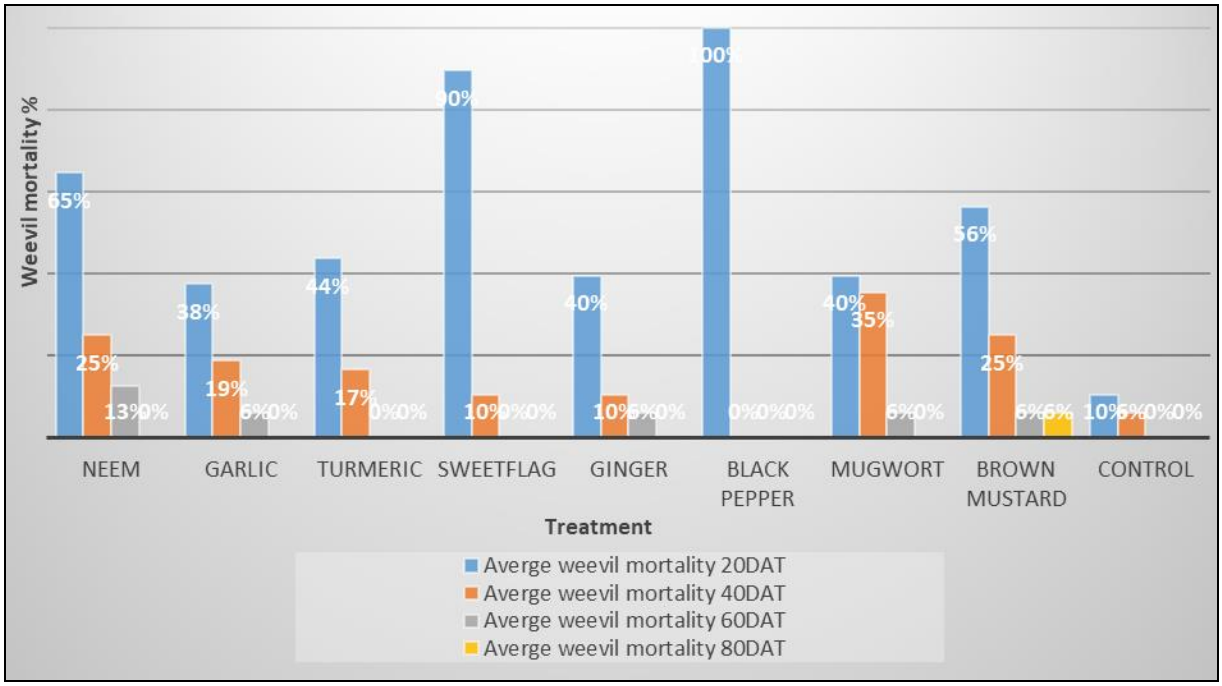

Fig 1: Effect of different treatments on weevil mortality (%) at days after treatment

In the experiment, all the weevils on the wheat treated with black pepper died within 20 days after treatment (fig 1). After Black pepper, sweet flag showed effectiveness against the maize weevil as it ensured the complete mortality of weevil within 40 days after treatment. Among botanical treated samples, the ginger followed by garlic showed the least effective against the weevils while minimum weevil mortality was seen in the control (fig 1).

Comparison between the initial and final germination percentage of seed

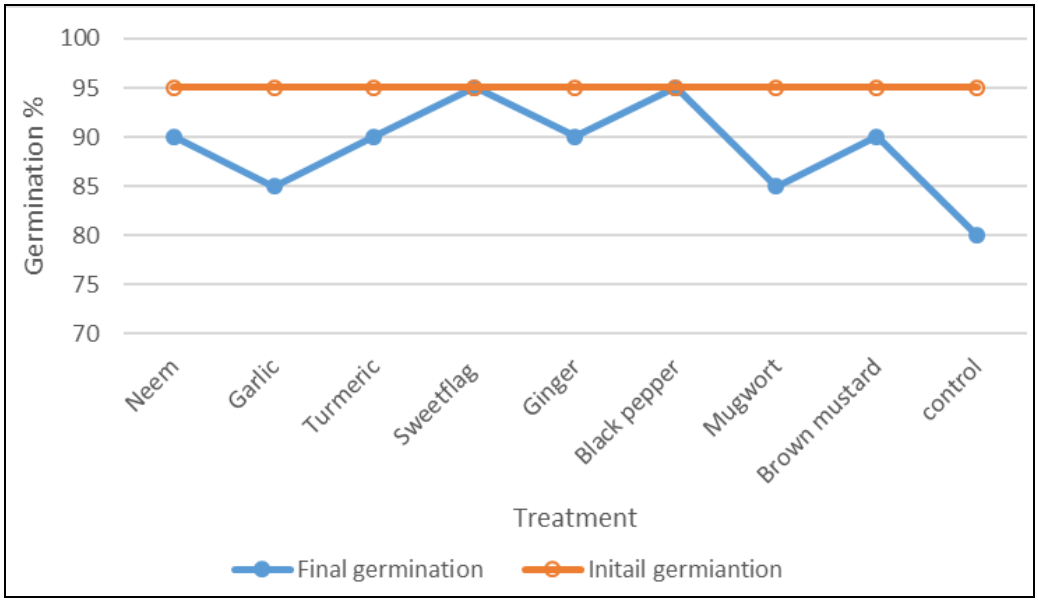

Fig 2: Comparison between the initial and final germination percentage of seed

Control showed the highest germination difference with initial germination percentage. While, sample treated with black pepper and sweet flag showed no germination difference at all (Fig 2).

Discussion

All botanical significantly affected the rate of weevil mortality as compared to untreated check (fig 1). Among treatments, black pepper (2% w/w) showed great effectiveness in the weevil mortality and showed the least weight loss and number of infected seeds in the experiment. Black pepper showed complete weevil mortality within 20 days after treatment, minimum average total weight loss (0.323g) and infected seed (6.333) (fig 1, table 1and 2). Similar result was found in earlier research when the mixture of 1g of black pepper with 1 kg of maize secured 100% maize weevil mortality within 96 hours [8]. Constituent chemical compounds like pipercide, dihydropipercide and guineensine present in black pepper was responsible for insecticidal properties [9]. Black pepper did not affect germination of the wheat seeds (fig 2). This might be the least infestation of weevil in the seed as the insects eats the storage food as well as eats the germ, leading to death of the seed and hence result in poor seed germination and lower vigor [10].

After black pepper, sweet flag 2% (w/w) treated sample showed less weight loss (0.43g) and infected seeds (8.9) securing complete mortality within 40 days after treatment. Likewise, in past research, weevil in control (untreated) wheat grains bored 43% in 60 days, which increased up to 90% in 150 days; while sweet flag powder treated grains @ of 10gm/kg of seed was less than 1% damage in 60 days and 2.46% damage grains in 150 days. ß-asarone is the compound with an insecticidal activity was found in bojho (sweet flag) rhizome thought to be responsible for the mortality of weevils [12]. There is no reduction in the germination percent in wheat seed with sweet flag 2% (w/w) & highest in control i.e. 15%. Earlier research also shows that least germination loss in sweet flag treated seeds and 43% germination loss in control [11].

Conclusion

Among the tested botanical, black pepper 2% (w/w) was found very effective followed by sweet flag to control Maize weevil in storage wheat in laboratory condition. Black pepper is the herb with maximum health benefits and no health hazard. Similarly, *Acorus calamus* (L.) is the herb which does not have any negative effect on human health and environment and available easily [12]. However, further research are needed to conform the long-term effectiveness of these botanical in large stores of farmer's conditions and minimum effective concentration of botanical also needed to find out.

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