Effectiveness of Some Chemical and Biological Pesticides against *Sitophilus zeamais* (Motschulsky)

Garima Bhandari[1], Sunil Aryal[2], Aakash Adhikari[3], Reshu Basnet[4]

[1,3,4]Himalayan College of Agricultural Sciences and Technology, Kathmandu, Bagmati, Nepal
[2]Horticulture Research Station, Nepal Agriculture Research Council, Kathmandu, Bagmati, Nepal
*Corresponding Author

Received:- 11 March 2022/ Revised:- 19 March 2022/ Accepted:- 24 March 2022/ Published: 31-03-2022

Abstract— *The study on "Effectiveness of some chemical and biological pesticides against S. zeamais" was carried out at National Entomology Research Center, NARC, Khumaltar, and Lalitpur. This study was carried out to find the residual effect of the pesticides on S. zeamais mortality. Each pesticide was applied in 3 concentrations.: Emmamectin Benzoate @ 0.3ml/ltr, @0.1ml/ltr and @0.6ml/ltr, Neem @ 5ml/ltr, @2.5ml/ltr and @10ml/ltr, Chloropyrifos (50%) + Cypermethrin (5%) @ 1.5ml/ltr, @0.75ml/ltr and @3ml/ltr; and Malathion @ 2ml/ltr, @1ml/ltr and 4ml/ltr. The residue of pesticide on weevil mortality was seen the highest on Chloropyrifos (50%) + Cypermethrin (5%) till the 87th Day and was least on Neem even on the 1st day of observation. The mortality % was highest (100%) on Chloropyrifos (50%) + Cypermethrin (5%) and Malathion and was lowest (0%) on Neem. The maximum weight loss was observed on Neem @2.5ml/ltr which was 9.4% whereas, minimum wt. loss was observed on Chloropyrifos (50%) + Cypermethrin (5%) @ 3ml/ltr which was 0.25% of the total grain weight. The maximum percent of damaged grain was observed on Neem which was 100% while the minimum percent of damaged grain was observed on Chloropyrifos (50%) + Cypermethrin (5%) @1.5ml/ltr which was 11.21% of the total grain. No weevil progeny emerged from Chloropyrifos (50%) + Cypermethrin (5%) @1.5ml/ltr treated seeds whereas the maximum number of progeny emerged from Neem @2.5ml/ltr treated seeds which were 149.67. Out of the 4 pesticides tested on the adult of Sitophilus Zeamais, Chloropyrifos (50%) + Cypermethrin (5%) was found to be most effective while Neem was the least effective. Since the residual of the chemical pesticides are long lasting, it is not recommend to use pesticides for consumption but can be used to store for seed purpose.*

***Keywords—* S. zeamais, mortality, biological pesticide, weevil, maize.**

I. INTRODUCTION

Maize development is a lifestyle for most farmers in the slopes of Nepal. It is a traditional crop which is cultivated as food, feed, and fodder on inclining land which is rain-fed upland in the hills. It is developed under downpour took care of conditions throughout the mid-year (April-August) as a solitary yield or transferred with millet later in the season. In the terai, internal terai, valleys, and low-lying river basin regions, maize is likewise grown in the winter and spring with irrigation system (Paudyal et al., 2001). Different cereal harvests have assumed significant parts intending to food security issues in Nepal. Lately, there have been vacillations in crop production and demand situations because of different reasons (Gairhe et al. 2018). Maize is the second most significant yield after rice as far as region and production in Nepal. It is a lifestyle for the farmers of the hilly area in Nepal. It is a traditional yield developed for food, feed, and fodder. Maize demand has been continually developing by about 5% yearly in last decades. Per capita, maize consumption in Nepal was 98 g/individual/day. The stored maize is attacked and harmed by a few pests that lead to quality fading driving farmers to sell at scaled down costs and underneath the production cost. Insect-Pests are frequently viewed as the main reason for maize grain losses. The main pests that cause harm to maize in the field and capacity are Lepidopterist stalk borers and Coleopterans weevils, respectively. In excess of 37 types of arthropod pests are related with maize grain in storage. During the storage time frame, insects -pests and diseases assume a huge part in diminishing production and productivity combined with germination potential (Alam et al., 2019). Among pests, maize weevil (*Sitopilus zeamais*) and Angoumois grain moth (*Sitotroga cerealla*) were the main pests found in stored maize in Nepal. This happens on the grounds that the majority of the maize produced by farmers stays on the open floor of their room without keeping up appropriate storage standards. The primary reason for this is farmer's absence of sufficient information in regards to the situation with insect pests in a stored condition. (Alam et al., 2019).

S. zeamais Motsch stays quite possibly the most serious and internal feeding pests of maize in storage (Pameru et al., 1997). It falls among the most dangerous pests in stored grain, particularly maize in tropical areas. Grown-up female of weevils causes harm by drilling into the kernel and laying eggs (ovipositing) (Longstaff., 1981). The larvae and pupae eat the inward pieces of the kernel, which brings about a harmed kernel and diminished grain weight. The pervasion boosts temperature and dampness content in the stored grain mass, which can prompt fungal growth, including toxigenic species, for example, *Aspergillus favus* Link. *S. zeamais* can cause an extensive loss in quality and amount of the grain on the field just as in the storage. (Bhusal and Khanal., 2019).

There have been different sorts of insecticides that have been suggested for the control of storage pests in Nepal (Neupane, 2000). In any case, direct utilization of such insecticides is neither relevant nor doable (Mallah et al., 2018.). The chemical control is compelling, quick, secure, and conservative yet it has some significant downsides: such as adverse consequence on products and surrounding environment; the steady peril of intoxication for people and animals; the presence of residue in various pieces of the plants; (RÖMBKE J et al., 2000). Disposal of these downsides should be possible by utilizing some fewer contaminating insecticides, from the IIIrd and IVth groups of toxicity, and by utilizing efficient dosages, as least as possible (Porca et al., 2003). Some storage gain can be protected with chemical and biological pesticides for seed and feed purposes. Therefore, this study has been devised to study the effective pesticides and their residual effects on mortality of maize weevil along with the grain damage assessment.

II. MATERIALS AND METHODS

The following experiment was conducted in the laboratory of the National Entomology Research Center of NARC, Khumaltar, and Lalitpur, Nepal. Rearing of *S. zeamais* was performed in a laboratory setting by maintaining appropriate temperature, and sanitary conditions. Firstly, about 1 kg of healthy, dry and pest-free maize of mixed variety was selected. For rearing *Sitophilus zeamais* (Maize weevil), a total of 5 cylindrical glass jar 16 cm × 8 cm were used. These cylindrical glasses were filled with 300gm of a mixed variety of maize in each vessel. Fifty *S. zeamais* each (without separating male and female) were kept in each vessel for mating. Black muslin cloth of suitable length was used to cover the open end of the cylindrical glass jar. After a week the fifty *S. zeamais* which were kept for mating were removed from each of the vessels and the rearing of *S. zeamais* was started. After 30-35days, adult *S. zeamais* started to emerge. The age of the weevil used in the experiments was of 1-7 days of age.

For the implementation of the experiment, 60 small, clean cylindrical plastic container was taken and labelled Manakamana-4 maize variety. Fifty gram each of maize grain was placed in those 60 containers and was covered with perforated lids. Chemical pesticides and bio-pesticides were selected and prepared in appropriate quantity according to the requirement for the experiment. Altogether, there were 4 treatments with 3 concentrations with 4 replications for each experiment. One treatment was assigned as control (Table 1). Each container with maize grain was treated with a particular dose of treatment and wait until the inoculation of test insect. On the 5th day, 10 weevils each was placed into each container and mortality was observed at the interval of 48hrs. Ten new weevil were added to each container after 5 days interval discarding the previously added dead/ alive until 25th Day. In the later stage, 10 weevils were added to each container at the interval of 10 days. During this process, the weevils were discarded after each observation. This experiment was conducted for 87 Days.

After the completion of an experiment to find the residual effect of pesticide on weevil mortality, the data to observe the weight loss, damaged grains and no of weevil progeny were taken which was a week after the final observation for weevil mortality of treatment 3 and 4 and 67 days after the final observation for weevil mortality of treatment 1 and 2.

TABLE 1
DESCRIPTION OF DIFFERENT INSECTICIDE USED IN THE EXPERIMENT AGAINST *SITOPHILUS ZEAMAIS*

SN	Trade name	Active Component	Formulation type	Dose1 (ml/ltr)	Dose2 (ml/ltr)	Dose3 (ml/ltr)
1	Top Killer	Emmamectin Benzoate 5.7% WDG	Water dispersible granule	0.3	0.1	0.6
2	Neem pro	Neem oil	Thick oil	5	2.5	10
3	G-Sunami	Chloropyrifos 50%+ Cypermethrin 5%EC	Liquid	1.5	0.75	3
4	Plant Malathion	Malathion 50% EC	Liquid	2	1	4
5	Control	Water	Liquid	5		

The weight loss percentage was determined by the following formula:

$$\text{Weight loss } \% = \frac{W1-W2}{W1} * 100\% \tag{1}$$

(Ngatia and Kimondo, 2011)

Similarly, the percentage of damaged grains was determined by the following formula:

$$\%\text{ damaged grain} = \frac{No.of\ damaged\ \ grains}{Total\ no\ of\ grains} * 100\% \tag{2}$$

The data was managed in the MS. EXCEL file. Later, two-way ANOVA was used to compare the mortality caused by different treatments and concentrations of different pesticide. Weight loss, damage % and the number of weevil progeny were also subjected to two-way ANOVA. The means were compared using Turkey HSD Test at 0.05 significance level (SPSS Inc., Chicago, II, USA).

III. RESULTS AND DISCUSSION

The residual effect of different concentration of pesticides was found significantly different after twelve days to sixty-seven days for weevil mortality (Table). Among the tested chemicals, the residue of pesticide on weevil mortality was seen the highest on Chloropyrifos (50%) + Cypermethrin (5%) till the 87th Day. The residue of pesticide on weevil mortality was least which was (0%) with no mortality of any weevil population for all three concentrations of Neem even on the 1st day of observation. i.e., on the 7th Day. The maximum mortality for control treatments was observed on the 22nd day which was 17.5% whereas the minimum mortality was 0% for all other days. Mortality percent of different concentrations was highly significant for the 12th, 17th, 22nd, 27th, 37th, 47th and 67th day among the concentrations ($P<0.01$) (Table 2). Similarly, the mortality percent were not significant for the 7th, 57th, 77th and 87th Day among the concentrations P (>0.01).The mortality percent of different treatments were highly significant for all the observations made on the 7th Day till the 87th Day among the treatments ($P<0.01$). Interaction of concentration and pesticides was highly significant for the 12th day, 37th day, 47th day and 67th day of observation among the different conc × trt ($P<0.01$). The resudial effect for emamectin benzoate was evident upto 27 days (Figure 1), for chlorpyrifos+cypermethrin and malathion was 87 days.

TABLE 2

MEAN MORTALITY PERCENTAGE (± SE) OF SITOPHILUS ZEAMAIS DUE TO THE RESIDUAL EFFECT OF VARIOUS CHEMICAL AND BIOLOGICAL PESTICIDES TREATMENTS ON DIFFERENT DAYS

Pesticide	Seven	Twelve	Seventeen	Twenty two	Twenty seven	Thirty seven	Forty seven	Fifty seven	Sixty seven	Seventy seven	Eighty seven
Emmamectin Benzoaate	12.5c±(4.01)	1.67c±(1.12)	2.5c±(1.30)	3.33d±(1.88)	0d	0d	0c	0c	0c	0c	0c
Neem	0d	0d	0d	0e	0d	0d	0c	0c	0c	0c	0c
Chloropyrifos (50%) + Cypermethrin (5%)	99.17b±(0.83)	83.33a±(2.24)	64.17a±(4.51)	56.67b±(4.97)	47.5b±(5.09)	70a±(4.08)	66.67a±(3.55)	5ab±(1.94)	50.83a±(4.16)	7.5b±(2.17)	4.17a±(1.48)
Malathion	100a	68.33b±(3.85)	61.67b±(5.05)	65.83a±(6.45)	51.67a±(7.86)	40b±(8.70)	38.33b±(9.03)	8.33a±(2.70)	30.83b±(9.49)	8.33a±(4.05)	1.67ab±(1.12)
Control	0d	0d	0d	5.83c±(3.98)	2.5b±(1.79)	2.5c±(1.79)	0c	0c	0c	0c	0c
Treatment	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.005
Concentration	0.33	<0.01	0.009	<0.01	0.006	<0.01	<0.01	0.028	<0.01	0.299	0.499
(Treatment * Concentration)	0.359	<0.01	0.124	0.271	0.021	<0.01	<0.01	0.057	<0.01	0.028	0.974

TABLE 3
MEAN PERCENTAGE (± SE) OF WEIGHT LOSS OF MAIZE GRAINS, PERCENTAGE OF DAMAGED GRAIN (± SE) AND MEAN NUMBER (± SE) OF WEEVIL PROGENY IN DIFFERENT TREATMENTS OF CHEMICAL AND BIOLOGICAL PESTICIDES.

Treatment	weight loss	% Damaged grains	Weevil Progeny
Emmamectin Benzoate	1.5± (0.34)	47.98±(4.44)	3.90±(1.20)
Neem	7.25± (0.80)	91.47± (0.00)	104.2± (18.65)
Chloropyrifos (50%) + Cypermethrin (5%)	1.25± (0.39)	12.84± (1.13)	0.25± (0.17)
Malathion	2.08± (0.47)	70.21± (2.69)	3.33± (1.32)
Control	3.23± (0.56)	66.37± (4.42)	57.25± (7.02)
Concentration	0.01	0.008	0.171
Treatment	0.01	0.01	0.01
Concentration* Treatment	0.096	0.01	0.17

Compared to Cypermethrin (5%) and Emmamectin bezoate based treatments, the percent weight loss was very high in Neem based treatment and control. The percent weight loss of three different concentrations of Malathion was 2.97% for Malathion @1ml/ltr, 1.91% for Malathion @2ml/ltr and 0.35 % for Malathion @4ml/ltr. The percent weight loss of three different concentrations of Chloropyrifos (50%) + Cypermethrin (5%) was 3.16% for @ 0.75ml/ltr, 0.73% for @ 1.5ml/ltr and 0.25% for @ 3ml/ltr. Similarly, the percent weight loss of three different concentrations of Emmamectin bezoate was 2.41% for @0.1ml/ltr, 0.9% for @0.3ml/ltr and 1.46% for @ 0.6ml/ltr. The percent weight loss was highest for Neem among all the other treatments which were 9.4% for @ 2.5ml/ltr Neem, 3.74 for @ 5ml/ltr Neem and 7.63% for @10ml/ltr Neem. The weight loss percentage was seen highest in the control treatment after Neem which was, 3.41% of the total weight.

The maximum percentage of damaged grain was observed on all three concentrations of Neem which were 100% for all the three concentrations. The minimum percentage of damaged grain was observed on Chloropyrifos (50%) + Cypermethrin (5%) @1.5ml/ltr which was 11.21% of the total grain. The percentage of the damaged grain of three different concentrations of Malathion was 79.23% @1ml/ltr, 68.3% for @2ml/ltr and 71.34 % for @4ml/ltr. The percentage of the damaged grain of three different concentrations of Chloropyrifos (50%) + Cypermethrin (5%) was 14.51% for @ 0.75ml/ltr, 11.21% for @ 1.5ml/ltr and 14.35% for @ 3ml/ltr. Similarly, the percent damaged grain of three different concentrations of Emmamectin benzoate was 39.2% for @0.1ml/ltr, 69.9% for @0.3ml/ltr and 38.73% for @ 0.6ml/ltr. The percent weight loss was highest for Neem among all the other treatments which were 100% for @ 2.5ml/ltr Neem, 100% for @ 5ml/ltr Neem and 100% for @10ml/ltr Neem. 61.63% of damaged grain was observed on the control treatment.

The movement of adults of *S. zeamais* was significantly affected by insecticide formulations, particularly due to the insecticides themselves as the sole biologically active ingredients of the formulations tested (velez et al., 2018). The F1 progeny emergence in different observations was significant among different management practices. The lowest number of weevil progeny emerged from Chloropyrifos (50%) + Cypermethrin (5%) @1.5ml/ltr treated seeds was 0 whereas the maximum number of weevil emerged from the Neem @2.5ml/ltr treated seeds was 149.67 (Table 3). Result of the present study show that the ingredient of neem caused no effect in the mortality of S. zeamais. In contrast to our finding, Neem was reported to be highly effective against S. zeamais and found that within 14 days of exposure maximum mortality of 99% and 100% reduction in F1 progeny (Nukenine et al., 2013). The number of weevil progeny that emerged from three different concentrations of Emmamectin bezoate was 2 for @0.1ml/ltr, 9.33for @0.3ml/ltr and 1for @ 0.6ml/ltr. (Parilama and Maheswori., 2011) also showed that the emamectin benzoate was effective in controlling maize weevil. The number of weevil progeny that emerged was highest for Neem among all the other treatments was 149.67for @ 2.5ml/ltr Neem, 81.5 for @ 5ml/ltr Neem and 96 for @10ml/ltr Neem. The number of weevil progeny emerged from three different concentrations of Chloropyrifos (50%) + Cypermethrin (5%) was 0.67 for @ 0.75ml/ltr, 0 for @ 1.5ml/ltr and 0.33for @ 3ml/ltr. Similarly, the number of weevil progeny that emerged from three different concentrations of Malathion was 7.33for Malathion @1ml/ltr, 5.33for Malathion @2ml/ltr and 0.33 for Malathion @4ml/ltr. Malathion was the best chemical in reducing S. zeamais population. This report corborate the previous report wherein malathion was more toxic 4.913 ppm against S. zeamais that exhibited superior toxicity (Pathak and Jha, 1999).

The number of weevil progeny that emerged in the control treatment was 49.67± (3.51). The weight loss (p=0.01) and percent damaged grains (p=0.008) were found to be significantly different among concentrations whereas there was no significant difference in the number of weevil progeny P (>0.171). Similarly, all the three dependent variables; weight loss, Percent damaged grains and no of weevil progeny were found to be highly significant P (=0.01) among the different treatments. As for the source (Concentrations × treatment), the percent damaged grain was found to be highly significant (P<0.01) while weight loss (p=0.096) and no of weevil progeny (p=0.017) were not significant (Table 3).

IV. CONCLUSION

Insects are often considered the principal cause of maize grain losses. Pests are one of the major constraints that limit the potentiality of maize in Nepal. They attack the maize plants directly from the seeds sown in the field during maturity and feed on all parts of the plants. The chemical control is effective, quick, secure and economical but it has some major drawbacks: negative impact on products and environment; the constant danger of intoxication for humans and animals; the presence of residues in different parts of the plants; appearance, at the pest species, of resistance to pesticide. Out of the 4 pesticides tested on the adult of *Sitophilus zeamais*, Chloropyrifos (50%) + Cypermethrin (5%) was most effective followed by Malathion, Emmamectin Benzoate and at last Neem. Neem treatment had a 0% mortality rate which showed no reduction of the weevil population, rather resulted in the highest no of progeny during the last stage of the data observation. This means these 3 pesticides except Neem can be recommended for control of *Sitophilus zeamais*. Chloropyrifos (50%) + Cypermethrin (5%) has a longer residual effect so that it could prevent damage from *S. zeamais* for a longer period which could be used to preserve maize seed. Chemical pesticide treated grains should not be used for consumption purpose.

ACKNOWLEDGEMENT

I would like to express by sincere thanks to Prof. Dr. Binayak Prasad Rajbhandari, Executive Chairperson, Himalayan College of Agriculture Sciences and Technology (HICAST), Kirtipur. I express my deep sense of gratitude to my thesis advisor Dr. Anupama Shrestha Shah, Adjunct Professor of HICAST, Kirtipur for her valuable guidance, and constructive suggestion at every stage of this study. I am extremely grateful to Dr. Sunil Aryal, Senior Scientist, NERC, and NARC for his continuous guidance during research tenure and thesis writing. I also acknowledge Ms. Resona Simkhada, Technical officer and Mr. Harka Balayar, Technical Assistant, NERC, NARC and Mrs. Kushum Shrestha who helped organizing material for smooth running of the experiment and the team for their encouragement and excellent guidance throughout the research duration.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

OPEN ACCESS

REFERENCES

[1] Alam, M. Ahmed, K., Hossen, B., Mozammel, H. and Hoque, A., (2019) Storage pests of maize and their status in Bangladesh. *Journal of Bioscience and Agriculture Research*, 20(2), pp.1724-1730.

[2] Bhusal, K. and Khanal, D. (2019) Role of Maize Weevil, *Sitophilus zeamais* Motsch. on Spread of *Aspergillus* section *flavi* in Different Nepalese Maize Varieties. *Advances in Agriculture*, 2019, pp.1-5.

[3] Gairhe, S., Shrestha, H. and Timsina, K. (2018) Dynamics of Major Cereals Productivity in Nepal. *Journal of Nepal Agricultural Research Council*, 4, pp.60-71.

[4] K.A.Pathak, and A.N. Jha (1999). Toxicity of some insecticides against adults of Sitophilus oryzae,Sitophilus spp. and Sitotroga cerealella . Indian Journal of Entomology. 61:320-325.

[5] K.C., G., Karki, T., Shrestha, J. and Achhami, B. (2015) Status and prospects of maize research in Nepal. *Journal of Maize Research and Development*, 1(1), pp.1-9.

[6] K.V Parimala and T. U Maheswari. 2011. EVALUATION OF SELECTED INSECTICIDES AS SEED PROTECTANTS AGAINST THE MAIZE WEEVIL (*Sitophilus zeamais* M.). International Journal of Applied Biology and Pharmaceutical Technology 2:316-322.

[7] Longstaff BC, 1981. Biology of the grain pest species of the genus Sitophilus (Coleoptera: Curculionidae): a critical review. Protection Ecology, 3(2):83-130.

[8] Mallah, M., Sapkota, R. and Kandel, B. (2018) Efficacy evaluation of common botanicals to manage maize weevil (*Sitophilus zeamais* M) in laboratory condition. *Farming & Management*, 3(2), pp.142-145.

[9] Neupane, F.P. (2000) Field Evaluation of Botanicals against the Insect Pests of Okra (*Abelmoschus esculentus* Moench.). *Undefined*.

[10] Ngatia, C. and Kimondo, M. (2011) Comparison of three methods of weight loss determination on maize stored in two farmer environments under natural infestation. *Journal of Stored Products and Postharvest Research*, 2(13), pp.254-160.

[11] Nukenine EN, Goudoungou JW, Mahama A, Adler C. Ability of neem seed powder and NeemPro® to protect stored bambara groundnut against the infestation of *Callosobruchus maculatus* F. (Coleoptera: Bruchidae) in the Adamawa region of Cameroon, in *The First International Conference on Pesticidal Plants*, icipe, Kenya. Book of Abstracts; 2013.

[12] Paudyal, K.R., Ransom, J.K., Rajbhandari, N.P., Adhikari, K., Gerpacio, R. v. and Pingali, P.L. (2001) *Maize in Nepal : production systems, constraints, and priorities for research*. NARC.

[13] Porca, M., Oltean, I. and Dobrin, I. (2003) CHEMICAL CONTROL OF BEAN WEEVIL, ACANTHOSCELIDES OBTECTUS SAY IN STORAGE CONDITION. *Journal of Central European Agriculture,* [online] 4. Available at:
<https://www.researchgate.net/publication/27201035>.

[14] R.B. Paneru, G.N.J. le Patourel, S.H. Kennedy. Toxicity of *Acorus calamus* rhizome powder from Eastern Nepal to Sitophilus granarius (L.) and Sitophilus oryzae (L.) (Coleoptera, Curculionidae), Crop Protection. 16:759-763.

[15] RÖMBKE J and J.F. MOLTMANN (2000) *Applied Ecotoxicology*. German Society for Tehnische Zosamnenarbeit (GTZ), Lewis Publishers.

[16] Vélez, M., Bernardes, R. C., Barbosa, W. F., Santos, J. C., & Guedes, R. N. C. (2019). Walking activity and dispersal on deltamethrin-and spinosad-treated grains by the maize weevil Sitophilus zeamais. *Crop Protection*, *118*, 50-56.