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Efficacy of *Chrysanthemum cinerariaefolium*, *Neorautanenia mitis* and *Gnidia kraussiana* against Larger Grain Borer (*Prostephanus truncatus* Horn) and Maize Weevil (*Sitophilus zeamays* Motschulsky) on Maize (*Zea mays* L.) Grain Seeds

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ABSTRACT

Studies to evaluate the effectiveness of natural protectants in controlling *Prostephanus truncatus* and *Sitophilus zeamays* in stored maize were conducted in a Completely Randomized Design (CRD) with three replications. The treatments consisted of natural protectants viz., pyrethrum (*Chrysanthemum cinerariaefolium*), *Neorautanenia mitis, N. mitis* with talc as carrier, *Gnidia kraussiana* powder and untreated control. Actellic Super Dust was included as a standard insecticide control. The data collected included the number of dead and live insects, number of damaged and undamaged maize seeds, number of holes per seed, percentage damage and weight loss. Seeds treated with Actellic super dust, pyrethrum and *G. kraussiana* powder had significantly lower number of live insects and damaged seeds as compared to untreated control. Among the natural protectants, pyrethrum and *G. kraussiana* powder showed good potential in protecting maize grain against *P. truncatus* and *S. zeamays*. Positive and significant correlations between the numbers of live insects with number of damaged seeds, percentage damaged seeds, average number of holes per seed and weight loss were observed.

Key words: Damage, insecticides, insects, mortality, weight loss

INTRODUCTION

Maize is one of the most important cereals grown in the world. It is an important food and cash crop in Tanzania and regarded as the major staple food accounting for up to 60% of dietary calories of the majorities of the Tanzanian rural population (Rwamugira, 1996). The crop can be grown over a wide range of environments and soil conditions. The Regions in the Southern highlands of Tanzania viz., Iringa, Mbeya, Rukwa and Ruvuma are the major producers of maize. The current production per unit area by small scale farmers is low, about 1,200 kg ha^{-1}, as opposed to potential average yield of 4,000-8,000 kg ha^{-1} (Skonhoft *et al*., 2006). The low production of this crop is attributed to several factors including diseases and insect pests. It is estimated that about 70% of the harvested grains stored in rural areas is lost to rodents and insects (Makundi, 2006). Post harvest losses due to insects are undoubtedly high, resulting to about 35% losses in some grains (Makundi, 2006).

Prostephanus truncatus (Coleoptera: Bostrychidae) and *Sitophilus zeamays* (Coleoptera: Curculionidae) are the major storage pests of maize causing heavy qualitative and quantitative losses of the crop (Rees *et al*., 1990). The effect of feeding activity of insects on maize grain include loss in weight, nutrients conversion to inferior food materials, reduction of germination, reduced vigor of seedlings and lowering of market values (Rees *et al*., 1990). The insects can destroy a large quantity of harvested maize within few months after harvest.

Currently, the control of *P. truncatus* and *S. zeamays* is largely dependent on the use of synthetic insecticides. Although, much success has been realized, there has been many problems associated with synthetic stored product protectants (Isman, 2006) leading to search for cheap, easily biodegradable natural products (Akob and Ewete, 2007). Control programs should rely on the use of relatively safe, low cost and locally available alternative tactics that prevent maize grain losses. Pesticides of botanical origin are seen as promising alternatives to the synthetics and are receiving attention (Golob *et al*., 1999; Mohan and Fields, 2002; Facknath, 2006; Akob and Ewete, 2007).

Plant and plant products are useful and desirable tools in pest management programs because they are effective and often complement the actions of natural enemies (Schmutterer, 1990; Ascher, 1993). In a number of investigations, chemical compounds that are potential pesticides have been isolated and identified from leaves and seeds of various plant species. For example, the potential pesticides activities of neem, pyrethrum and tephrosia products have been reported (Akhtar and Isman, 2004; Greenberg *et al*., 2005; Mbaiguinam *et al*., 2006; Iloba and Ekrakene, 2006). Therefore, identification and evaluation of locally available effective botanicals will provide a sustainable alternative to control storage pests, thus increasing food security. The objective of this study, therefore, was to evaluate the efficacy of locally available botanical products as grain protectants on survival of *P. truncatus* and *S. zeamays* in stored maize grains.

MATERIALS AND METHODS

Study location: The experiment was conducted at the Pest Management Centre laboratory, Sokoine University of Agriculture, Tanzania (06°50'S, 37°38'E, 525 m a.s.l) from December, 2006 to May, 2007.

Rearing of experimental insets: Cultures stocks of *P. truncatus* and *S. zeamays* were collected from infested shelled maize grains from the Morogoro Municipality central market. Maize grains weighing 1 kg were introduced into two separate large jars, covered with perforated lids. The jars were kept in a room maintained at a temperature of 28-29°C and 65-70% relative humidity. The aim was to produce a steady and sufficient supply of beetles of known age for experimental purpose.

Experimental layout: Treatments were arranged in a Complete Randomized Design (CRD) and replicated three times. Clean and well-sieved maize grain of the Staha variety was bought from smallholder farmers. They were adequately dried to 15% moisture content. The maize grains were disinfested by keeping them in a deep freezer at a temperature of -1°C for 48 h. This harvested maize had no history of insecticide treatment.

Treatments were Actellic Super Dust (0.3% permethrin and 1.6% pirimiphos methyl) applied at a rate of 1 g per 200 g of maize grains (control); *Chrysanthemum cinerariaefolium* Vis. (Asteraceae), *Neorautanenia mitis* (A. Ritch) Verdcourt (Papilionaceae), *N. mitis* with talc as carrier, *Gnidia kraussiana* Meisn. (Thymelaeaceae) powders, all applied at the rate of 2 g per 200 g. The maize grains and pesticides were mixed and tumbled thoroughly for 5 min. Ten pairs of newly emerged adults of either *P. truncatus* or *S. zeamays* were introduced into each bottle that was then covered with perforated lids.

Data collection: Data collected included number of dead and live insects, number of damaged and undamaged maize grains and average number of holes per maize seed. In addition, percentage damaged maize seeds and weight losses were calculated.

Data analysis: All data collected were subjected to Analysis of Variance (ANOVA) procedure (SAS, 1990). Tukey test was used to detect mean differences between treatments. A Multivariate Analysis of Variance (MANOVA) was used to calculate partial correlation coefficients for investigated variables.

RESULTS

Table 1 shows the ANOVA table for investigated variables for *P. truncatus*. Results show that treatments differed significantly ($p \leq 0.05$) for all investigated variables except number of dead insects. A similar trend was observed on the effect of treatments on *S. zeamays* (Table 2).

The effects of Actellic Super Dust and pyrethrum were higher than all other treatments for all variables investigated except number of dead insects (Table 3, 4).

The remaining protectants did not significantly ($p \geq 0.05$) differ on any number of the variables studied. However, the effects of *G. kraussiana* were superior to the other protectants. The mean effects of *G. kraussiana* were significantly ($p \leq 0.05$) different from the control for all the variables studied except number of dead insects. The effects of *N. mitis* in most cases were similar to the

Table 1: ANOVA table for the investigated variables for *P. truncatus*

		Mean square						
SOV	df	Dead insect	Live insect	Damaged seeds	Damaged seed (%)	No. of holes $seed^{-1}$	Weight of undamaged seed	Weight loss
Treatment	5	35.58	15331.13***	58249.94***	66096***	28***	10581***	1058.08***
Error	172	24.80	991.49	2944.12	2863	235	510.25	510.25
Total	177							

***$p \leq 0.001$

Table 2: ANOVA table for investigated variables for *S. zeamays*

		Mean square						
SOV	df	Dead insect	Live insect	Damaged seeds	Damaged seed (%)	No. of holes $seed^{-1}$	Weight of undamaged seed	Weight loss
Treatment	5	2.07	36558.79***	25012.47***	742.23***	30616.20***	4925.86***	4929.86***
Error	172	18.90	2486.50	2512.03	74.36	3059.74	690.61	690.61
Total	177							

***$p \leq 0.001$

Table 3: Mean separation for effect of treatments on *P. truncatus* insect pest

Treatments	Dead insects	Live insects	Damaged seeds	Damaged seeds (%)	No. of holes seeds^{-1}	Weight of undamaged seeds	Weight loss
Control	0.800	54.533a	104.870a	16.836a	113.970a	155.330c	44.670a
Actellic	2.000	0.000c	0.000c	0.000c	0.000c	199.507a	0.493c
Pyrethrum	1.900	1.133c	42.000c	0.649c	4.800c	198.300a	1.700c
N. mitis	2.567	34.733b	80.700ab	13.364ab	80.500b	161.911bc	38.089ab
N. mitis with talc	2.300	42.367ab	78.700ab	12.389ab	86.170b	167.314b	32.686b
G. kraussiana	4.133	37.567b	75.670b	11.700b	78.830b	172.433b	27.567b
$\bar{x}$	2.283	28.389	57.350	9.156	60.712	175.799	64.418

Means with the same letter(s) in each column are not significantly different ($p \le 0.05$)

Table 4: Mean separation for effect of treatments on *S. zeamays* insect pest

Treatments	Dead insects	Live insects	Damaged seeds	Damaged seeds (%)	No. of holes seeds^{-1}	Weight of undamaged seeds	Weight loss
Control	2.033	91.230a	72.230a	12.440a	81.700a	169.240b	30.760a
Actellic	2.000	0.000c	0.000c	0.000c	0.000c	197.960a	2.030b
Pyrethrum	2.000	0.000c	0.100c	0.017c	0.300c	198.030a	1.966b
N. mitis	2.167	57.27b	54.130ab	9.337ab	57.100ab	170.370b	29.630a
N. mitis with talc	2.667	39.10b	35.700b	6.165b	34.970b	178.403b	21.597a
G. kraussiana	2.333	37.83b	29.800b	5.146b	37.130b	181.575b	18.425a
$\bar{x}$	2.200	37.57	31.990	5.610	35.200	182.590	17.400

Means with the same letter(s) in each column are not significantly different ($p \le 0.05$)

Table 5: Partial correlation coefficients for investigated variables for *P. truncatus* insect pest

Variables	No. of dead insects	No. of live insects	No. of damaged seeds	Damaged seeds (%)	No. of holes seeds^{-1}	Weight loss
No. of dead insects	1	0.06	0.02	0.03	0.04	0.09
No. of live insects		1	0.92***	0.91***	0.87***	0.83***
No. of damaged seeds			1	1.00***	0.94***	0.87***
Damaged seeds (%)				1	0.93***	0.86***
No. of holes seeds^{-1}					1	0.92***
Weight loss						1

***$p \le 0.001$

Table 6: Partial correlation coefficients for investigated variables for *S. zeamays* insect pest

Variables	No. of dead insects	No. of live insects	No. of damaged seeds	Damaged seeds (%)	No. of holes seeds^{-1}	Weight loss
No. of dead insects	1	0.006	0.027	0.027	0.025	-0.028
No. of live insects		1	0.942***	0.942***	0.932***	0.757***
No. of damaged seeds			1	0.999***	0.972***	0.841***
Damaged seeds (%)				1	0.972***	0.841***
No. of holes seeds^{-1}					1	0.805***
Weight loss						1

***$p \le 0.001$

untreated control. However, *N. mitis* powder and untreated control did not differ significantly ($p \ge 0.05$) in their effects on number of damaged seeds, percentage damaged seeds and weight loss. Similarly, the effect of *N. mitis* with talc as a carrier on number of live insects, number of damaged seeds and percentage damaged seeds was not statistically ($p \geq 0.05$) different from untreated control. No significant ($p \geq 0.05$) difference was observed among the *G. kraussiana*, *N. mitis* with talc as a carrier and *N. mitis* powder for all the studied variables (Table 3). In general, pyrethrum performed better than all the natural protectants, i.e., in all cases the effects were not significantly ($p \leq 0.05$) different from standard control. Among the remaining treatments, *G. kraussiana* performed relatively better i.e., in most cases the effects were significantly ($p<0.05$) different from untreated control.

Similar trends were observed on the treatment effects on *S. zeamays* (Table 4). The effects of pyrethrum were not significantly ($p \geq 0.05$) different from the effects of standard control, i.e., Actellic super dust for all the variables studied. On the other hand, the effects of the remaining protectants were not significantly ($p \geq 0.05$) different. However, the effects of *G. kraussiana* were significantly ($p \leq 0.05$) different from the untreated control, except on weight loss.

There were positive and significant ($p \leq 0.001$) correlations among the investigated variables between number of live insects with number of damaged seeds, percentage damaged seeds, average number of holes per seed and weight loss (Table 5, 6).

DISCUSSION

This study has revealed that Actellic super dust and pyrethrum performed better than other treatments for the all tested variables and insect pests. This is a good indication because there is much information on the use of pyrethrum in controlling pests. The chemistry, toxicology, extraction, refining and environmental fate of pyrethrum extracts have been reviewed by Casida and Quistad (1995). Products from pyrethrum have low mammalian toxicity, are easily degraded making them relatively safer to the environment and consumers. Control of insect pests in stores and other consumer products have also been given by Casida and Quistad (1995).

The powder of *G. kraussiana* performed better than untreated control for all tested variables for both species, except on reducing weight loss due to *S. zeamays*. The mixture of *N. mitis* and talc out-performed untreated control in reducing number of holes per seed and weight loss due to *P. truncatus*. However, for *S. zeamays*, this pesticide performed better than untreated control for all variables investigated except the number of dead insects and reduction of weight loss. *Neorautanenia mitis* performed better than no pesticide application by having less number of holes per seed and live insects for *P. truncatus*. The effects of *N. mitis* against storage pests *S. oryzae* and *P. truncatus* in wheat and maize were reported by Chimbe and Galley (1999). Many *Neorautanenia* species are used as insecticides by people in Central and South Africa (Van Puyvelde *et al*., 1987). Joseph *et al*. (2004) reported the larvicidal and mosquitocidal effects of crude extracts of *N. mitis* in Tanzania. In their study, the crude extracts of *N. mitis* had mosquitocidal effects comparable to those of standard mosquitocides like deltamethrin and alphacypermethrin. Decoctions of the roots of *N. mitis* have also been reported to have pharmacological effects in rats and mice (Vongtau *et al*., 2005). Van Puyvelde *et al*. (1987) isolated various compounds from the roots of *N. mitis* include hydroxyrotenone, a compound known to have insecticidal and acaricidal properties.

Although, there was no significant ($p \geq 0.05$) difference among the three botanicals *G. kraussiana* seemed to be more effective than either *N. mitis* or *N. mitis* with talc as a carrier as indicated by the low number of damaged seeds for both pests. Similarly, this treatment performed better than untreated control for all investigated variables in all storage pests. The results therefore, indicate that *G. kraussiana* has potential for use as a post harvest grains protectant. The extracts of *G. kraussiana* are used in different way in Tropical Africa, Central and Southern Africa where it occurs. The plant is used as fish poison (Neuwinger, 2004) and as a cure for various injuries and ailments. The extracts of *G. kraussiana* have also shown to have some activity against lypmhocrytic leukaemia (Boris and Cordell, 1984).

The results of this study show that botanical products could be useful and desirable tools in pest management programs (Schumutterer, 1990; Ascher, 1993). The present findings showed that pyrethrum and *G. kraussiana* powders could be used in protecting stored maize grains against maize storage pests through suppressing number of emerged adult insects, number of holes, damaged seeds, percentage damaged seeds and weight loss.

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