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Integrating Neem seed and Mexican tea powder for the management of the maize weevil, Sitophilus zeamais Mostch. (Coleoptera: Curculionidae) on stored maize at Bako, western Ethiopia

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Combinations of different rates of Neem seed and Mexican tea powder were evaluated against the maize weevil in no choice situations. Each experiment was laid out in a Randomized Complete Design with three replications. The experiment was re-infested to evaluate the persistence of the treatments 90 days after application. Data were collected on percentages of adult weevil mortality, numbers and weight of damaged and undamaged maize kernels, number of progeny weevils emerged, percentages of grain damaged, grain weight losses and seed germination. Analysis of variance showed significant differences among the treatments in all parameters. The rate of mortality in all of the treatment combinations ranged from 2-100%, while that of the untreated check ranged from 0-6% 90 dai. Similarly, the number of progeny weevils emerged, percentages of grain damaged and seed weight losses in all of the treatment combinations were significantly lower than that of the untreated check 90 dai. The mortality effects of the different treatment combinations were equivalent to the standard check following 90 dai. Percentages of weevil mortality in 40%+20% and 50%+10% combinations of Mexican tea and neem seed powder were significantly (P<0.01) higher than that of the other treatment combinations following 156 dai. The number of progeny weevils emerged, percentages of grain damaged and seed weight losses in all of these treatments were significantly lower than that of the untreated check. It can also concluded that combinations of Mexican tea and neem seed powder at 40%+20% and 50%+10%, can be used to protect maize from the maize weevil

Keywords: Neem seed powder, Mexican tea leaf powder and maize weevil

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INTRODUCTION

Post-harvest losses of food grain due to insect pests are significant nutritional and economic burden to subsistence farmers in developing countries (Firdisa and Abraham, 1998). The lack of improved storage structures for grain storage and absence of storage management technologies force maize growers to sell their produces immediately after harvest (Abraham, 1991; 2003; Emana and Assefa, 1998). Consequently, farmers receive low market prices for surplus grain they produce (Abraham, 1991; Beyene *et al*., 1996). Storage problems have been aggravated as traditional varieties have been replaced by high yielding and improved varieties which are generally more susceptible to insect damage than those of local cultivars (Sculten, 1976; Fortier *et al*., 1982; Dobie, 1984 and Arnason *et al*., 1994).

Despite heavy losses incurred in storage, much attention has not been given to research on stored product pests until recently (Abraham, 1991; 1997). Comprehensive studies on stored grain insect pests in our country began in 1989/90 when the problem was considered as an area of investigation by postgraduate studies at Alamaya University of Agriculture (Abraham, 1997).

Since then different management options such as physical (solar heating), inert dusts (wood ash, sand and SilicoSec), varietals screening, mixing with small cereal grains such as tef and dagussa, botanicals (plant powders and vegetable oil) and synthetic chemicals have been tested. Among the botanicals tested so far the Mexican tea (*Chenopodium ambrosiodes* (L.)) powder was found to be the most effective and comparable to the synthetic insecticides (Pirimiphos-methyle 2% D) at the recommended rate (Mekuria, 1995; Adane and Abraham, 1995a; Abraham, 2003). Similarly, neem (Azadrachta *indica)* leaf and seed powders were effective against the maize weevils at Bako (Firdisa and Abraham, 1998; Abraham, 2003). According to Abraham (2003), the percentage mortality of maize weevils was observed to increase with the increased rates of neem leaf powder. Neem leaf powder at and above 10% w/w caused over 70% mortality of adult weevils within 10 days after infestation. The highest significant mortality was recorded in 25 and 30% w/w neem leaf powder (Abraham, 2003)

Regardless of numerous control strategies available, storage insect pests are still problematic and Ethiopian farmers relay on synthetic chemicals. Although the use of pesticides are one means of protecting stored grain, the associated side effects on the environment and human health, development of genetically resistance insect strains, erratic supply and prohibitive costs have become a major concern and thus given imputes to the search for alternative methods of pest control. Uses of locally available plant products are other options to reduce reliance on synthetic chemicals. In recent years research on the efficacy of the use of locally available plant products and vegetable oil as stored grain protectants against insects have been intensified (Obeng-Ofor and Reichmuth, 1999; Obeng- Ofori and Amiteye, 2003).

The importance of integrating several tactics lies in the desire for sustainability or durability of management program (Larry, 2002). It was also reported that integrating one control strategy with another sustainable pest control method would provide long lasting solution to losses in storage for the reason of their synergetic effects (Dobie, 1977). This indicates the need for the development of alternative control options as part of integrated pest management. In view of this background that efforts have been made to move away from reliance on a single control options and instead to adopt an approach termed as Integrated Pest Management (IPM). The importance of combining two or more control options may minimize risk and costs of chemical, reduce resistance development against the treatments and increases effectiveness of the treatments. Based on the above inspiration the present study is initiated with the following objectives: -

OBJECTIVE (S)

-To assess the combined effect of a botanical, Mexican tea (*Chenopodium ambrosoides)* leaf and neem seed powder recommended for use against the maize weevil
- Determine the minimum effective rate(s) of the combinations that can provide adequate protection to maize against the pest.

MATERIALS AND METHODS

Preparation of experimental materials and Establishments of culture of weevils

Maize hybrid BH-540 was obtained from Bako National Maize Research Program and multiplied in the center to obtain the F_2 generation seeds in sufficient amount for the experiments. Mexican tea (*Chenopodium ambrosoides)* was collected from Holetta and Addis Ababa areas along roadside, and neem seed (*Azadrachta Indica*) was obtained from the Worer Research Center. The botanicals were dried under shade, decorticated and ground into fine powder with mortar and pestle. Malathion 5%D was obtained from General Chemical Trading PLC.

Sufficient number of adult *S. zeamais* was reared on F_2 seeds BH540 maize variety following procedure suggested by Strong and Subur (1968) and used by Abraham (1991). Hundred kilograms of the maize variety with moisture content of 12.5-13% were disinfested by putting in deep freezer at -20^{o}c for fortnight. The kernels were divided into two (2 kg each) parts. The kernels were put in three-liter capacity plastic jars and arranged into five replications. Adult weevils that were collected from the farm Bako Agricultural Research Center store were introduced into each replication in the ratio of 1 (weevil): 2-3 gm kernels (600 weevils/ 2 kg maize)) for incubation. Seven days later the adult weevils were sieved and transferred to another disinfested and newly prepared kernels of the same variety. Finally, all of the adult weevils were removed and discarded. The grain was kept for progeny emergence. As soon as the progeny emergence begun, emerged adults were collected on daily basis until sufficient numbers of weevils for the studies were obtained. Those emerged on the same day were transferred to a one-glass jar. So that each jar was containing adults of identical age for the experiments.

Applications of treatments and data collection

The maize experimental kernels were cleaned and disinfested following the same procedure as above. The moisture content of the kernels was adjusted by slow drying under shade or by adding water as recommended by Wright *et al.* (1989). Two hundred gram maize kernels were put in 250 cm^3 capacity glass jars with brass screen lids that permit ventilation. Adult maize weevils were introduced in each jar at the ratio of one weevil to two to three (1:2-3 gm) maize kernels (50 weevils/200 gm maize). Daily temperature and relative humidity of the laboratory were recorded daily. Treatment combinations were applied accordingly and the treatments were arranged in a completely randomized block design (CRD) with three replications. Proportions of neem seed and Mexican tea powder treatments are:-

> **T_1**= 0% NSP(0 gm) NSP+100% MTP(10 gm), **T_2**= 10% NSP (0.4 gm) + 50% MTP (5 gm), **T_3**= 20% NSP (0.8 gm) + 40%MTP (4 gm), **T_4**= 30% NSP (1.2 gm) + 30% MTP (3 gm), **T_5**= 40% NSP (1.6 gm) + 20% MTP (2 gm), **T_6**= 50% NSP (2 gm) + 10%MTP (1 gm), **T_7**= 100% NSP (4 gm) + 0%MTP (0 gm), **T_8**= untreated check and **T_9**= Malathion 5% D (0.1 gm) (standard check). **T**=treatment, NSP=Neem seed powder, MTP=Mexican tea powder

Dead weevils were counted at the 2^{nd}, 4^{th}, 6^{th}, 12^{th}, 24^{th} and 30^{th} days after infestation. At the 30^{th} day, both dead and live weevils were counted and removed and the grains were kept under the same conditions for emergence of F_1 generation. The F_1 progeny weevils were counted and removed each day until emergence was ceased. Data was collected on number of adult weevil mortality, percent grain damaged, number of progeny weevils emerged, number and weight of damaged and undamaged grains. Percentages of seed weight losses were calculated using the count and weigh method (Boxall, 1986).

$$\text{Weight loss (\%)} = \frac{(W_u \times N_d) - (W_d \times N_u)}{W_u (N_d + N_u)} \times 100$$

Where, Wu= weight of undamaged seed, Nu=Number of undamaged seed, Wd= weight of damaged grains, Nd= Number of damaged seed, Seed germination was determined by taking one hundred randomly collected seed from each replication and placing on moist filter paper in a Petri dish for five days. All experimental seeds were re-infested with the same number of weevils after the first data was collected (3 months) to see the persistence of the different treatments used.

STATISTICAL ANALYSIS

All parameters were expressed in percentages except for the number of progeny weevils emerged. Mortality data was corrected before analysis using Abbot's formula,

$$\%CM = \frac{(\%T - \%C)}{(100 - \%C)} \times 100;$$

Where CM corrected mortality, T mortality in treated grain and C mortality in untreated grain (Abbott, 1925**)**. All data were transformed prior to analysis, except for percentages of germinations. Percentages of mortality were transformed by angular (ASIN) transformation and number of progeny weevils emerged, percentage grain damaged and grain weight losses were transformed into square root. Data were subjected to statistical analyses using SAS Version 6.12 computer software. Mean separations were made using Student-Newman-Keuls (SNK) Range Test.

RESULTS

Effect of Neem seed and Mexican tea powder combinations

Combinations of different rates of NSP and MTP showed significant ($p<0.01$) differences between the treatments and the untreated control with respect to adult mortality (Table 1). Significantly higher percentages of mortality were recorded in all of the treatments than that of the untreated check at all days after infestation. The rates of mortality in T_9 and T_1 were significantly ($p<0.01$) higher than the other treatments following four and six days after infestation (Table 1). Similarly, the magnitude of mortality in all treatment combinations ranged from 31-37% and 40-46% following four and six dai, respectively. The rate of mortality was 100% following 12 days of infestation, in all of the treatments except for the untreated control (Table 1).

The number of progeny weevils emerged, percentages of grain damaged and grain weight losses recorded in the different combinations of NSP and MTP were significantly lower ($p<0.01$) than that of the untreated control (Table 2). The differences among the treatment combinations were not significant. The percentage of seed germination

Table 1. Effect of combinations of different rates of NSP and MTP on the weevils mortality.

Neem seed powder (2% w/w) (NSP)	Mexican tea powder (5 % w/w) (MTP)	Percent weevils mortality			
		2 dai	4 dai	6 dai	12 dai
T_1= 0% (0 gm)	+ 100% (10 gm)	22.67(28.26) ± 4.05 ^{ab}	77.33(61.77) ± 4.05 ^{a}	100.00(89.47) ± 0.00 ^{a}	100.00(89.47) ± 0.00 ^{a}
T_2= 10% (0.4 gm)	+ 50% (5 gm)	20.00(26.52) ± 2.00 ^{ab}	37.33(37.66) ± 0.67 ^{b}	42. 67(40.80) ± 1.33 ^{bc}	100.00(89.47) ± 0.00 ^{a}
T_3= 20% (0.8 gm)	+ 40% (4 gm)	16.67(23.98) ± 2.67 ^{b}	36.67(37.28) ± 0.67 ^{b}	46.67(43.10) ± 2.40 ^{b}	100.00(89.47) ± 0.00 ^{a}
T_4= 30% (1.2 gm)	+ 30% (3 gm)	22.00(27.94) ± 2.00 ^{ab}	37.33(37.68) ± 0.67 ^{b}	40.67(39.63) ± 1.33 ^{c}	100.00(89.47) ± 0.00 ^{a}
T_5= 40% (1.6 gm)	+ 20% (2 gm)	22.00(27.97) ± 1.15 ^{ab}	31.33(34.05) ± 1.76 ^{b}	46.67(43.10) ± 1.76 ^{b}	100.00(89.47) ± 0.00 ^{a}
T_6= 50% (2 gm)	+ 10% (1 gm)	23.33(28.86) ± 1.76 ^{a}	32.67(34.86) ± 1.76 ^{b}	44.00(41.56) ± 3.05 ^{bc}	100.00(89.47) ± 0.00 ^{a}
T_7=100% (4 gm)	+ 0% (0 gm)	22.67(28) ± 1.76 ^{ab}	32.67(34.86) ± 1.07 ^{b}	44.00(41.95) ± 0.67 ^{bc}	100.00(89.47) ± 0.00 ^{a}
T_8= untreated check		0.00(0.41) ± 0.00 ^{c}	0.00(0.41) ± 0.00 ^{c}	3.33(10.40) ± 0.67 ^{d}	2.67(9.27) ± 0.67 ^{b}
T_9= Malathion 5% D (standard check) (0.1 gm)		24.00(29.23) ± 3.46 ^{a}	76.00(60.81) ± 3.46 ^{a}	100.00(89.47) ± 0.00 ^{a}	100.00(89.47) ± 0.00 ^{a}
CV %		11.36	6.47	3.51	15.59
Lsd		4.84	4.22	2.96	21.12

Means followed by the same letter within a column are not significantly different from each other at 1% level of probability (Student-Newman-Keul`s Range Test). ***ANOVA*** *was conducted on transformed values.* ***NSP***=*neem seed powder,* ***MTP***= *Mexican tea powder,* ***dai***= *days after infestation. Values in the* ***parenthesis*** *are angular transformed value.* ***CV (%), Lsd*** *and* ***mean separations*** *were calculated from transformed value*.

was significantly ($p<0.01$) lower in the untreated check than in all of the other treatments. The difference among the other treatments was not significant (Table 2).

The differences among different combinations of NSP and MTP were significant with respect to adult weevil mortality (Figure 1). The rates of mortality were significantly higher in all of the treatments than that of the untreated check (T_8) following all of the days after infestation. The amounts of weevil mortality were significantly ($p<0.01$) lower in T_4, T_5, T_6 and NSP (T_7) alone than the other treatment combinations after two, four, six and 12 dai (Fig. 1). However, the percentages of mortality were significantly higher in T_1, T_2, T_3 and T_9 than that of in all of the other treatments following all of the days considered (Figure 1).

The residual effects of NSP and MTP combinations on the numbers of progeny weevils emerged, percentages of damaged grain, grain weight losses and seed germination are shown in Table 3. There were significant differences between the untreated check (T_8) and all of the other treatments (Table 3). The numbers of progeny weevils emerged, percentage of grain damaged and seed weight loss were significantly ($p<0.01$) higher in the untreated check than that of the other treatments (Table 3). The number of progeny weevils emerged, percentages of damaged grain and seed weight losses were significantly lower in T_2 and T_3 than that of the other treatment combinations. The effects of T_2 and T_3 were similar to MTP (T_1) and the synthetic insecticide (T_9) alone. The difference between T_2 and T_3 was not significant (Table 3). The number of progeny weevils emerged and percentages of grain damaged were significantly higher in T_5 and T_6 than that of the other treatment combinations. The percentage of seed germination was significantly ($p<0.01$) lower in the untreated check than that of all of the other treatments (Table 3).

Table 2. Effects of NSP and MTP combinations on progeny weevils emergence, percentages of grain damaged, grain weight losses and seed germination after three months of treatment application and infestation.

Neem seed powder (2% w/w) (NSP)	Mexican tea powder (5 % w/w) (MTP)	Number of progeny weevils emerged	Percent damaged grain	Percent grain weight loss	Percent seed germination
T_1= 0% (0 gm)	+ 100% (10 gm)	0.67(1.08) $\pm$ 0.33 [b]	0.99(1.21) $\pm$ 0.01 [bc]	0.00(0.71) $\pm$ 0.00 [d]	93.00 $\pm$ 0.58 [a]
T_2= 10% (0.4 gm)	+ 50% (5 gm)	1.00(1.22) $\pm$ 0.00 [b]	0.99(1.21) $\pm$ 0.01 [bc]	0.02(0.72) $\pm$ 0.00 [bc]	93.33 $\pm$ 0.67 [a]
T_3= 20% (0.8 gm)	+ 40% (4 gm)	1.00(1.22) $\pm$ 0.00 [b]	1.00(1.22) $\pm$ 0.01 [bc]	0.03(0.73) $\pm$ 0.00 [b]	93.67 $\pm$ 0.33 [a]
T_4= 30% (1.2 gm)	+ 30% (3 gm)	1.33(1.34) $\pm$ 0.33 [b]	1.00(1.22) $\pm$ 0.01 [bc]	0.01(0.72) $\pm$ 0.00 [bc]	92.33 $\pm$ 0.33 [a]
T_5= 40% (1.6 gm)	+ 20% (2 gm)	1.33(1.34) $\pm$ 0.33 [b]	1.02(1.23) $\pm$ 0.04 [bc]	0.01(0.72) $\pm$ 0.00 [bc]	93.67 $\pm$ 0.89 [a]
T_6= 50% (2 gm)	+ 10% (1 gm)	1.33(1.34) $\pm$ 0.33 [b]	0.96(1.21) $\pm$ 0.03 [c]	0.02(0.72) $\pm$ 0.00 [bc]	92.67 $\pm$ 0.89 [a]
T_7=100% (4 gm)	+ 0% (0 gm)	1.33(1.34) $\pm$ 0.33 [b]	1.03(1.23) $\pm$ 0.03 [b]	0.03(0.72) $\pm$ 0.00 [b]	92.00 $\pm$ 0.52 [a]
T_8= untreated check		63.00(7.96) $\pm$ 2.64 [a]	13.39(3.73) $\pm$ 0.07 [a]	1.22(1.31) $\pm$ 0.02 [a]	87.33 $\pm$ 0.89 [b]
T_9= Malathion 5% D (standard check) (0.1 gm)		0.67(1.08) $\pm$ 0.00 [b]	0.98(1.22) $\pm$ 0.00 [bc]	0.00(0.71) $\pm$ 0.00 [d]	92.67 $\pm$ 0.67 [a]
CV %		7.28	1.09	0.64	1.59
Lsd		0.250	0.030	0.009	1.460

Means followed by the same letter within a column are not significantly different from each other at 1% level of probability (Student-Newman-Keul`s Range Test). ***ANOVA*** *was conducted on transformed value. Values in the* **parenthesis** *are angular transformed values.* ***CV (%)***, ***Lsd*** *and mean separations were calculated from transformed value.*

DISCUSSIONS

The importance of exploring the possible joint action of oil and conventional synthetic insecticides in simple mixtures to make them cost effective and attractive has been emphasized (Donpedro, 1989; Abraham, 2003). In the current study, higher mortalities were achieved from all combinations of NSP and MTP treatments, and provided significant protection to maize from the maize weevil for more than three months. Similarly, significant protection from the maize weevil was obtained in all combinations of MTP and NSP following 90 dai. Following 156 dai, MTP at the rates of 40% and 50% combined with the lowest rate of NSP provided significant protection to maize from the maize weevil. The period of protection lasted for about five months at the laboratory conditions. This is inline with the work of Khalequzzaman and Farhan (2003) who reported that mixing oils of different plants and pirimiphos-methyl resulted in complete protection of maize from the maize weevil for more that six months. The rates of mortality increased with time after infestation is also in agreement with Khalequzzaman and Farhan (2003) and Abraham (2003) who reported similar results when lower doses of plant oils combined with synthetic chemical. Combination of treatments against weevils produced an additive effect and reduced the concentrations of the protection materials used, increased the mortality of adult weevils and suppressed progeny emergence of the pest. In addition, the same study also indicated that pirimiphos-methyl and the mixtures remained effective after the treated seeds have been stored for more than 80 days.

Lale and Mustepha (1999) suggested that the integrations of natural plant products from locally available plants for use in storage against *C. maculatus* may lead to the sustainable management of the weevil especially in subsistence agriculture. In this study, combinations of different rates of MTP & NMO and NSP & MTP showed that there is a possibility to enhance their effectiveness and persistence. The mixtures provided complete protection to maize from the weevil. This is probably because

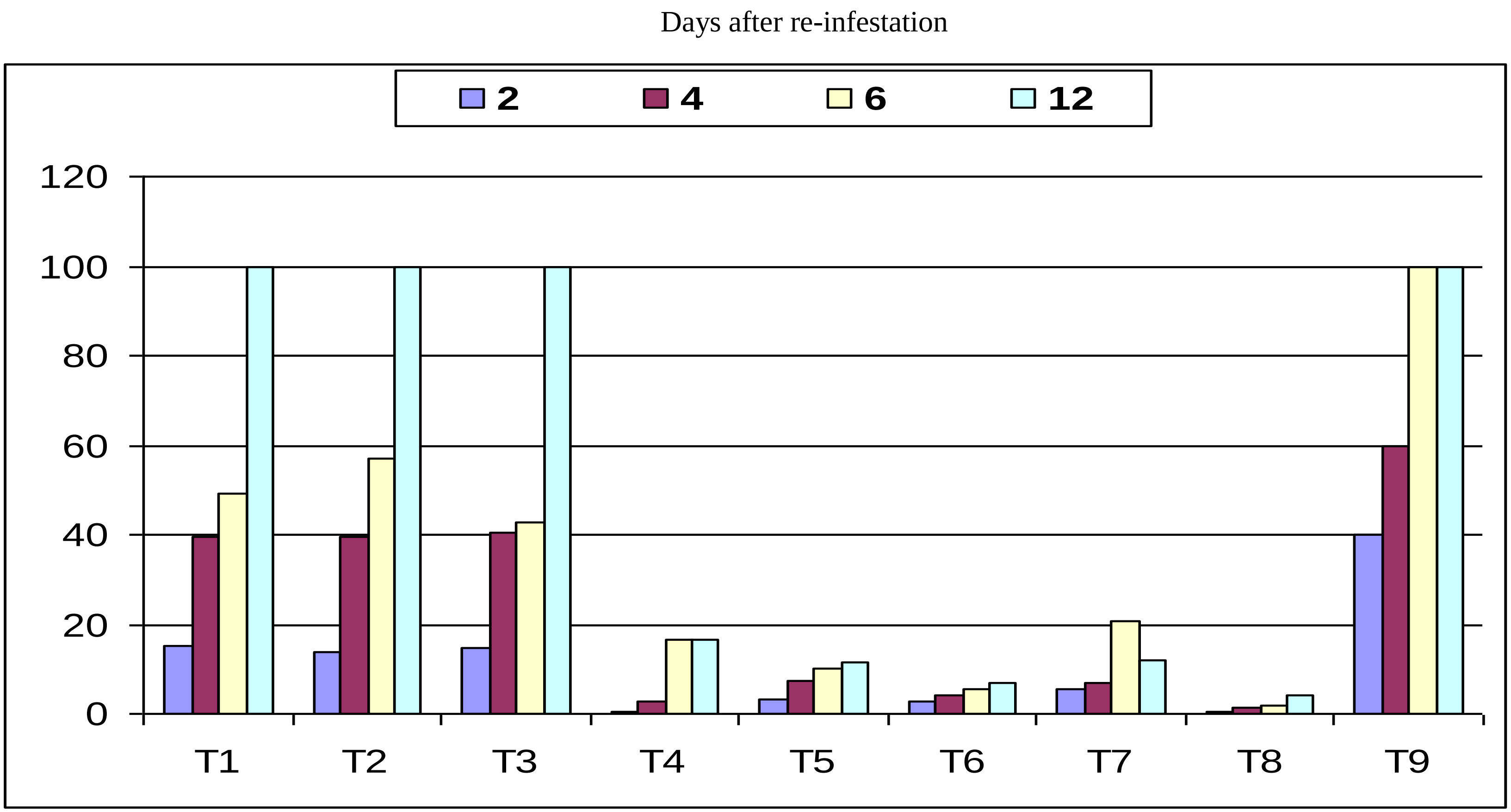

Figure 1. Residual effects of combinations of NSP and MTP on the amount of weevil mortality when grains were re-infested after three months of treatment.

of the mixtures inhibited the development of the eggs, early and late larval stages of *S. zeamais* (Obeng-Ofori, 1995).

Even though the efficacy of most botanicals declined with increased time after treatment, MTP provided longer period of protection similar to malathion indicating that it has longer persistence than the other botanicals studied. Tapondjou *et al.* (2002) pointed out that *Chenopodium ambrosioides* (MTP) is very effective against many stored grain pests and provided adequate protection to maize compared to the synthetic insecticide. Gonzalo *et al.* (2005) also reported that MTP at 1% and 2% (w/w) caused over 90% mortality of the maize weevil and was the best among 22 different botanicals tested at different rates.

Both NSP and MTP are known to have pesticidal effect on the maize weevil (Saxena, *et al*., 1988; Firdisa and Abraham, 1998; Abraham, 1991; 2003). In our study NSP very effective against the weevil for a short time storage (three months). Other workers also indicated that the efficacy of NSP decreased with increased time

Table 3. Residual effects of NSP and MTP combination on progeny emerged, percentages of damaged grain, grain weight losses and seed germination when grains was re-infested after three months of treatment.

Neem seed powder (2% w/w) (NSP)	Mexican tea powder (5 % w/w) (MTP)	Number of progeny weevils emerged 66 dari	Percent grain damaged 156 dai	Percent grain weight loss 156 dai	Percent seed germination 156 dai
T_1= 0% (0 gm)	+ 100% (10 gm)	2.67(1.62) $\pm$ 0.33 ^{de}	1.53(1.23) $\pm$ 0.08 ^{d}	0.07(0.27) $\pm$ 0.01 ^{c}	89.20 $\pm$ 0.58 ^{a}
T_2= 10% (0.4 gm)	+ 50% (5 gm)	3.33(1.82) $\pm$ 0.33 ^{d}	1.81(1.34) $\pm$ 0.01 ^{d}	0.02(0.14) $\pm$ 0.00 ^{d}	90.00 $\pm$ 0.58 ^{a}
T_3= 20% (0.8 gm)	+ 40% (4 gm)	3.00(1.71) $\pm$ 0.57 ^{de}	1.48(1.20) $\pm$ 0.31 ^{d}	0.03(0.17) $\pm$ 0.01 ^{d}	89.33 $\pm$ 0.00 ^{a}
T_4= 30% (1.2 gm)	+ 30% (3 gm)	57.33(7.57) $\pm$ 0.67 ^{c}	10.05(3.17) $\pm$ 0.40 ^{c}	1.47(1.21) $\pm$ 0.01 ^{b}	89.22 $\pm$ 1.20 ^{a}
T_5= 40% (1.6 gm)	+ 20% (2 gm)	79.33(8.90) $\pm$ 0.89 ^{b}	14.18(3.76) $\pm$ 0.17 ^{b}	1.46(1.21) $\pm$ 0.02 ^{b}	89.31 $\pm$ 0.58 ^{a}
T_6= 50% (2 gm)	+ 10% (1 gm)	78.33(8.84) $\pm$ 2.02 ^{b}	14.38(3.79) $\pm$ 0.24 ^{b}	1.47(1.21) $\pm$ 0.10 ^{b}	89.00 $\pm$ 0.58 ^{a}
T_7=100% (4 gm)	+ 0% (0 gm)	78.33(8.84) $\pm$ 2.02 ^{b}	14.12(3.75) $\pm$ 0.11 ^{b}	1.50(1.22) $\pm$ 0.14 ^{b}	90.00 $\pm$ 1.85 ^{a}
T_8= untreated check		126.67(11.25) $\pm$ 1.45 ^{a}	29.36(5.41) $\pm$ 1.03 ^{a}	2.37(1.54) $\pm$ 0.01 ^{a}	60.67 $\pm$ 0.18 ^{b}
T_9= Malathion 5% D (standard check) (0.1 gm)		2.33(1.52) $\pm$ 0.33 ^{e}	1.41(1.18) $\pm$ 0.41 ^{d}	0.05(0.14) $\pm$ 0.00 ^{d}	89.67 $\pm$ 0.33 ^{a}
CV %		2.74	4.01	5.89	2.02
Lsd		0.270	0.190	0.080	1.740

Means followed by the same letter within a column are not significantly different from each other at 1% level of probability (Student-Newman-Keul`s Range Test). ***ANOVA*** *was conducted on transformed values. dari= days after re-infestation, dai=days after infestation. Values in the* ***parentheses*** *are square root transformed values.* ***CV (%), Lsd*** *and* ***mean separations*** *were calculated from transformed value.*

after infestation (Abraham, 2003; Girma, 2006). On the other hand, MTP had longer persistence and protected the grains for long period (more than five months in this study) and similar findings were reported by Abraham, (2003). Combining NSP and MTP caused high level of mortality at all combinations and completely protected the grain from the maize weevil for three months. The study showed that the efficacy and persistence of NSP improved when applied in mixture with MTP

SUMMARY AND CONCLUSION

The study was made to evaluate combined effects of different control options against the maize weevil, to determine the minimum effective rate(s) of the combinations that can provide adequate protection to maize from the maize weevils.

The percentages of damaged grain and grain weight losses were significantly lower in all of the combinations of MTP and NSP than that of the untreated check 90 dai. Following 156 dai, MTP at 40% and 50% combined with NSP at 20% and 10%, respectively, provided significant protection to the maize grain next to the standard check. The period of protections extended to about five months under the conditions of the experiment.

From these studies, it can be concluded that ,all treatment combinations of the experiment can effectively protect maize grain from the maize weevil for at least three months. Combinations of Mexican tea and neem seed powder, at 40%+20% and 50%+10% are used to protect maize from the maize weevil.

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