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Management of tef shoot fly, *Atherigona hyalinipennis* (Reg.) (Diptera: Muscidae) on tef at Ambo, West Showa of Ethiopia

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Tef [*Eragrostis* tef (Zucc.) Trotter: Poaceae] is one of the major cereal crop and stable food crop of Ethiopia where it originated and diversified. Tef shoot fly (*Atherigona hyalinipennis*) is a serious pest of tef grown on black clay soils. Therefore, the present study was taken to assess the status of tef shoot fly on both row planted and broadcasted tef at small-scale farm. The experiment was laid out in randomized complete block design (RCBD) with three replications. Kuncho (Dz-Cr-387) variety was used for the experiment. Six treatments [two botanical extracts (*Nicotiana* sp. and *Azadirachta indica*) and two entomopathogenic fungi, (*Beauveria bassiana* and *Metarhizium anisopliae*) were evaluated against tef shoot flies. The result shows that all the treatments were significant ($P \leq 0.05$) from untreated control. *Nicotiana* sp. exhibited high mortality rate on both broadcast and row planted tef to a level of 80.09 and 82.59%, respectively. However, *A. indica* showed high mortality rate only for tef planted in rows (77.7%). *Metarhizium anisopliae* caused high mortality rate only in tef planted in rows. The highest yield loss (9.03%) was recorded in broadcasted on *M. anisophliae* followed by untreated control and in row planted *B. bassiana* and *M. anisophliae* were estimated as 8.03 and 8.23%, respectively. Hence, all treatments gave promising efficacy percent and can be used for tef shoot fly management under field conditions.

Key words: Botanicals, *Metarhizium anisopliae*, *Beauveria bassiana*, tef shoot fly, management.

INTRODUCTION

Tef [*Eragrostis* tef (Zucc.), Trotter: Poaceae] originated and diversified in Ethiopia. In Ethiopia tef is grown as a staple food crop for centuries. Over 2.8 million hectares of land is covered with tef every year with its mean productivity at national level predicted at 1228 kg ha^{-1} (CSA, 2011). During cropping season, tef occupied 22.6% of the cultivated lands under cereals, while maize occupied 17%, sorghum 15.92%, wheat 11.89% (CSA, 2012).

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Although, tef is annually cultivated in a large area of lands in Ethiopia, it gives relatively low yield compared to the other cereals (CSA, 2010). One of the main reason for the low yield of tef is biotic factors (insects, diseases and unimproved seeds). In addition, inappropriate crop manage-ment practices that mainly include sowing methods, weeding practices, harvesting stage, cropping system, and fertilization contributed for the low productivity of tef in Ethiopia. Tef crop management practices such as tillage and cropping systems were studied and reported in order to develop improved practices for various tef producing regions in Ethiopia (Worku et al., 2005).

Major insect pests recorded on this crop include, *Atherigona hyalinipennis* (tef shoot fly), *Delia arambourgis* (Barley fly), *Decticoides brevipennis* (Wello bush cricket), *Eriangerius niger* (Black tef beetle), *Macrotermes subhyalinus* (Mendi termes), and *Mentaxya ignicollis* (red tef worm). Others such as *Acrotylus spp.*, *Aiolopus longicornis*, *Carbula recurva* and *Odontotermes* sp. also cause damage to tef (HARC, 1989). The species composition of tef shoot fly in Haramaya area includes: *Elachiptera simplicipes* (Becker), *Mlanochaeta vulgaris* (Adams), *Osicinella nartschukiana* (Beschovsky), *O. acuticornis* (Becker) and *Rhopalopterum* sp. in the Chloropidae and *Atherigona hyalinipennis* and *Atherigona* sp. of the family Muscidae (Sileshi, 1994, 1997).

The status of tef shoot fly, *A. hyalinipennis* as a major pest of tef was reported in five regional state of the country (Tadesse, 1987). It caused 4.9 up to 24% yield loss in Tigray Region, East and South West Showa zone (DZARC, 2000; Bayeh et al., 2008) with more than 90% of panicle damage (Sileshi, 1997). Similarly, Bayeh *et al.* (2009) also reported that shoot fly cause serious damage on seedlings and panicle stages of tef.

The control of tef shoot fly using chemical and cultural practices has been attempted earlier to some extent. However, they were not adequate to minimize the density of tef shoot fly and thereby alleviating the yield loss caused by the pest, hence it is necessary to develop Integrated Pest Management (IPM) tactics. Therefore, the present study was designed to evaluate bio-pesticides, and to compare the infestation level of shoot flies on row planting and traditional broadcasting system of tef crop.

MATERIALS AND METHODS

Description of the study area

The experiment was conducted at Ambo district, Boji Gebissa Kebele, West Showa of Ethiopia, during the main cropping season of 2013. The experiment site is located about 116 km West of Addis Ababa at an altitude of 2184 m.a.s.l., latitude of 37° 49'E and longitude of 8° 56'N. The annual mean minimum and maximum temperature is about 15 and 21°C, respectively. The annual rainfall is about 500-900 mm; the soil type is Vertisol and consists of 60%; Clay, 15%, Silt, 20% and Sand 5% (AWAB, 2012). The farming system of the study site is cereal crops dominated.

Crop establishment

A seed of tef, Kuncho variety (DZ-cr-387) was obtained from Ambo District Agricultural Office. Each plot was (3 x 2 m) = 6 m^2 with in row planting (20 cm between row) and broadcast. All necessary agronomic practices and fertilizers applications were carried out.

Experimental design and treatments

The experiment was carried out using randomized complete block design (RCBD) arranged factorially with three replications at farmers' field conditions. Factor "A" (treatments) was in the main plot (Figure 2), while Factor "B" (Row planting/Broadcast) in the sub plot (Figure 1). The treatments were: tobacco leaf and stalk aqueous extract (*Nicotiana spp., local variety),* neem seed powder aqueous extract (*A. indica), Beauveria bassiana (PPRC-6), M. anisopliae (PPRC-56),* Endosulfan 35% E.C and untreated check.

Extraction and preparation of botanicals

Nicotiana sp. (tobacco)

Tobacco leaves and stalks were collected from the gardens of farmers around Ambo areas, Ethiopia. The collected materials were dried under shade, 10.8 g of dried leaves and stalks were crushed and mixed with 0.54 L of water and 10 mg of soap flake was added as adhesive agent (Tadele et al., 2013). The prepared extract was showed in (Figure 5).

Azadirachta indica (neem)

The neem seeds were collected from Melka Werer Agricultural Research Center, Ethiopia. The seeds were ground and then 18 g of neem powder was mixed with 0.72 L of water, and extracted over night (Tadele et al., 2013). The next day, it was filtered with the help of cheese cloth and mixed with liquid soap at the rate of 1 mL/L of extract (Figure 4). Then the solution was ready for spray on infested shoot fly (Stoll, 2000).

Rate of botanicals and chemical used against tef shoot fly

The rate of botanicals *Nicotiana spp.* (local var.) leaves and stalks, *A. indica* (seeds) and Endosulfan 35% EC were 3 and 5 kg and 2 L per hectare and mixed with 150, 200 and 100 L amount of water required per hectare, respectively.

Entomopathogenic fungi (EPF)

Two indigenous EPF viz. *B. bassiana* (PPRC-6) and *M. anisopliae* (PPRC-56) were obtained from Ambo Plant Protection Research Center, Ambo, Ethiopia. Sabouraud Dextrose Yeast Agar (SDYA) media was used for sub-culturing of both EPF. The cultures were incubated at 28°C for 10 days in the dark. On each culture plate,

Figure 1: Row planted tef

Figure 2: Broadcasted tef

spores were harvested by flooding 10 mL of distilled sterilized water and 0.01% Tween 20 on plates. The spore suspensions were again filtered through cheese cloth and diluted (1:10) in sterile water. The suspensions were vortexed for 8 min to avoid clumping of the spores. The conidial concentration of each isolate was adjusted to 1×10^7 conidia/ml using haemocytometers (Seneshew et al., 2003) and then made ready for foliar application by hand sprayers.

Data collection and statistical analysis

Germination and number of tef plants per plot were recorded up to its economic threshold level. The number of dead heart per plot and number of larvae per plant were recorded before and after application.

Yield loss percentage was calculated by comparing the weight of protected grain yield with other treatments.

$$\text{Yield loss (\%)} = \frac{X - Y}{X} \times 100$$

Where, X = Mean grain yield of treated plot; Y = Mean grain yield of untreated plot.

Data were analyzed using Statistically Analysis Software (SAS, 2000). The mean comparisons were carried out using Duncan's Multiple Range Test (DMRT). Efficacy data was analysed after being transformation to arcsine (Gomez, 1984).

RESULTS AND DISCUSSION

Effects of botanicals on shoot fly in broadcasted tef field

The effect of botanicals on tef shoot flies population in the broadcasting plots is given in Table 1. The infestation was high with increasing trend of damage on the crop during mid September to early October. Non significant differences were observed between both treatments and the three and ten days after application a percent mortality of tef shoot flies. All treatments were significantly ($P\leq0.05$) different from the untreated control. The rate of mortality in all of the treatments were recorded within three and ten days after application ranged from 0.01 - 85.89%. The plot which was treated with *Nicotiana* sp. (leaf and stalk) showed significantly high mortality rate (80.09%). Tobacco extract provided the best control of tef shoot flies than the plots treated with *A. indica*. The better treatment effect was recorded within three days after application and the analysis of variance also indicated significant ($p\leq0.05$) differences from that of untreated control. Similarly, Tadele et al. (2013) reported that the tobacco aqua extract solutioncontrolled onion thrips which reduces the population number of nymph and adults stage after three days of application.

Effects of entomopathogenic fungi on shoot fly in broadcasted tef field

The data presented in Table 1 shows that *B. bassiana* and *M. anisopilae* caused 77.92% and 67.56% mortality on tef shoot flies after ten days applications, respectively. It was observed that the effect of *B. bassiana* on the mortality rate of tef shoot flies within ten days after application was significantly higher when compared with that of the treatment of *M. anisopilae*. Three days after application of treatments, entomopathogenic fungi and untreated control showed no significant differences. The effectiveness of both treatments were recorded within ten days after application and indicated significant ($p\leq0.05$) differences from that of the untreated.

Daglish (1998) reported that the efficacy of *B. bassiana* against the larvae, pupae, and adult females of the Mexican fruit fly, *Anastrepha ludens* (Loew) showed high levels of mortality for adult flies. Some of the major economic insect pests are susceptible to this fungus (Tanada and Kaya, 1993).

Effects of botanicals on shoot fly in row planted

The effect of botanicals on tef shoot flies populations that were planted in rows showed that the infestation level was low when compared with broadcasting method. The damage on the crop during mid September to early October was very low. All the treatments gave significant (P≤0.05) differences when compared with untreated plots. Both exhibited no significant difference between the two treatments and three and ten days after application and percent of mortality tef shoot flies. The rates of mortality in all of the treatments were recorded three and ten days after application which ranged from 0.01 - 83.86%. The highest mortality rate of tef shoot flies three days after application in the plots treated with *Nicotiana* spp. (leaf and stalk) and *A. indica* (seed) were 82.59 and 77.71%, respectively.

The effect of *Nicotiana* spp. and *A. indica* on tef shoot flies population were significantly increased three and ten days after application when compared to untreated plots and the analysis of variance indicated significant (p≤0.05) differences from untreated control. Singh and Batra (2001) studied the bio-efficacy of different neem formulations along with recommended insecticide endosulfan in forage sorghum against shoot fly. Rao and Panwar (1992) reported that the efficacy of neem reduced the infestation level of shoot fly, *A. socata* and *A. naquii* in maize. Juneja et al. (2004) reported that neem seed kernel suspension were the most effective in the reduction of shoot fly (*A. approximate*) infestation.

Effects of entomopathogenic fungi on shoot fly in row planted

The data presented in Table 1 shows that *B. bassiana* and *M. anisophliae* caused 70.85 and 63.45% mortality of tef shoot flies after ten days application, respectively. The results show that the mortality rate of tef shoot flies, *B. bassiana* and *M. anisophliae* was significantly (p≤0.05) different from the untreated control. After three day application of treatments, entomopathogenic fungi and untreated control had no significant difference. The result was confirmed with the previous work of Booth and Shank (1998) that found that the *M. anisopliae* was extensively used for the biological control of insect pests and various other soil borne *Popillia japonica* was controlled by using *B. bassiana* and *M. anisopliae*.

In experimental field condition, there was no side effect due to the application of botanicals and entomopathogenic fungi on the crop. The treated crops were not different in appearance and growth performance from that of standard check on both row planted and broadcasted tef.

Effects of botanicals and entomopathogenic fungi on yield

Broadcasting methods

The tef crops were harvested on November, 2013, threshed and the yield was measured and presented in Table 2. The treatments included *Nicotiana* sp., *A. indica* and *B. bassiana*; recorded statistically no significant differences on yield. There was significant increase in tef yield in the plots treated with *Nicotiana spp.* (local var.) when compared to untreated control.

The highest yield loss presented in the Table 2 on the treatment of *M. anisophliae* was estimated as 9.03% followed by untreated control (17.13%). This showed that the yield loss due to tef shoot fly infestation was high and significantly (P≤0.05) different among the treatments. The tef yield loss due to tef shoot fly in different areas of the country varies depending on certain environmental condition. In East and South West Shewa Zones was less than 5%. Similarly, in Gojam area tef shoot fly did not cause yield losses (AARC, 2002). On the other hand, in Tigray Region where precipitation is low and the soil was degraded (Tesfaye and Zenebe, 1998), the tef shoot fly population that built- up on sorghum might have caused several damage (378 to 522 kg ha^{-1}) (Sileshi, 1997).

Row planting methods

Nicotiana spp., A. indicia and *B. bassiana* showed a non significant difference. There were an increased tef yields in those treated with *Nicotiana spp.* (local Var.) when compared to untreated plot. Row planted tef produced higher and stronger tiller, and increased number of seeds /panicle.

The losses of tef yield presented in Table 2 shows that tef yield loss attributed to tef shoot fly infestation (Figure 3). Treatments *B. bassiana* and *M. anisopliae* showed no significant differences. The highest yield loss recorded from the treatments of *B. bassiana* and *M. anisopliae* was estimated as 8.03 and 8.23% compared to the untreated control. This shows that the yield losses due to tef shoot fly infestation was very high and significantly (P≤0.05) different among the treatment. Row planted tef yield losses due to tef shoot fly infestation was low compared

Table 1. Percent mortality of tef shoot flies under field condition in planted tef at Ambo, West Shawa Ethiopia in 2013/14.

Treatment	Days after treatment application a percent mortality of tef shoot flies			
	Broadcasted tef		Row planted tef	
	3rd day	10th day	3rd day	10th day
Nicotiana spp. (local var.)	95.58(80.09±1.39)[ab]	95.58(80.09±1.39)[ab]	95.24(82.59±1.44)[a]	95.24(82.59±1.44)[a]
Azadirachta indica (seed)	89.66(71.35±1.25)[b]	89.66(71.35±1.25)[b]	93.33(77.71±1.36)[a]	93.33(77.71±1.36)[a]
Beauveria bassiana	0(0.01±0)[c]	93.52(77.92±1.36)[ab]	0(0.01±0)[b]	88.68(70.85±1.23)[ab]
Metarhizium anisophliae	0(0.01±0)[c]	85.25(67.56±1.18)[b]	0(0.01±0)[b]	77.66(63.45±1.08)[b]
Endosulfan 35% EC	98.49(85.89±1.49)[a]	98.49(85.90±1.49)[a]	96.67(83.86±1.46)[a]	96.67(83.86±1.46)[a]
Control (untreated)	0(0.01±0)[c]	0(0.01±0)[c]	0(0.01±0)[b]	0(0.01±0)[c]
MSE	5.14	6.66	6.98	7.40
CV (%)	12.99	10.44	16.98	11.80

Means with the same letter are not significantly different (P≤0.05), and Figures in the brackets are Arcsin $\sqrt{percent}$ transformation value.

Table 2. Mean yield and yield loss of tef against tef shoot flies on broadcasted and row planted of tef at Ambo, 2013 /14.

Treatments	Broadcasted tef		Row planted tef	
	Mean yield/Plot (kg)	Percentage yield loss (%)	Mean yield/plot (kg)	Percentage yield loss (%)
Nicotiana spp.(loca var)	1.25[ab]	3.73[d]	1.62[ab]	3.30[d]
Azadirachta indica	1.23[bc]	7.83[bc]	1.55[bc]	7.07[c]
Beauveria bassiana	1.09[bcd]	7.03[c]	1.57[bc]	8.03[b]
Metarhizium anisophliae	1.05[cd]	9.03[b]	1.53[c]	8.23[b]
Endosulfan 35% EC	1.42[a]	0.83[e]	1.67[a]	0.74[d]
Control (untreated)	0.91[d]	17.13[a]	1.40[d]	12.67[a]
MSE	0.09	0.82	0.04	0.46
CV (%)	8.6	10.82.82	2.56	6.87

Means with the same letter are not significantly different (p≤0.05).

Figure 3: Tef infected by tef shoot fly

Figure 4: Neem seeds extract

Figure 5: Tobacco leave and stalk extract

to broadcasted tef (Table 2). The yield loss ranged from 0 to 12.67% during the study period.

Conflict of Interests

The author(s) have not declared any conflict of interests.

CONCLUSIONS AND RECOMENDATION

Botanical and entomopathogenic fungi were effective to reduce tef shoot flies population infesting tef crops. Among tested botanicals, *Nicotiana spp.* (local var.) was effective in reducing population of tef shoot flies after application of three days. Entomopathogenic fungi *B. bassiana* (PPRC-6) was effective in reducing tef shoot flies population after application of ten days in both tef sowing methods. Hence, use of this technology (botanicals and entomopathogenic fungi) can play a vital role in reducing tef shoot flies under field conditions.

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