Efficacy and mode of application of indigenous local *Beauveria bassiana* isolates in the control of the tea weevil compared to Karate

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ABSTRACT

The tea crop in Kenya ubiquitously is exposed to biotic and abiotic stresses which can be devastating. These include damage by five species tea weevils. Tea weevils reported to occur in Kenya include, the tea root weevil (*Aperitmetus brunneus*) (Hust), Nematocerus weevil (*Nematocerus sulcalus*), Systates weevil (*Systates* sp.), Kangaita/Kimari Weevil (*Entypotrachelus meyeri*) (micans/Kolbe) and Nyambene weevils (*Sprigodes mixtus*), among others. Adult weevils damage tea by defoliating nursery as well as newly established and mature tea orchard. Kimari/Kangaita weevils are documented to occur throughout the tea growing areas of Kenya. Occasional isolated epidemic outbreaks occur causing variable level of damage by defoliating mature tea bushes. Studies were conducted to determine the efficacy of two *Beauveria bassiana* isolate compared with a pesticide, Karate, which contains lambdacyholothrin as the active ingredient, in two different major tea weevils occurring geographic regions namely; i) Kenya Tea Development Agency (KTDA) Igembe Factory catchment, Giciaro Tea Farm of Meru District, and ii) KTDA Mununga Factory catchment in Kirinyaga County, Njogu Kiruki's farm. In Njogu Kiruki's farm, the fields were laid out in a random complete block design with three replicates. The treatments were of two efficacious locally isolated *B. bassiana* isolates at a rate of 1×10^{13} conidia/ha (in 200L of water) applied with two mode of application; a solid state fermented mixture in wheat bran and broadcasted on trash and a spores liquid formulation sprayed on foliage. Karate was sprayed on trash and the control was the formulation used for spraying fungus that contained no *B. bassiana* propagules. The effects of the treatments on made tea yields, weevil damage, canopy formation and light interception were determined. The results show that there is a significant difference of the treatments on weevil damage on tea. The isolates in both mode of application performance were comparable to that of Karate which killed the weevils at the rate of .2L/ha in 200L of water. This study suggest the possibilities of the use of *B. bassiana* isolates to control tea weevils at the rate of 1×10^{13} conidia/ha.

Key words: *Beauveria bassiana,* **Indigenous, Isolates, Karate, Tea weevil**

INTRODUCTION

Besides the favourable environmental conditions prevalent in the tea growing zones of Kenya, successful tea cultivation has largely been attributed to focused research and development through adequate funding of commodity specific Tea Research Foundation and statutory marketing through auctions since 1920. However, owing to global climatic changes and nonadherence to good agricultural practices, the crop has become exposed to biotic and abiotic stresses. The devastating biotic stresses include damage by tea mites (red crevice mites, red spider mites and purple mites), scale insects (*Aspidiotus* sp., green soft scales and brown scales), weevils (Systates weevils, tea root weevils, *E. meyeri*), tea thrips (*Scirtothrips kenyensis*), termites, tea mosquito bug (*Helopeltis* sp.), tea crickets and chafer grubs, among others arthropods (Anon, 2004). The two main diseases include one major wood rot (*Hypoxylon serpens*) and a sporadic root rot caused by *Armillaria* spp. of fungi. The most prevalent weeds are grass weeds such as couch grass (*Penisetum* sp.) and *Cynodon dactylon* (Anon, 2004). Arthropods appear to be the main determinants of reduced tea yields.

LITERATURE REVIEW

Tea weevils comprise about 27 species (Benjamin, 1968). Tea weevils reported to occur in Kenya include, the tea root weevil (*A. brunneus*) [hust], Nematocerus weevil (*Nematocerus sulcalus*), Systates weevil (*Systates* sp.), Kangaita/Kimari weevil (*E. meyeri*) [micans/kolbe] and Nyambene weevil (*Sprigodes mixtus*) (Anon, 2006). Adult weevils damage tea by defoliating nursery, newly established and mature tea orchards (Benjamin and Demba, 1968; Muraleedharan and Chen, 1997). Kimari/Kangaita weevils are documented to occur throughout the tea growing areas of Kenya. Occasional epidemicisolated outbreaks occur causing variable level of damage (Sudoi *et al.,* 1999). Weevils are polyphagus and feed on over 14 plant families (Benjamin *et al.,* 1968) crossing commodity groups making the weevil a high risk pest (Mannion, 2003). Presently, the management strategies against tea weevils include cultural practices and spraying with an insecticide known as Karate, a synthetic pyrethroid which contains lambdacyhalothrin as the active ingredient. Hand picking is applied where the weevil population is low (Anon, 1986). Biological control may offer better potential against the tea weevils (Sudoi *et al.,* (1999) isolated entomopathogenic fungus, *Hirsutella* spp. which gave high mortality rate on Kangaita weevil. Preliminary investigation at Tea Research Foundation of Kenya (TRFK) has indicated that locally isolated *B. bassiana* using *Galleria* larva moth as an indicator showed good prospects in the control of the Kangaita tea weevil (*E. meyeri*) and the tobacco cricket (Anon, 2001; Anon, 2003; Anon, 2006).

Enthomopathogenic fungi have been used successfully elsewhere to control several pests in plantations such as the brown leafhopper on rice (Agunda *et al.*, 1988), *Leucenia psylid* on leucaenia (Ahmad, 1993) and banana root weevil (Mesquita, 1988; Muraleedharan *et al.*, 1997). *B. bassiana* is a fungus that is found naturally in soils throughout the world and acts as a parasite on various insect species, causing white muscardine disease. *B. bassiana* strains and races have successfully been used to control several pests such as Tobacco spider mites (*Tetranychus evensi*) and Pritchard (*Acinina tetraychidae)* infesting tomatoes (Wekesa, 2006). Botanigard, an imported formulation of *B. bassiana,* is being used commercially in Kenya as a biological insecticide to control a number of sucking insects including thrips, aphids and whiteflies on French beans and snow peas (PCPB, 2011). This fungus has shown success also in management of diamond back moth *Plutella xylostella* (Vandenberg, *et al.*, 1998) and potato beetle *Leptimotarsa decemlinaeta* (Wraight *et al.*, 2002). Trudel (2006) suggests that *B. bassiana* had a potential to persist in the environment and for horizontal transmission between weevils if used. He proposes more investigations on its ability to control populations of white pine weevil *Pissodes strobi*. *B. bassiana* has proved to be competitive with chemical insecticides for protection of forests and farms against pests (Sevim *et al.,* 2013). However, no proven documented report has been published on the fungus potential in the control of the tea weevils using different modes of application in Kenya. Therefore, the objectives of this study was to assess the efficacy and mode of application two indigenous *B. bassiana* isolates in control of the tea weevils compared to a conventional insecticide.

MATERIALS AND METHODS

Experimental sites

This study to determine field efficacy of *B. bassiana* on tea weevils in Eastern tea growing region of Kenya was conducted from June 2012 to November 2013 in two different major tea weevils occurring geographic regions:

i. KTDA, Igembe Factory catchment, Giciaro Tea Farm of Meru District at an altitude of 1650 m.a.s.l. and coordinates at Latitude $0^0$08'S, Longitude 37^0 54'E. Giciaro Tea Farm is located in Igembe sub-location, North Meru location of Meru County and about 18 km west of Maua Town. Giciaro Tea Farm is planted with a pure clone of TRFK 31/8.

ii. KTDA Mununga Factory catchment, Mr. Njogu Kiruki's farm, in Kirinyaga County at an altitude of 1784 m.a.s.l. and coordinates at Lat. 0027'S, Long.370 13'E. The farm is located in Kaguyu Sub-location, Mutira Location of Kirinyaga Central District about 1½ km from Mununga KTDA Tea Factory. The farm (Mr. Kiruki's) is planted with about 3,398 tea bushes of mixed clones. The farmers were previously having coffee plantation before tea establishment in years 1994 and 2003 respectively.

The soils in the two areas consist of well-drained, deep reddish brown to dark red friable clay with acidic humic top soil (humic nitosol) and a pH range of 4.4 – 5.6 (Siderius and Muchema, 1977, Jaetzold *et al.,* 2007). The mean maximum and minimum temperatures are 23 ^oC and 13^oC respectively. They receive an average rainfall of about and above 1000 mm per year. The rainfall is bimodal and long rains are received between October and December while the short rains fall between March and June.

Experimental design and treatments

Two sets of experiments were set up in each site. Each set starting June 2012 and September 2012 respectively. The tea fields in Giciaro Farm Igembe that hosted the tea fields comprised of mature tea bushes of clone TRFK 31/8, which were established in 2003 with a spacing of 4 x 2 ft. Mr. Kiruki's farm comprised of mature tea bushes of mixed clones of TRFK 6/8, PMC 51 and TRFK 31/8 which were planted with a spacing of 5 x 2½ft. Field efficacy of the isolates against the tea weevil was evaluated using three replicates in a randomized complete block design. Each replicate consisted of five plots associated with treatments and one control. Each plot consisted of at least 20 bushes and surrounded by two rows of tea bushes as buffer zone; The treatments were of two efficacious *B. bassiana* isolates at a rate of 1×10^{13} conidia/ha (either applied with wheat bran on trash or sprayed on foliage) vis-à-vis isolates Bb7a and 6a which were originally isolated locally in early 2012 (Cheramgoi *et al.*, 2013) and maintained in TRFK laboratory, Karate, a synthetic pyrethriod which contains lambdacyhalothrin 25% EC as the active ingredient was sprayed on trash and a control which was the formulation that contain no *B. bassiana.*

NPK fertilizer application was done twice in a year at a rate of 100N/ha/year. Plucking rounds were between 9 and 12 days. The fields were maintained weed free for the duration of the study by manual removal (either hand hoeing or hand manual removal). Pruning time was done as per KTDA schedule, which takes place normally in July of the pruning year, with either three or four pruning year cycle. Giciaro tea field for the first setup of experiments (starting July 2012) was pruned in July 2011 and later in July 2013 while the second experiment (starting September 2012) was pruned in July 2012. In Mununga field trial area which started in July 2012, pruning was done in July 2010 before setting up the experiment while Mununga second trial tea field was pruned in July 2011 and all the neighbouring, surrounding tea bushes area was pruned in July 2013. NPK fertilizer application was done twice in a year at a rate of 100N/ha/year and plucking rounds were between seven and ten days in Munuga and weeding was manually done.

Formulation and fungi applications for spraying

Beauveria bassiana isolates were applied using a modified formulation basing on modified version as in Burges (1998) review. The *B. bassiana* formulation was made up of 1% skimmed milk, 2% glycerol, 4% corn oil and 5% clay (diatomous earth, known as Kaolin). Oil was used because it is an excellent adhesive, promoting contact between the active ingredient (the conidia) and the lipophilic insect cuticle while also increasing the conidia's rain-fastness on the waxy leaf surface of treated host plants (Burges, 1998). Clay was added to protect conidia against UV light (Butt, 2002). Glycerol was included due to its role as nutrient, as humectant, nutrient and adhesive; whereas skimmed milk acted as nutrient and humectant as well (Burges, 1998). For each treatment, water containing the required concentration of conidia was added to the final formulation. Long-term effects of the formulation ingredients on the viability and virulence of the *B. bassiana* are unknown, so the final mixing of the formulation was conducted immediately prior to application, as recommended by Goettel *et al.* (2002). All treatments were applied at intervals of once every month. The foliar sprays were applied taking care to thoroughly wet both sides of the foliage. A knapsack sprayer was used at a constant pressure of 40 psi and a low volume flow rate of 200l/ha.

Formulation and fungi applications with wheat bran

The fungal isolate was first cultured on Potato Dextrose Agar (PDA) at 25°C for ten days and stored at 4°C until use. In preparation of the seeding inoculums, aerial conidia taken from a stock culture growing on a PDA agar plate was suspended in sterile water. The number of conidia in the suspension was counted using a haemocytometer, followed by dilution to 1.0×10^8 conidia/ml. One ml of the conidium suspension was inoculated into a 250 ml Erlenmeyer flask containing 100 ml of liquid media, followed by culturing at 25 ± 0.1°C using a rotary shaking incubator operated at 200 rpm. The resulting suspension was then used as the seeding inoculum for solid-state fermentation (SSF) for aerial conidia production

In preparation of SSF, moistened wheat bran medium was transferred into a container and autoclaved at 121°C for 25 minutes. The container with moistened solid media was then cooled, after which the seeding culture was added at 10% inoculum size (10^7 conidia/g wet medium) to each container, followed by thorough mixing using a sterilized spoon. The specimens were then incubated at room temperature and relative humidity for a period of 60 days from where it was removed mixed and broadcasted in to the fields. All the treatment applications were done once every month.

Influence of rainfall and temperature on weevil attack in the field

Records of prevailing weather in the field were taken at both Mununga KTDA factory (near Mr. Kiruki's Farm and with similar climatic conditions) and at Igembe KTDA Tea Factory (with similar weather conditions as Giciaro Farm) throughout the experiment period in order to relate to the weevil incidences. The rainfall was recorded daily using a rain gauge and monthly means determined. The temperature recording was done by use of minimum and maximum thermometer and monthly means calculated. Weevil incidences determination was done by counting the number of weevils in the control plots and relating to the damage scores. To determine the influence of seasonal variation on the weevil abundance and distribution, records of prevailing weather conditions were recorded in order to relate to the records on damage score which was used to give an indication of weevils incidences throughout the period.

Data on damage score, Photosynthetically Active Radiation intercepted by the plant canopy, ground cover and harvestable fresh green weight were collected in the field experiments.

Damage score

The damage score assessment was made every once every month from the initiation of the experiment until the end of the trials. A score scale ranging from of 1 to 4 was used; where 1 represented damage from 0% to 25%, 2 represent damage from 26% to 50%, 3 was within the range of 51% and 75% damage level, and 4 was within the range of 76% and 100% damage (Weigand and Bishara, 1991). Damage score was done on mature leaves and on fresh pluckable shoots separately and was conducted in a randomly selected area using a grid of 40 x 40 cm.

Ground cover

Ground cover (GC) was measured by placing a 1.2 x 0.8 m, grid with squares of 0.0036 m^2 just above each of three randomly selected plants' canopy and the cover in each square assessed from directly above. Following the method used by Burgess (1992), squares was recorded as fully covered (>75%), half covered (25%-75%) or empty (<25% cover). The GC was expressed as the product of the total number of squares counted and multiplied by 0.0036 m^2 to get canopy cover area.

Photosynthetic active radiation intercepted by plant canopy

Photosynthetically active radiation (PAR) intercepted by the plant canopy was determined using tube solarimeter. Readings were taken between 1200 and 1300 every month starting two weeks after treatment. By holding the solarimeter horizontally, incident PAR reading was taken above plant canopy. Then by holding the solarimeter perpendicular to the tea bushes, rows an average of ten readings were taken below the plant canopy of ten randomly sampled plants. The difference between the PAR above plant canopy and that below was taken as the amount of solar radiation intercepted by plant canopy. This was expressed as a percentage fraction (F) of radiation above and calculated using the formula below (squire, 1990).

$$\%F = \frac{\text{Above canopy Average PAR} - \text{Below canopy Average PAR} \times 100}{\text{Above canopy average PAR}}$$

This parameter was essential since defoliation by weevil ultimately tampers photosynthetic capacities of tea.

YIELD DATA

The yield was determined in the experimental plots by regular conventional plucking of two leaves and a bud every 10 to 14 days. Yield of green leaf was converted to kilograms of made tea per hectare (mt/ha) by multiplying by a standard factor of 0.225. To determine if there is seasonal variation on weevil effect, cumulative yield (mt/ha) per season and for the whole trial period was determined.

Data damage score, percentage damage, PAR and yield were subjected to analysis of variance using SAS, version 9.0. Treatment means were separated using Duncan's multiple range tests at $P \leq 0.05$.

RESULTS

Effect of tea weevils on productivity of tea when treated with *B. bassiana* isolates compared with Karate is a discussed below.

Giciaro site

The weevil species found to be occurring in Giciaro area were predominantly the *S. mixtus* (Nyambene weevils) and their infestation was sporadic, that is, one field may be infested heavily while a neighbouring field with the same clone was not. In the July 2012 to July 2013 Giciaro trial (Trial One), the treatments had a significant ($P < 0.01$) effect on average monthly tea yield. The average monthly yield of tea at Giciaro tea field was significantly higher in all the plots treated with *B. Bassiana* Isolates compared with plots treated with Karate and the control (30% higher). Similarly, mean monthly damage scores on pluckable leaves varied significantly ($P \leq 0.0075$) between treatments. Plots treated with Karate, Isolates Bb 6 and Isolates Bb7 had lower damage score compared with the control plots. Percentages of damaged leaves varied significantly ($P \leq 0.05$) between treatments. Percentage pluckable damaged leaves on plots sprayed with Karate, and the two isolates were similar and had lower number of damaged leaves compared to the control. Similar trends are portrayed by the canopy cover data and mature leaves damage score and damage percentage (Table 1).

Table 1: Effect of Nyambene weevil on productivity of tea when treated with *B. bassiana* and Lambdacyhalothrin in Giciaro Farm (Trial 1).

Treatments	Yield Mt/kg	Canopy cm^2	Damage score Pluckable	Damage score mature	% damage pluckable	% damage mature
Isolate 7 spray	292.24a	7073.2b	1.15b	1.15ba	16.40b	20.62b
Isolate 7 in wheat Bran	290.82a	7134.6b	1.15b	1.17ab	22.38ab	24.35ab
Isolate 6 spray	281.32a	7699.4a	1.16b	1.20ba	17.50b	24.32ab
Isolate in wheat bran	265.66ab	8175.8a	1.3a	1.18ba	17.7b	22.78b
Karate	228.95b	7489.8ab	1.11b	1.09b	16.05b	19.67b
Control	224.46b	6223.9c	1.4a	1.3a	28.31a	29.83a
P value	0.0049	0.0001	0.0075	0.327	0.02	0.06
% CV	35.40	22.27	23.25	26.12	71.52%	51.21
LSD	45.39	789	0.16	0.18	8.06	6.90

Means in a column followed by the same letter are not significantly different at $P < 0.05$, from each other according to Duncan's Multiple Range Test.

Except for the canopy changes, all the other parameters recorded did not show any significant variance between treatments for Trial Two (September 2012 to September 2013) in Giciaro. Percentage damage was very low through this second trial, below 18% on mature leaves and below 13% on the pluckable leaves. The canopy cover data portrays that only the plots sprayed with *B. bassiana* Isolate 7 had significantly higher canopy cover compared to the control and the other treatments (Table 2) meaning that isolates protected tea leaves.

Table 2: Effect of Nyambene weevil on productivity of tea when treated with *B. bassiana* and lambdacyhalothrin in Giciaro Farm Trial 2 (September 2012 to 2013).

Treat	Yield Mt/kg	Canopy cm^2	Damage score Pluckable	Damage score mature	% damage pluckable	% damage mature
Isolate 7 spray	104.25	5092a	1	1	9.78	13.63
Isolate 7 in wheat bran	94.08	4286b	1.04	1	9.52	13.41
Isolate 6 spray	94.21	4566.2b	1	1	11.18	13.85
Isolate 7 in wheat bran	109.33	4148b	1	1	13.67	16.56
Karate	82.33	4236.6b	1	1	11.67	16.56
Control	120.50	3952b	1	1	10.56	18.63
P value	0.50	0.04	0.42	0		
% CV	78.72	32.18	7.8	0	83.61	64.09
LSD	NS	718.6	NS	NS	NS	NS

Mununga site

The treatments had a significant effect (*P* < 0.0004) on mean monthly tea yield (kg mt/ha). Mean monthly tea yields on plots treated with spray of spores of Isolates 6 and Isolates 7 were significantly (*P* ≤ 0.05) higher up to 18% more compared with the control and Isolate 6 applied in wheat bran, although Isolate 6 in both mode of application performed better than the control, likewise Karate did not vary significantly with the isolates treatments. Canopy cover varied significant among the treatments. The treatments had no significant (*P* ≤ 0.05) effect on Photosynthetic Active Radiation (PAR). Damage score on leaves varied significantly with the different treatments (*P* ≤ 0.0001) in Mununga Trial One. Plots treated with sprays of isolates Bb 6, Bb7 and Karate had lower damage score compared with plots treated with the same isolates in wheat bran (WB) substrate and the control (Table 3). Percentage damaged leaves varied significantly with the different treatments (*P* ≤ 0.016). Percentages of both pluckable and mature damaged leaves on plots treated with Karate, both mode of application of Isolates 6 and Isolate 7 were significantly (*P* ≤ 0.05) lower compared with the control (Table 3).

Table 3: Effect of tea weevils on productivity of tea when treated with *B. bassiana* and lambdacyhalothrin per month at Mununga (July 2012 to September 2013 Trial).

Treatment	Yield kg mt/ha	Canopy	PAR	Damage rate pluckable	Mature damage rate	% pluckable damage	% mature damage
Isolate 7 spray	250.86a	151142.5b	30.25ab	1.3d	1.42b	47.37b	52.69b
Isolate 7 in wheat bran	244.598a	14548.7b	30.23ab	1.6b	1.60b	50.08b	51.54b
Karate	240.546ab	16964.0a	30.52a	1.41cd	1.44b	48.24b	51.68b
Isolate 6 spray	238.429ab	14957.3b	30.12ab	1.42cd	1.44b	46.74b	53.477b
Isolate 6 in wheat bran	224.052bc	12595.0c	30.34ab	1.58bc	1.58b	50.11b	53.97b
Control	211.876c	16359a	29.25b	2.2a	2.13b	53.94a	57.67a
P value	<.0004	<.0001	0.4557	<.0001	<.0001	0.0016	0.0008
% CV	19.63	15.76	10.28	26.45	29.22	18.30	14.02
LSD (*P* < .05)	18.54	955.98	ns	0.168	0.19	3.634	3.01

Similarly, in the 2nd trial in Mununga, the treatments had a significant (*P* < .0001) effect on average monthly yield (kg mt/ha), canopy cover, photosynthetic active radiation (PAR) and damages on mature and pluckable leaves. The mean yield on plots treated with Karate was significantly higher than the others. All the isolates except (Isolate 6 when sprayed) did not vary significantly among each other. Mean yield of the plots sprayed with Isolate 6 did not vary significantly with the control. Canopy cover indicates that Karate was more superior although the other treatments performed better than the control. Karate and all isolates treated plots intercept more light compared to the control. Isolate 7 (in both applications) showed the lowest damages on pluckable leaves (Table 4).

Table 4: Effect of Tea Weevils species on productivity of tea when treated with *B. bassiana* and lambdacyhalothrin in Mununga Trial Two from September 2012 to August 2013.

Treatment	Yield kg mt/ha	Canopy	PAR	Damage Score on pluckable leaves	Damage Score on mature leaves	% pluckable damage	% mature damage
Karate	366.37a	16898.4a	25.19a	1.2cd	1.17bc	47.5a	53.52bc
Isolate 6 in WB	327.25b	16229.1ab	25.36a	1.17bc	1.23b	48.72a	56ab
Isolate 7 spray	319.87b	14666.0ab	25.14a	1d	1.18b	50.14a	53.64bc
Isolate 7 in WB	310.64b	15329.9ab	25.17a	1d	1.31b	48.79a	57.6a
Control	261.21c	15615.5ab	23.69b	1.55a	1.55a	49.67a	53.81bc
Isolate 6 spray	247.63c	11892.7c	25.38a	1d	1.02c	42.79b	51.38c
P value	<.0001	<.0001	0.0286	<.0001	<.0001	0.0047	0.0046
% CV	27.12	26.996	10.45	27.00	29.62	16.42	13.85
LSD (*P*<.05)	35.69	1753.2	1.123	0.14	0.155	4.004	3.23

Based on the weevils collected in the control plots and the damage scores recorded, there was a positive relationship between damage and weevil population as obtained in the correlation analysis (Figures 1 and Figure 2) where $y = 0.2569 + 1.3689$; $R2 = 0.5296$ indicating that yield loses accrued when an average of 1.5 weevils defoliate more than 43% of leaves in Mununga Trial One.

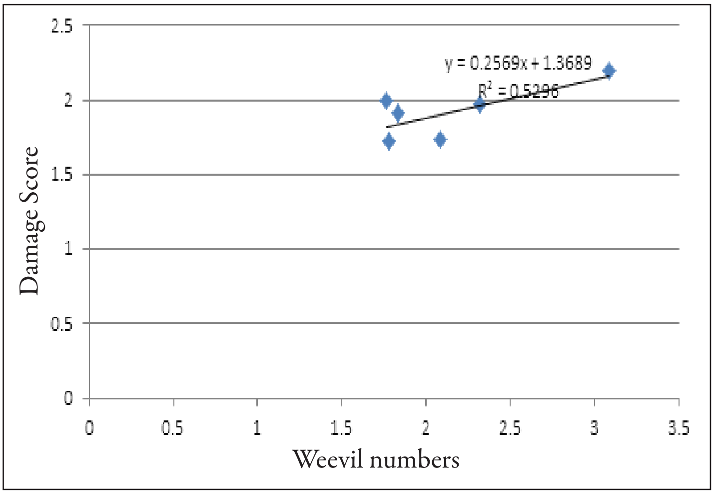


Figure 1: Relationship between weevil damage scores and weevil numbers at Mununga Trial One (July 2012 to July 2013).

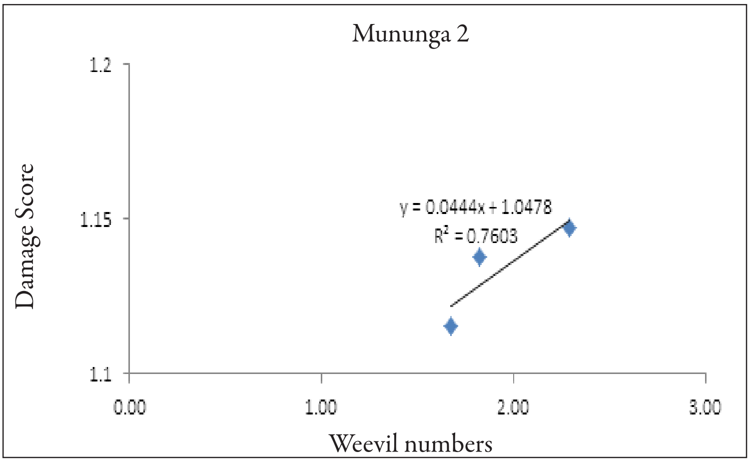
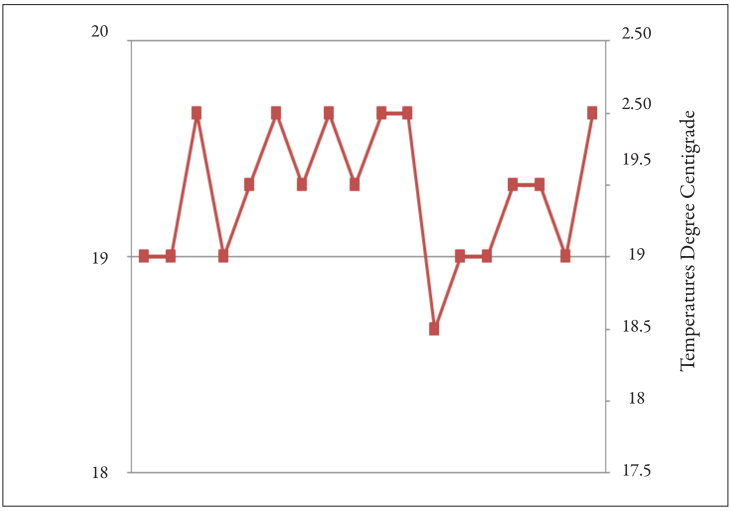


Figure 2: Relationship between weevil damage scores and weevil numbers at Mununga Trial Two (September 2012 to September 2013).

Influence of rainfall and temperature on weevil damage in Mununga

The damages that occurred in the field at Mununga varied and fluctuated with the season of the year (Figure 3). Increased rainfall corresponds to a drop in damage and vice versa for temperature.

a)



b)

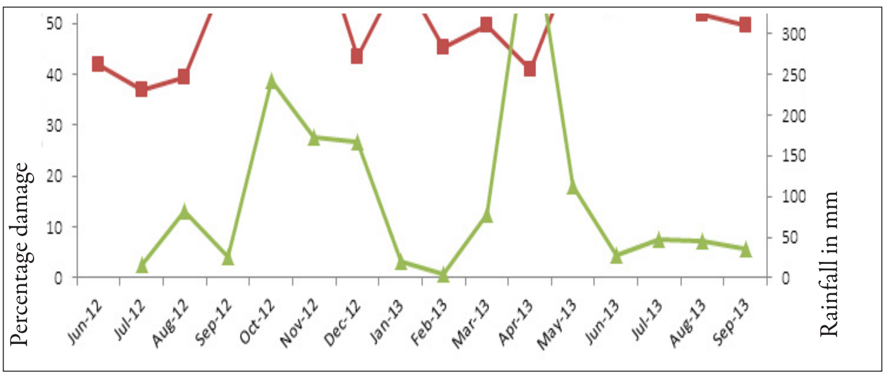


Figure 3: Trends on Nyambene weevil damages on tea leaves versus rainfall and temperature in a) Mununga, Kiruki's Farm, Mununga b) KTDA Catchment between July 2012 and June 2013.

SOURCE OF RAINFALL AND TEMPERATURE: MUNUNGA KTDA FACTORY

Influence of rainfall on weevil damage in Giciaro Farm

The trend was as in the preceded evaluation above, the damages that occurred in the field at Giciaro varied and fluctuated with the season of the year (Figure 4). Increased rainfall > 500 mm correspond to a following drop in damage and vice versa for temperature (>20°C).

Figure 4: Trends on Nyambene weevil damages on tea Leaves versus rainfall and Temperature in Giciaro Farm, Igembe KTDA Catchment between July 2012 and June 2013 (Source of Rainfall Data, Giciaro Farm: Temperature Igembe KTDA Factory).

DISCUSSION

Weevil occurrence in a tea field area was found to be sporadic, this can be due to the aggregative behaviour of the tea weevils; several reports have indicated this behaviour (xiao-Ling *et al.*, 2010) and attributed it to volatiles involved in the attractants of conspecifics to either locate host plant or as a pheromone synergist. This phenomenon could be the results of what was observed in the second field trial in Giciaro Farm where damage was very low throughout the trial period. The damage score indicates very low damage (between 9% and 18%) and this could be the reason for none significance difference between treatments. Compared to controls all the pesticides (chemical pesticide and biopesticides) used (except Karate in Giciaro) demonstrated their efficacy on reducing either weevil damage or yield loss as a result of high weevil infestations. The poor performance of Karate insecticides in Giciaro Farm in terms of yield can be attributed to plots having low yields in the start of the experiment or the insecticides have developed resistance in that field or it could be as a result of slight phytotoxic to the clone in those fields.

The study has shown that weevils can cause economic damage at less rainy seasons of the year with yield loss ranging between 18% and 39% and that damage is relative to weevil population. These results corroborated those of Kpindou *et al.* (2013), that chemicals such as imidacloprid, lambdacyhathrin and flubendiamide and biologicals, *B. bassiana* and *M. anisopilae*, significantly reduced the density of pest compared to the controls and they concluded that there is a possibility of *B. bassiana* and *M. anisopilae* being used as alternatives to chemical insecticides for cotton pests control. In conclusion, *B. bassiana* Isolates has the potential for use in the management of tea weevils. *B. bassiana* Isolates Bb 7a and Isolates Bb 6 can be recommended for the management of the weevils either as sprays or by broadcasting in solid substrate like wheat bran. There is therefore need to develop further appropriate formulation of these isolates for use by the tea growers affected by the weevils in times of posterity. In addition, various application strategies, formulation and modes of introducing the fungus into plantations should be consistently studied and integrated into routine practices of tea husbandry.

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