Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2018; 6(2): 576-579

Received: 18-01-2018
Accepted: 21-02-2018

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Management dynamics of potential bio-pesticides against polyphagous sucking pests on eggplant (*Solanum melongena* L.)

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Abstract
Brinjal (*Solanum melongena* L.) is a very important solanaceous crop of tropics and sub-tropics. It is cultivated on large area and commonly grown vegetables across the globe. The brinjal is of much importance in the warm areas. Number of insect pests that attack on crop during the growth period and cause severe losses to this crop. Insect pest caused quantitative and qualitative losses in many brinjal producing areas. In the present study, the efficacy of *Beauveria bassiana* and *Trichoderma harzianum* against the insect pests of brinjal was evaluated. Experiment was run out under randomized complete block design (RCBD) with three replications. The data was taken after 12, 24, 48, and 72 hours and then on a weekly basis after application. Results revealed that after 12 hours post treatment combination of *B.bassiana* and *Trichoderma harzianum* was found to be most effective in the mortality of White fly, jassid, aphid and dusky bug, (4.65, 4.11, 6.48 and 6.88) after 24 hours post treatment combination of *B. bassiana* and *Trichoderma harzianum* was found to be most effective in the mortality of White fly, jassid, aphid and dusky bug (6.71, 6.21, 8.92 and 8.91) After 48 hours post treatment combination of *B. bassiana* and *Trichoderma harzianum* was found to be most effective in the mortality of White fly, jassid, aphid and dusky bug (12.62, 16.84, 16.74 and14.32) after 72 hours hours post treatment combination of *B. bassiana* and *Trichoderma harzianum* was found to be most effective in the mortality of White fly, jassid, aphid and dusky bug (26.98,36.89,36.69 and 32.67) after 7days post treatment combination of *B. bassiana* and *Trichoderma harzianum* was found to be most effective in the mortality of White fly, jassid, aphid and dusky bug (45.87,56.45,54.35 and 45.78) after 14 days post treatment combination of *B. bassiana* and *Trichoderma harzianum* was found to be most effective in the mortality of White fly, jassid, aphid and dusky bug, (68.92, 68.93, 68.94 and 62.73) as compared to alone *B.bassiana* and Trichoderma harzianum caused less mortality than combination of these two Entomopathogenic fungi. Lowest mortality is caused by control treatment.

Keywords: Entomopathogenic fungi, *Beauveria bassiana*, *Trichoderma harzianum*, biological control and *Solanum melongena*

Introduction
Solanum melongena L., commonly known as Brinjal, is an important vegetable. It is widely grown in tropical and sub-tropical areas of the world including Pakistan (Anonymous, 2010). since ancient times Brinjal is being used in a variety of culinary preparations. It is a staple vege graph in many tropical countries. Purple fruits have higher aminoacid content. Brinjal fruits have medicinal properties as well. (S. Rajan and Lissy Markos, 2002) [8]. *Solanum melongena* is amongst the top ten horticultural crops all over the world. India is the leading producer in this regard and all other Asian countries contributing almost 94% production of that commodity (FAO, 2007) [5]. In Pakistan alone this valuable vegetable is grown an area of about 385578 ha with the output of almost 3116808 tons. In Punjab, the total cultivated area of brinjal is about 4452 hectares having annual production of 54159 tons (GOP, 2015) [6]. Number of biotic and abiotic factors affect the plant growth and yield. In biotic factor, insect pests play key role in yield reduction. Many and chewing pests damage the brinjal crop to the whole cropping period. Some important pests of brinjal becoming the challenge are brinjal fruit borer, Brinjal stem borer, leaf roller beetles, aphids, jassid, thrips, mites and white fly (Johnson, *et al*., 1982) [7]. It has been reported that in the South East Asia the sucking pest caused 67% yield losses (Nagia *et al*., 1993) [9].

The only method utilized for these pests is the chemical control. Repeated use of these pesticides not only poses the environmental hazards but the major contribution is the development of resistance in targeted pests as well as disturb the ecological balance (Dadmal *et al*., 2004 a) [4]. Microbial insecticides are ignored alternatives to chemical pesticides in suppressing the insect pests. bio efficacy of microbial insecticides against pests of brinjal is very efficient as it evident from the reports of Chatterjee and Roy (2004) [3] and Suradkar *et al*. (2008) [14]. Microbial control along with biological control can have a dramatic effect on control tactics of *Solanum melongena* L. Now a day whole the globe is turning over the biological control of insect pests. In Pakistan no work yet has been done on managing the brinjal pests using *Beauveria bassiana* and *Trichoderma harzianum.* So there was a dire need of this experiment. The current study the efficacy of *Trichoderma harzianum*a and *Beauveria bassiana* against insect pests of brinjal (*solanum melongena*).

Materials and Methods

Effect of bio-pesticides against sucking insect pests of brinjal crop under field conditions was carried out during the year 2015-16. This current study was conducted in Department of Entomology, University of Agriculture, Faisalabad, Pakistan. Four treatments were used in this experiment including *B. bassiana* and *T. harzianum* in combination in T1. While T2 was only *Beauveria bassiana* and T3 was of *Trichoderma harzianum.* T4 was regarded as control treatment. The temperature maintained in this experiment was 25-30 ^{0}C and relative humidity of 75%.

Experimental Layout

Field experiment were conducted in Young wala, Entomological Research Area at main campus, University of Agriculture Faisalabad, Pakistan, during 2015-16. The seeds of Dudhia variety of eggplant were sown in mid of June. The recommended dose of fertilizers and hand hoeing for weed removal were done and the field was irrigated after 3-4 days' interval.

Pot Experiment

The nursery plants with 4-5 leaves were shifted to pots at the end of August. The pots were irrigated with 2-3 days' interval. The experiment was laid out in a RCBD with four treatments and three replications. The treatments were applied by foliar application method when pests were near to economic threshold level.

Source of Bio Insecticides

All of the below mentioned Bio insecticide formulations were imported from an Agri life Medak District (Hyderabad), Andhra Pradesh, India.

Fungal Formulation

There were following formulations which were used in study.

- *Beauveria bassiana* (Biosoft) (10^6 CFU/g) 10 g/l,
- *Trichoderma harzianum* (Biozim) (10^4)CFU/g) 10 g/l,

Data Analysis

Insect's population data was collected by visual observation on per plant. The two sprays were carried out, and observed their efficacy after 24, 48, 72, 96 hours 1 week and 2 weeks of spray and compared with control.

The collected data was transformed into percent population reduction/increase by the following formula:

$$\text{Percent Population Reduction} = \frac{\text{PBTA} \times \text{PATA}}{\text{PBTA}} \times 100$$

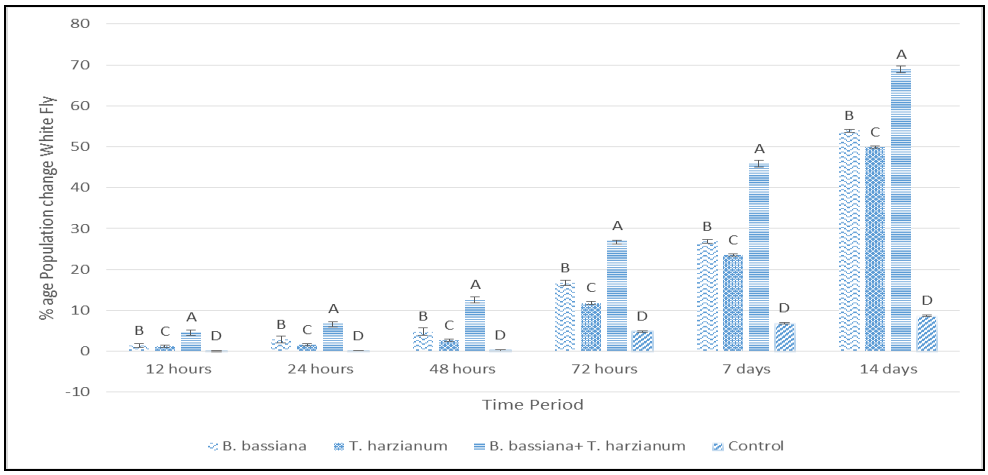
- PBTA = Population before treatment application
- PATA= Population after treatment application

Statistical Analysis

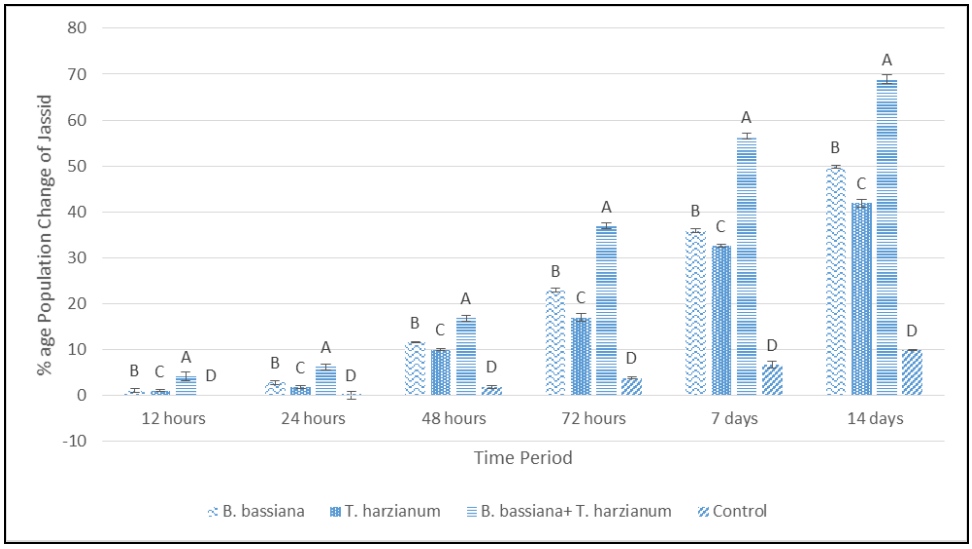
The data collected was subjected to statistical analysis using analysis of variance to know the significance of differences in the population of various insect pests and infestation at different intervals after treatment and mean comparison using HSD test was performed.

Results

The combined effect of *B. bassiana* and *T. harzianum* on the population of sucking insect pests of brinjal was most effective and as time period increased, the pest population showed more variation and mortality level increased as time period increased. As graph 1 showed that the combination of *B. bassiana* and *T. harzianum* causes maximum mortality of whitefly (4.65) after 12 hours (F=95.06, P=0.0001) and the mortality level was gradually raised as time period increased (68.95 over 14 days of application) similar results was observed in the cases of *A. biguttula* (68.93, F=5111.83 and P=0.0001), *A. gossypii* (68.94, F=785.83 and P=0.0001) and *O. hyalinipennis* (62.79, F=783.8 and P=0.0001) with over 14 days of microbial pesticides. *Trichoderma harzianum* was less effective to control white fly (49.88), aphid (41.69), jassid (41.88) and dusky cotton bug (35.78) after 14 days. *Beauveria bassiana* produce more mortality in *B. tabaci* (53.89) while least effective against *O. hyalinipennis* (42.56) similarly white fly showed maximum response to *T. harzianum* while dusky cotton bug least effected as mentioned in table 1 and 2. The F and P values showed that all microbial bio insecticides effectively caused mortality in giving sucking insect pests of brinjal.



Graph 1: Mean value percentage population change of white fly (*Bemisia tabaci*) under the influence of *Beauveria bassiana* and *Trichoderma harzianum* after different time periods. Each column, mean value followed by same latter are not significant to each other; Df=3; Tukey and HSD test ≤ 0.05; *= Significant, ** = Highly Significant, NS = Non-Significant.



Graph 2: Mean value percentage population change of Jassid (*Amrasca biguttula*) under the influence of *Beauveria bassiana* and *Trichoderma harzianum* after different time periods. Each column, mean value followed by same latter are not significant to each other; Df=3; Tukey and HSD test ≤ 0.05; *= Significant, ** = Highly Significant, NS = Non Significant

Table 1: Mean value percentage population change of Aphid (*Aphis gossypii*) under the influence of *Beauveria bassiana* and *Trichoderma harzianum* after different time periods. Each column, mean value followed by same latter are not significant to each other; Df=3; Tukey and HSD test ≤ 0.05; *= Significant, ** = Highly Significant, NS = Non Significant

Time period / **treatments**	12 hours	24 hours	48 hours	72 hours	7 days	14 days
B. bassiana	$3.21^{B} \pm 0.43$	$3.62^{B} \pm 0.54$	$8.98^{B} \pm 0.21$	$21.43^{B} \pm 0.22$	$34.67^{B} \pm 0.22$	$48.98^{B} \pm 0.56$
T. harzianum	$3.11^{C} \pm 0.22$	$3.08^{C} \pm 0.15$	$7.9^{C} \pm 0.22$	$21.00^{C} \pm 0.87$	$31.98^{C} \pm 0.77$	$41.69^{C} \pm 0.12$
B. bassiana+ T. harzianum	$6.48^{A} \pm 0.51$	$8.92^{A} \pm 0.21$	$16.74^{A} \pm 0.43$	$36.69^{A} \pm 0.44$	$54.38^{A} \pm 0.35$	$68.94^{A} \pm 0.11$
Control	$0.78^{D} \pm 0.11$	$0.88^{D} \pm 0.76$	$4.21^{D} \pm 0.76$	$6.78^{D} \pm 0.32$	$7.89^{D} \pm 0.23$	$12.43^{D} \pm 0.33$
Anova	$F=134.29^{**}$ P=0.0001	$F=178.09^{**}$ P=0.0001	$F=744.80^{**}$ P=0.0001	$F=3112.00^{**}$ P=0.0001	$F=5111.83^{**}$ P=0.0001	$F=785.83^{**}$ P=0.0001

Table 2: Mean value percentage population change of Dusky cotton bug (*Oxycarenus hyalinipennis)* under the influence of *Beauveria bassiana* and *Trichoderma harzianum* after different time periods. Each column, mean value followed by same latter are not significant to each other; Df=3; Tukey and HSD test ≤ 0.05; *= Significant, ** = Highly Significant, NS = Non Significant

Time period / **Treatments**	**12 hours**	**24 hours**	**48 hours**	**72 hours**	**7 days**	**14 days**
B. bassiana	$2.56^{B} \pm 0.43$	$4.32^{B} \pm 0.76$	$6.74^{B} \pm 0.98$	$22.56^{B} \pm 0.67$	$28.98^{B} \pm 0.45$	$42.56^{B} \pm 0.45$
T. harzianum	$2.00^{C} \pm 0.76$	$3.78^{C} \pm 0.12$	$5.78^{C} \pm 0.43$	$19.98^{C} \pm 0.33$	$24.56^{C} \pm 0.32$	$35.78^{C} \pm 0.33$
B. bassiana+ T. harzianum	$6.88^{A} \pm 0.54$	$8.91^{A} \pm 0.33$	$14.32^{A} \pm 0.65$	$32.67^{A} \pm 0.21$	$45.78^{A} \pm 0.78$	$62.76^{A} \pm 0.78$
Control	$0.00^{D} \pm 0.08$	$0.26^{D} \pm 0.32$	$2.62^{D} \pm 0.29$	$4.54^{D} \pm 0.43$	$6.98^{D} \pm 0.18$	$9.87^{D} \pm 0.41$
Anova	$F=134.29^{**}$ P=0.0001	$F=178.09^{**}$ P=0.0001	$F=744.80^{**}$ P=0.0001	$F=3112.00^{**}$ P=0.0001	$F=5111.83^{**}$ P=0.0001	$F=783.83^{**}$ P=0.0001

Discussion

Results revealed that after 12 hours post treatment combination of *B.bassiana* and *Trichoderma harzianum* was found to be most effective in the mortality of white fly, jassid, aphid and dusky bug, (4.65, 4.11, 6.48 and 6.88) while *B.bassiana* alone showed the less control (1.38, 1.03, 3.21 and 6.88) which is followed by *T. harzianum* (1.2, 0.97, 3.11 and 2.00) . After 24 hours combined treatment of *B.bassiana* and *Trichoderma harzianum* was found best treatment which showed maximum mortality of all insects including white fly, jassid, aphid and dusky bug (6.71, 6.21, 8.92 and 8.91) but *T. harzianum* was least effective for controlling of sucking insect pests (1.57, 1.77, 3.08 and 3.78) as compared to control treatment. After 48 hours, the combined effect of *Trichoderma harzianum* and *B. bassiana* was found highly effective treatment for controlling of sucking insect pests including white fly, jassid, aphid and dusky bug with 12.62, 16.84, 16.74 and 14.32 but other treatments were least effective while highest damage caused by insects was observed in control conditions. The synergistic effect of *B.bassiana* and *Trichoderma harzianum* caused highest mortality in different sucking insects like white fly, jassid, aphid and dusky bug with 26.98,36.89,36.69 and 32.67 respectively after 72 hours while alone *B. bassiana* (16.67, 22.84, 21.43 and 22.56) and *T. harzianum* (2.71,9.95,7.9 and 5.78) treatments showed less effective results. As time of exposure increased mortality rate also rose up as combination of *B.bassiana* and *Trichoderma harzianum* was observed most effective in the mortality of white fly, jassid, aphid and dusky bug (45.87, 56.45, 54.35 and 45.78) than other treatments. After 14 days post treatment combination of *B.bassiana* and *Trichoderma harzianum* was found to be most effective in the mortality of white fly, jassid, aphid and dusky bug (68.92, 68.93, 68.94 and 62.73) similar results were obtained with different concentrations of *B.bassiana* by (Joshi *et al*., 2010; Nayak *et al*. 2013) [10, 11]. described the similar results. Similarly, Boopathi *et al.* (2015) [2] checked *Metarhizium anisopliae*, *Beauveria bassiana*, *Lecanicillium lecanii* and *Isaria fumosorosea* and entomopathogenic fungi were their potential to control the mysterious strengthening whitefly *Aleurodicus dispersus* (Hemiptera: Aleyrodidae) during 2 seasons (2011-2012 and 2012-2013) on cassava (*Manihot esculenta*). The fungi *I. fumosorosea* and *L. lecanii* and caused more than 70% mortality of the white fly population). Percent mortality increased both season overtime. *I. fumosorosea* caused more mortality to *A. dispersus* than other entomopathogenic fungi compared to the other in both seasons. These results most similar the present studies. Similarly, Moraga *et al*., (2006) and Padin *et al.* (2002) mentioned the similar results under lab conditions.

Conclusion

It is concluded that the combination of *Beauveria bassiana* and *Trichoderma harzianum* showed synergistic effect and most efficient results to control the sucking insect pests of brinjal, as they are also save to environment, other organisms and human also. So it is suggested that theses fungus species should be used in IPM programs to control the sucking insect pests of brinjal.

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