RESEARCH ARTICLE

IN VITRO BIO-EFFICACY OF ENTOMOPATHOGENIC FUNGI *BEAUVERIA BASSIANA* (BALS.) VUILL., AGAINST GRAM POD BORER, *HELICOVERPA ARMIGERA* HUBNER ON CHICKPEA

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Abstract: The present study was conducted at Bio-control lab, Department of Entomology, College of agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur during 2015-16 and 2016-17. The results of *in vitro* experiments revealed that the 2-3rd instars larvae of *Helicoverpa armigera* susceptible to different doses of *Beauveria bassiana*. Mortality of larvae was started after 2-3 day of treatment. Among the doses of *B. bassiana* T_4 (*B. bassiana* @5000g/ha) 0.00-75.00% show the maximum mortality followed by T_3 (*B. bassiana* @3000g/ha) 0.00-45.00%, T_2 (*B. bassiana* @2500g/ha) 0.00-32.00% and T_1 (*B. bassiana* @2000g/ha) 0.00 to 15.00 % but superior than control T_7 (0.00 %) in both the year.

Keywords: Chickpea, *Helicoverpa armigera*, *Beauveria bassiana*

INTRODUCTION

Chickpea (*Cicer arietinum* L.) belongs to the family Leguminosae and commonly known as Chana, Bengal gram or Garbanzo, is mainly used for human consumption and also a small proportion forms the part of animal and poultry feed. It has one of the highest nutritional compositions as of any dry edible legume and is not reported to contain any specific major anti-nutritional factors. In India, during 2014-15 Bengal gram production area was 8250.5 (In ' 000 Hectare), production 7331.8 (In ' 000 Tonne) tones and productivity 889 (In Kg./Hectare). In Chhattisgarh during 2014-15 the production area was 280.6 (In ' 000 Hectare), production 267.6 MT (In '000 MT) and productivity 1035 (In Kg./Hectare) (Anonymous, 2016). The potential seed yield of about 5 t/ha has been reported in chickpea. However, the realized seed yield hovers around 850 kg/ha which has stagnated over the years. Series of biotic and abiotic stresses reduce the yield and yield stability leaving room only marginal for improvements and the key biotic constraint is the pod borer, *Helicoverpa armigera* Hubner.

The gram pod borer, *Helicoverpa armigera* Hubner, (Lepidoptera: Noctuidae) is a major threat to intensive agriculture (Sigsgaard, 2002). It is one of the most destructive and cosmopolitan insect pests of field crops worldwide and is highly polyphagous causing severe damage to a wide range of food, oil, fodder, vegetables, horticultural, ornamental, aromatic and medicinal plants (Neoliya, 2007, Kontsedalov *et al.* 2012). Yield losses due to this pest in chickpea may range from 70 to 95% (Prakash *et al*., 2007). Due to its wide host range, production of multiple generations per year, high fecundity, migratory behavior and pronounced resistance to many insecticides, the control up to desired level has become difficult (Mccaffery *et al.* 1998). Moderate to high level of resistance to conventional insecticides such as (chlorinated hydrocarbons, organophosphates, carbamates and pyrethroids) as well as to neonicotinoids pesticides and Insect Growth Regulator (IGR's) has been reported in field populations of *H. armigera* (Nauen and Bretschneider 2002). Chemical control is the most commonly used method in insect pest management. Due to adverse effects on non-target organisms, toxicity to mammals and birds and the risk of environmental pollution, chemical control measure should be replaced by the other environmentally friendly control methods to refrain from consumption and other ways it can be replaced (Fields, 1998). Therefore, with the current urgent and conflicting goals of reduced pesticide usage while maintaining adequate agricultural production, microbial control agents with selectivity and a low environmental impact could become ideal components of integrated pest management programs (IPM) in this century (Lacey and Goettel, 1995). The entomopathogenic fungus has been used for biological control of pests to reduce pesticide usage. More than 700 fungal species from about 90 genera are pathogenic to insects (Hong, 2003). Under natural conditions, these pathogens are frequent and often cause natural mortalities of insect populations.

The entomopathogenic hyphomycetes fungi have great potential as biological control agents against insect pests and are used as an important component in integrated pest management systems, particularly *Beauveria bassiana* (Balsamo) Vuillemin, *Metarhizium anisopliae* (Metch) Sorok, *Verticillium lecanii* Zimmeman and *Nomuraea rileyi* (Farlow) Samson have been found to be promising in the control of several agriculturally important insect pests and are facultative pathogens (Lingappa *et al.*, 2005). Among the entomopathogenic fungi *B. bassisna* (Balsamo) Vuill, (Deuteromycetes:

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Hyphomycetes) belonging to sub division Deuteromycotina grows naturally in soils throughout the world and acts as a parasite on various arthropod species, causing white muscardine disease. Over 200 species of insects in nine orders, mainly lepidoptera, coleoptera and hemiptera have been recorded as hosts (Li and Yang, 1988). *B. bassiana* are characterized by having conidiophores consisting of whorls and dense clusters of sympodial, short and globose or flask shaped conidiogenous cells with apical denticulate rachis and one celled conidia. This fungal biopesticide receives more attention because of its more eco-safe, eco-friendly environmental control measures. Its spores may be formulated and applied in a similar way as chemical pesticides and, therefore, could be adopted as a new technology. This includes oil based, dust, powder formulations and ultralow volume application, cheap to produce and may provide low cost control (Langle, 2006).

MATERIAL AND METHOD

Rearing of the insects

Gram pod borer, *Helicoverpa armigera* (Hubner) larvae were collected from nearby fields and brought into the laboratory for further rearing. Larvae were reared individually in plastic tube/plastic disposal cup with cap/plastic petriplates (size,9cm diameter)/glass petriplates (size, 9 cm diameter) on artificial diet (Krishnareddy and Hanur, 2015, Ahmed *et al.* 1998) to get pure line culture. Freshly emerged larvae from pure line culture were used for experimental purpose (Namasivayam, *et al.* 2015).

Experimental Protocols

The experiment was conducted with 7 treatments including control and in each replication 10 larvae (2^{nd} - 3^{rd} instars) were used. The experiment was replicated four times. Commercial formulation of 1.15% WP ($1x10^8$ cfu/g min) of *B. bassiana,* was used in this experiment. The observations were recorded at 24 hrs interval upto eight (8) days. All experiments were conducted in BOD having optimum temperature and humidity ($25\pm 2\ ^0$C and 70 ± 10% RH). Calculated amount (ml) of each fungal suspension ($1x10^8$ cfu/g) was taken in a petridish/plastic beaker 1000 ml size 15cm length and 12cm diameter and 2^{nd}- 3^{rd} instars larvae was treated by leaf dip- sprays method. One to two pieces of chickpea leaves cut into 5 cm-7 cm pieces were dipped in fungal conidial suspension for contaminated both sides of the leaf surfaces then left on a laboratory bench to allow to dry for 2–3 min under aseptic conditions in laminar air flow.

Ten larvae were then placed on the conidia treated leaves in each petridish then also spray conidial suspension on larvae using a potters sprayer (agriculture hand sprayer) and allowed to feed for 24 h, after which the remains of the leaf material and frass were carefully removed. The larvae were then provided with unsprayed leaves. The control larvae (10 larvae per exposure) were sprayed sterile distilled water (Tefera and Pringle, 2003, Elizabeth *et al.,* 2008, Senthamizhlselvan, 2010). The dead larvae were surface sterilized by sodium hypochlorite and placed on petridish lined with moist filter paper. These petridishes were incubated at 25 ± 2°C and 70 ± 10% RH to encourage fungal growth and sporulation in order to confirm infection of microbial agents on the larvae which showed mycelial growth were considered to have died of infection and only those counts were used to compute the pathogenicity of microbial agents. Slides was prepared by taking spores from dead larvae and observed under microscope to study its morphology for confirmation.

RESULT AND DISCUSSION

First Year

In vitro bio-efficacy of *B. bassiana* against *H. armigera* Hubner on Chickpea year 2015-16 presented (table 1 Fig 1) revealed that at 1 day after treatment among the treatment T_6 (Profenophos 50% EC @1000ml/ha) 100.00 % show the superior mortality over the other treatment, followed by T_5 (Neem oil Azadirechtin 0.03%@5000ml/ha) 62.00 % which is not on par with T_4 (*B. bassiana* @5000g/ha) 0.00%. Among the doses of *B. bassiana* show 0.00 % mortality similar to control T_7 0.00 %. At 2^{nd} day among the treatment T_6 (Profenophos 50% EC @1000ml/ha) 100.00 % show the superior mortality over the other treatment, followed by T_5 (Neem oil Azadirechtin 0.03%@5000ml/ha) 72.50 % which is not on par with T_4 (*B. bassiana* @5000g/ha) 5.00%. Among the doses of *B. bassiana* T_4 (*B. bassiana* @5000g/ha) 5.00% show the maximum mortality but another treatment T_3, T_2 and T_1 showed similar to control T_7 0.00%. At 3^{rd} day among the treatment T_6 (Profenophos 50% EC @1000ml/ha) 100.00 % show the superior mortality over the other treatment, followed by T_5 (Neem oil Azadirechtin 0.03%@5000ml/ha) 85.00 % which is not on par with T_4 (*B. bassiana* @5000g/ha) 15.00 %. Among the doses of *B. bassiana* T_4 (*B. bassiana* @5000g/ha) 15.00% show the maximum mortality followed by T_3 (*B. bassiana* @3000g/ha) 0.00 % and T_2 (*B. bassiana* @2500g/ha) 0.00 % and T_1 (*B. bassiana* @2000g/ha) 0.00 %. In this day the percent mortality of treatment T_2 and T_1 was similar to control T_7 (0.00%).

At 4^{th} day among the treatment T_6 (Profenophos 50% EC @1000ml/ha) 100.00 % show the superior mortality over the other treatment, followed by T_5 (Neem oil Azadirechtin 0.03%@5000ml/ha) 90.00 % which is not on par with T_4 (*B. bassiana* @5000g/ha) 25.00%, T_3 (*B. bassiana* @3000g/ha) 15.00% and T_2 (*B. bassiana* @2500g/ha) 15.00%. Lower percent mortality recorded in T_1 (*B. bassiana* @2000g/ha) 10.00 % but superior than control. At 5^{th} day among the treatment T_6 (Profenophos 50% EC @1000ml/ha) 100.00 % and T_5 (Neem oil Azadirechtin 0.03%@5000ml/ha) 100.00 % show the superior

mortality over the other treatment, which is on par with each other. Among the doses of *B. bassiana* T_4 (*B. bassiana* @5000g/ha) 30.00% show the maximum mortality followed by T_3 (*B. bassiana* @3000g/ha) 15.00% and T_2 (*B. bassiana* @2500g/ha) 15.00%. Lower percent mortality recorded in T_1 (*B. bassiana* @2000g/ha) 10.00 % but superior than control. At 6th day among the treatment T_6 (Profenophos 50% EC @1000ml/ha) 100.00 % and T_5 (Neem oil Azadirechtin 0.03%@5000ml/ha) 100.00 % show the superior mortality over the other treatment, which is on par with each other. Among the doses of *B. bassiana* T_4 (*B. bassiana* @5000g/ha) 60.00% show the maximum mortality followed by T_3 (*B. bassiana* @3000g/ha) 30.00% and T_2 (*B. bassiana* @2500g/ha) 20.00%. Lower percent mortality recorded in T_1 (*B. bassiana* @2000g/ha) 15.00 % but superior than control T_7 (0.00 %).

At 7th day among the treatment T_6 (Profenophos 50% EC @1000ml/ha) 100.00 % and T_5 (Neem oil Azadirechtin 0.03%@5000ml/ha) 100.00 % show the superior mortality over the other treatment, which is on par with each other. Among the doses of *B. bassiana* T_4 (*B. bassiana* @5000g/ha) 75.00% show the maximum mortality followed by T_3 (*B. bassiana* @3000g/ha) 40.00% which is on par with T_2 (*B. bassiana* @2500g/ha) 30.00%. Lower percent mortality recorded in T_1 (*B. bassiana* @2000g/ha) 15.00 % but superior than control T_7 (0.00 %). At 8th day among the treatment T_6 (Profenophos 50% EC @1000ml/ha) 100.00 % and T_5 (Neem oil Azadirechtin 0.03%@5000ml/ha) 100.00 % show the superior mortality over the other treatment, which is on par with each other. Among the doses of *B. bassiana* T_4 (*B. bassiana* @5000g/ha) 75.00% show the maximum mortality followed by T_3 (*B. bassiana* @3000g/ha) 45.00% which is on par with T_2 (*B. bassiana* @2500g/ha) 32.00%. Lower percent mortality recorded in T_1 (*B. bassiana* @2000g/ha) 15.00 % but superior than control T_7 (0.00 %).

Second year

In vitro bio-efficacy of *B. bassiana* against *H. armigera* Hubner on Chickpea year 2016-17 presented (table 2 Fig 2) revealed that at 1 day after treatment among the treatment T_6 (Profenophos 50% EC @1000ml/ha) 100.00 % show the superior mortality over the other treatment, followed by T_5 (Neem oil Azadirechtin 0.03%@5000ml/ha) 57.00 % which is not on par with T_4 (*B. bassiana* @5000g/ha) 0.00%. Among the doses of *B. bassiana* show 0.00 % mortality similar to control T_7 0.00%. At 2nd day among the treatment T_6 (Profenophos 50% EC @1000ml/ha) 100.00 % show the superior mortality over the other treatment, followed by T_5 (Neem oil Azadirechtin 0.03%@5000ml/ha) 77.50 % which is not on par with T_4 (*B. bassiana* @5000g/ha) 5.00%. Among the doses of *B. bassiana* T_4 (*B. bassiana* @5000g/ha) 5.00% show the maximum mortality but another treatment T_3, T_2 and T_1 showed similar to control T_7 0.00%. At 3rd day among the treatment T_6 (Profenophos 50% EC @1000ml/ha) 100.00 % show the superior mortality over the other treatment, followed by T_5 (Neem oil Azadirechtin 0.03%@5000ml/ha) 90.00 % which is not on par with T_4 (*B. bassiana* @5000g/ha) 15.00%. Among the doses of *B. Bassiana* T_4 (*B. bassiana* @5000g/ha) 15.00% show the maximum mortality which is on par with T_3 (*B. bassiana* @3000g/ha) 5.00% and T_2 (*B. bassiana* @2500g/ha) 5.00%. The lower percent mortality recorded T_1 (*B. bassiana* @2000g/ha) 0.00 % similar to control T_7 (0.00%).

At 4th day among the treatment T_6 (Profenophos 50% EC @1000ml/ha) 100.00 % and T_5 (Neem oil Azadirechtin 0.03%@5000ml/ha) 90.00 % show the superior mortality over the other treatment, which is on par with each other. Among the doses of *B. bassiana* T_4 (*B. bassiana* @5000g/ha) 25.00% show the maximum mortality followed by T_3 (*B. bassiana* @3000g/ha) 17.50% which is on par with T_2 (*B. bassiana* @2500g/ha) 15.00%. Lower percent mortality recorded in T_1 (*B. bassiana* @2000g/ha) 10.00 % but superior than control. At 5th day the treatment T_6 (Profenophos 50% EC @1000ml/ha) 100.00 % and T_5 (Neem oil Azadirechtin 0.03%@5000ml/ha) 90.00 % show the superior mortality over the other treatment, which is on par with each other. Among the doses of *B. bassiana* T_4 (*B. bassiana* @5000g/ha) 30.00% show the maximum mortality which is not on par with T_3 (*B. bassiana* @3000g/ha) 17.50%, T_2 (*B. bassiana* @2500g/ha) 15.00% and T_1 (*B. bassiana* @2000g/ha) 12.50 % but superior than control. At 6th day among the treatment T_6 (Profenophos 50% EC @1000ml/ha) 100.00 % and T_5 (Neem oil Azadirechtin 0.03%@5000ml/ha) 100.00 % show the superior mortality over the other treatment, which is on par with each other. Among the doses of *B. bassiana* T_4 (*B. bassiana* @5000g/ha) 55.00% show the maximum mortality which is not on par with T_3 (*B. bassiana* @3000g/ha) 30.00% and T_2 (*B. bassiana* @2500g/ha) 22.50%. Lower percent mortality recorded in T_1 (*B. bassiana* @2000g/ha) 12.50 % but superior than control T_7 (0.00 %).

At 7th day among the treatment T_6 (Profenophos 50% EC @1000ml/ha) 100.00 % and T_5 (Neem oil Azadirechtin 0.03%@5000ml/ha) 100.00 % show the superior mortality over the other treatment, which is on par with each other. Among the doses of *B. bassiana* T_4 (*B. bassiana* @5000g/ha) 67.50% show the maximum mortality followed by T_3 (*B. bassiana* @3000g/ha) 40.00% which is on par with T_2 (*B. bassiana* @2500g/ha) 32.50%. Lower percent mortality recorded in T_1 (*B. bassiana* @2000g/ha) 12.50 % but superior than control T_7 (0.00 %). At 8th day among the treatment T_6 (Profenophos 50% EC @1000ml/ha) 100.00 % and T_5 (Neem oil Azadirechtin 0.03%@5000ml/ha) 100.00 % show the superior mortality over the other treatment, which is on par with each other. Among the doses of *B. bassiana* T_4 (*B. bassiana* @5000g/ha) 72.50% show

the maximum mortality followed by T_3 (*B. bassiana* @3000g/ha) 45.00% which is on par with T_2 (*B. bassiana* @2500g/ha) 32.50%. Lower percent mortality recorded in T_1 (*B. bassiana* @2000g/ha) 12.50 % but superior than control T_7 (0.00 %).

Earlier similar work was done by Prasad, *et al.* (1990) recorded five entomopathogenic fungi for their infectivity to 2nd -instar larvae of *Heliothis armigera* [*Helicoverpa armigera*] by spraying them with conidial suspensions. Among them, *B. bassiana* (Bapatla isolate) was found to be the most virulent, recording the lowest LC_{50} of 2.17×10^5 conidia/ml. Tefera *et al.* (2003) also reported the effects of exposure methods, conidial concentrations, and temperature on mortality, mycosis and sporulation in second instar *Chilo partellus* cadavers infected by *B. bassiana* in laboratory. Larvae directly sprayed with conidia, exposed to conidia-treated leaves and dipped into conidial suspension resulted in high mortality (98–100%). The longest LT_{50} (3.5 days) and days to mortality (2.6 days) were observed in the treated-leaves exposure method. The shortest LT_{50} (1 day) and time for mortality (1 day) were recorded for the dipping method.. Exposure of larvae to treated-leaves resulted in high sporulation.

Prasad *et al.* (2010) also worked to control the pest population of *H. armigera* (Hubner) with an ecosafe entomopathogen *B. bassiana* (Balsamo). Four different concentrations (0.1, 0.125, 0.2 and 0.25 ml $\times 10^8$ spores/ml) were sprayed topically against most damaging 4th instar larvae of *H. armigera* (Hubner) and a dose dependent mortality was observed that went up to 76.7 percent with highest dose of 0.25 ml $\times 10^8$ spores/ml. Mortality started after two to three days of treatment. Senthamizhlselvan, *et al.* (2010) collected fungal isolates from Karaikal and tested against seven insect pests using different inoculation methods *viz*., spraying, crawling and dipping. Dipping method was found to be highly effective (82.50 per cent) to coccinellids followed by spraying and crawling methods (48.75 and 13.75 per cent). Larval mortality of spotted pod borer in pulses was more with spraying method (85.00 per cent). Among the three methods, spraying method was considered to be superior.

Similarly, Kumar and Chowdhry (2004) also reported that 18 *B. bassiana* isolates were found pathogenic to *H. armigera*. The larval mortality ranged from 40.0 to 90.0%. The maximum larval mortality was recorded in isolate HBB-2 (90.0%), followed by DBB-1 (87.5%) and HBB-1 (75.0%). The mean LC50 values for *B. bassiana* HBB-2 and *M. anisopliae* HMA-2 against the second instar larvae of *H. armigera* were $0.955x10^3$ and $1.243x10^3$ spores/ml, respectively. Hatting, (2012) bioassayed three entomopathogenic fungi, *B. bassiana* (Balsamo-Crivelli) Vuillemin, *N. rileyi* (Farlow) Samson and *Isaria fumosorosea* Wize in laboratory employing topical versus *per os* inoculation techniques. At a dose of 3.75×10^5 conidia per larva, *N. rileyi* out-performed both *I. fumosorosea* and *B. bassiana*, causing a mean of 87±1.4% mortality. Notably, no difference was detected between the two inoculations techniques employed with any of the three fungal species assayed. The incubation periods for topical applications ranged from 4 days (PPRI 7201 and 8072) to 7 days (PPRI 7758) while *per os* treatments responded on Day 4 (PPRI 8072) and Day 5 (PPRI 7758 and 7201) post-inoculation.

Table 1. "*In vitro* bio-efficacy of *Beauveria bassiana* against *H. armigera* Hubner on Chickpea year 2015-16

T. N.	Treatments	Doses kg/ha	Percent mortality of *H. armigera* up to 8 days							
			1 day	2 day	3 day	4 day	5 day	6 day	7 day	8 day
T_1	*B. bassiana* 1.15% WP ($1x10^8$ cfu/g)	@2000g/ha	0.00 [c] (0.544)	0.00 [d] (0.544)	0.00 [d] (0.544)	10.00 [c] (18.439)	10.00 [c] (18.439)	15.00 [d] (22.500)	15.00 [d] (22.500)	15.00 (22.500)
T_2	*B. bassiana* 1.15% WP ($1x10^8$ cfu/g)	@2500g/ha	0.00 [c] (0.544)	0.00 [d] (0.544)	0.00 [d] (0.544)	15.00 [c] (22.500)	15.00 [c] (22.500)	20.00 [d] (26.565)	30.00 [cd] (33.055)	32.50 (34.557)
T_3	*B.bassiana* 1.15% WP ($1x10^8$ cfu/g)	@3000g/ha	0.00 [c] (0.544)	0.00 [d] (0.544)	5.00 [d] (9.481)	15.00 [c] (20.051)	15.00 [c] (20.051)	30.00 [c] (32.898)	40.00 [c] (39.164)	45.00 (42.057)
T_4	*B. bassiana* 1.15% WP ($1x10^8$ cfu/g)	@5000g/ha	0.00 [c] (0.544)	5.00 [c] (9.481)	15.00 [c] (22.500)	25.00 [c] (29.889)	30.00 [b] (32.832)	60.00 [b] (50.895)	75.00 [b] (63.453)	75.00 (63.453)
T_5	Neem oil Azadirechtin 0.03% EC	@5000ml/ha	60.00 [b] (50.835)	72.50 [b] (58.608)	85.00 [b] (69.948)	90.00 [b] (76.447)	100.00 [a] (89.455)	100.00 [a] (89.455)	100.00 [a] (89.455)	100.00 (89.455)
T_6	Profenophos 50% EC	@1000ml/ha	100.00 [a] (89.455)	100.00 [a] (89.455)	100.00 [a] (89.455)	100.00 [a] (89.455)	100.00 [a] (89.455)	100.00 [a] (89.455)	100.00 [a] (89.455)	100.00 (89.455)
T_7	Control	-	0.00 [c] (0.544)	0.00 [d] (0.544)	0.00 [d] (0.544)	0.00 [d] (0.544)	0.00 [d] (0.544)	0.00 [e] (0.544)	0.00 [e] (0.544)	0.00 [e] (0.544)
	CD at (0.05%)		2.677	6.663	9.594	11.556	9.082	6.136	10.847	11.449
	SE(m)		0.909	2.266	3.263	3.927	3.088	2.086	3.687	3.892
	C.V.		8.908	19.865	23.668	21.361	15.819	9.351	15.284	15.933

*Figures in parentheses are arc sine transformed values.

Table 2. "*In vitro* bio-efficacy of *B. Bassiana* against *H. armigera* Hubner on Chickpea year 2016-17

T. N.	Treatments	Doses kg/ha	Percent mortality of *H. armigera* up to 8 days							
			1 day	2 day	3 day	4 day	5 day	6 day	7 day	8 day
T_1	*B. bassiana* 1.15% WP ($1x10^8$ cfu/g)	@2000g/ha	0.00 [c] (0.544)	0.00 (0.544)	0.00 (0.544)	10.00 (15.990)	12.50 (20.464)	12.50 (20.467)	12.50 (20.464)	12.50 (20.464)
T_2	*B.bassiana* 1.15% WP ($1x10^8$ cfu/g)	@2500g/ha	0.00 [c] (0.544)	0.00 (0.544)	5.00 (9.481)	15.00 (22.500)	15.00 (22.500)	22.50 (28.227)	32.50 (34.557)	32.50 (34.557)
T_3	*B. bassiana* 1.15% WP ($1x10^8$ cfu/g)	@3000g/ha	0.00 [c] (0.544)	0.00 (0.544)	5.00 (7.043)	17.50 (24.535)	17.50 (24.535)	30.00 (32.898)	40.00 (39.104)	45.00 (42.057)
T_4	*B. bassiana* 1.15%	@5000g/ha	0.00 [c]	5.00	15.00	25.00	30.00	55.00	67.50	72.50

	WP ($1x10^8$ cfu/g)		(0.544)	(9.481)	(19.680)	(29.736)	(32.832)	(47.947)	(58.998)	(61.941)
T_5	Neem oil Azadirechtin 0.03% EC	@5000ml/ha	57.50 [b] (49.383)	77.50 (65.117)	90.00 (76.447)	100.00 (89.455)	100.00 (89.455)	100.00 (89.455)	100.00 (89.455)	100.00 (89.455)
T_6	Profenophos 50% EC	@1000ml/ha	100.00 [a] (89.455)	100.00 (89.455)	100.00 (89.455)	100.00 (89.455)	100.00 (89.455)	100.00 (89.455)	100.00 (89.455)	100.00 (89.455)
T_7	Control	-	0.00 [c] (0.544)	0.00 [c] (0.544)	0.00 [d] (0.544)	0.00 [d] (0.544)	0.00 [f] (0.544)	0.00 [e] (0.544)	0.00 [e] (0.544)	0.00 [e] (0.544)
	CD at (0.05%)		3.133	11.071	14.726	7.854	6.355	6.530	12.939	11.848
	SE(m)		1.065	3.765	5.004	2.669	2.160	2.220	4.397	4.028
	CV		10.523	31.714	34.478	13.723	10.801	10.058	18.500	16.668

*Figures in parentheses are arc sine transformed values.

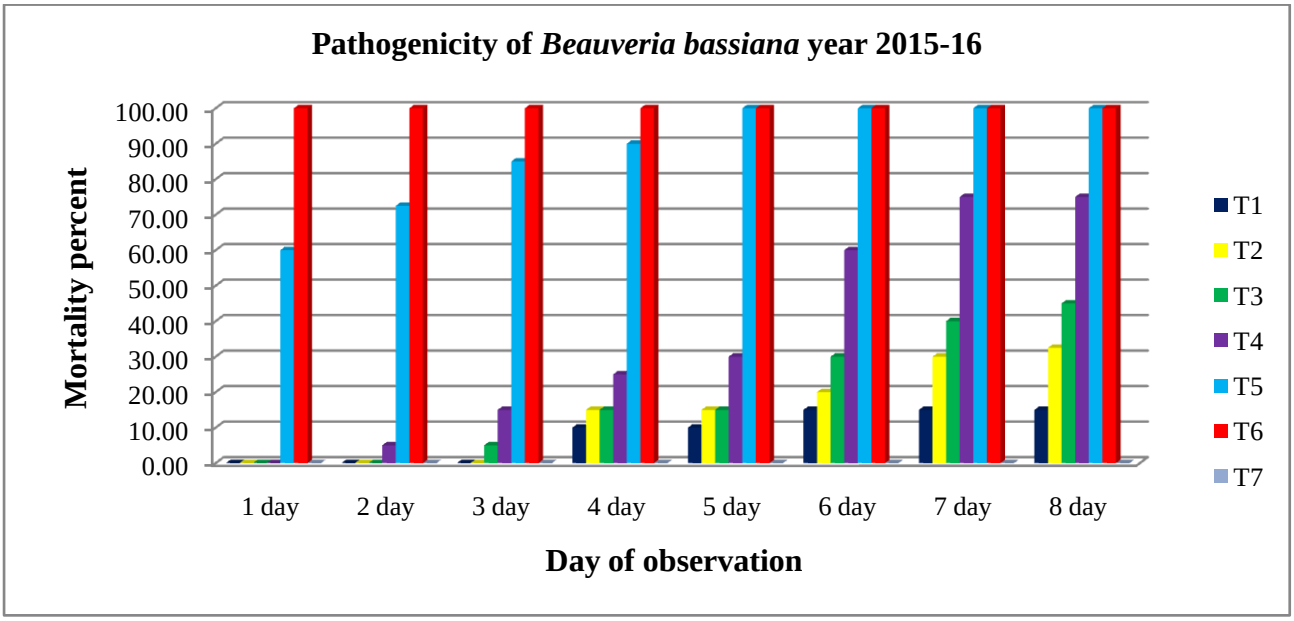

Fig 1: *In vitro* pathogenicity of *Beauveria bassiana* against *Helicoverpa armigera* Hubner

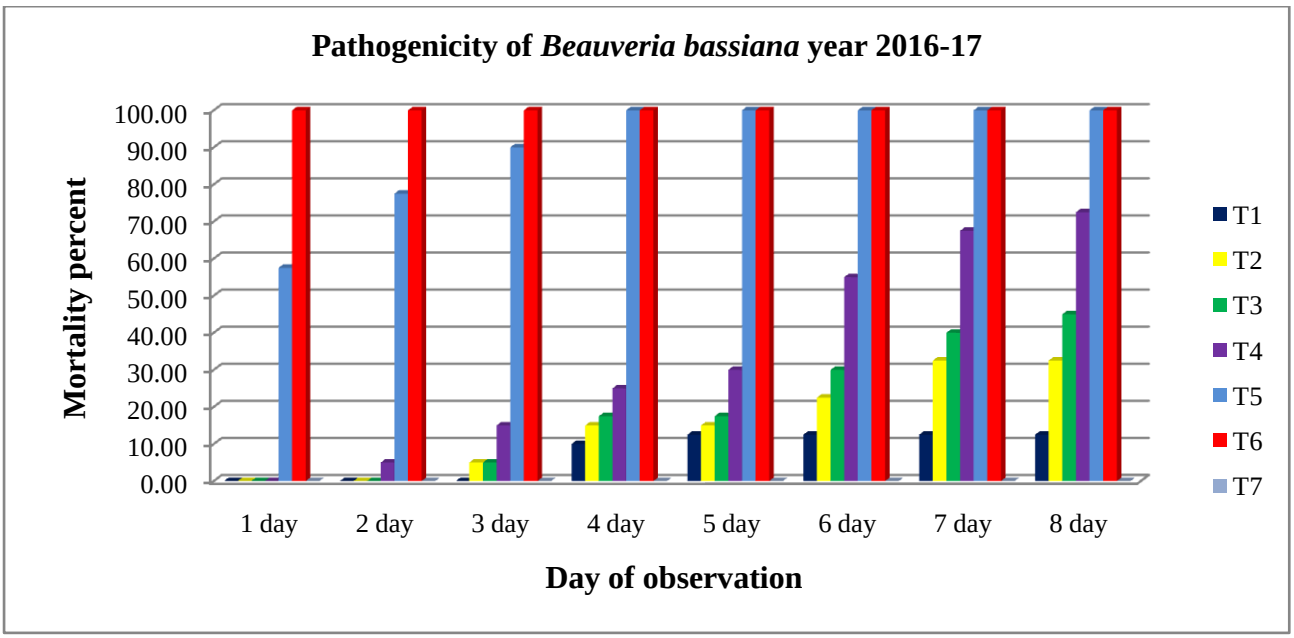

Fig 2: *In vitro* pathogenicity of *Beauveria bassiana* against *Helicoverpa armigera* Hubner

CONCLUSION

In both the year among the doses of *B. bassiana* T_4 (*B. bassiana* @5000g/ha) show the maximum mortality followed by T_3 (*B. bassiana* @3000g/ha), T_2 (*B. bassiana* @2500g/ha). Lower percent mortality recorded in T_1 (*B. bassiana* @2000g/ha) but superior than control T_7. In this experiment we can conclude that *B. bassiana* can useful bio-pesticide in integrated insect pest management for eco-friendly management of insect pests.

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