Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2021; 10(1): 1467-1474
Received: 04-11-2020
Accepted: 06-12-2020

Shyam Singh
Department of Plant Pathology, Sant Kabir College of Agriculture and Research Station, Indira Gandhi Krishi Vishwavidyalaya, Kawardha, Chhattisgarh, India

Anjeet Jangre
BRSM College of Agricultural Engineering and Technology and Research Station (IGKV) Pandariya Road Mungeli, Chhattisgarh, India

RKS Tiwari
Department of Plant Pathology, B.T.C. College of Agriculture and Research Station, Indira Gandhi Krishi Vishwavidyalaya, Bilaspur, Chhattisgarh, India

Corresponding Author:
Shyam Singh
Department of Plant Pathology, Sant Kabir College of Agriculture and Research Station, Indira Gandhi Krishi Vishwavidyalaya, Kawardha, Chhattisgarh, India

Performance of *Beauveria bassiana* and *Metarhizium anisopliae* against Pyrilla (*Pyrilla perpusilla*) in sugarcane

Shyam Singh, Anjeet Jangre and RKS Tiwari

DOI: https://doi.org/10.22271/phyto.2021.v10.i1u.13552

Abstract
Sugarcane plant hopper (*Pyrilla perpusilla* Walker) is a most destructive sucking pest of sugarcane in Chhattisgarh and it's appearing sporadically on sugarcane though out the sugarcane growing areas of this state. It is responsible for low cane yield and low sugar recovery and causes quantitative and qualitative losses in sugarcane and sugar production. In the recent years, it's appeared in severe form and become a major problem of sugarcane in this region due to heavy infestation on sugarcane. Therefore, present investigation was carried on management of sugarcane Pyrilla (*Pyrilla perpusilla*) with *Beauveria bassiana* and *Metarhizium anisopliae*. Results indicated that the most effective treatment was *Metarhizium anisopliae* Kawardha isolate @ 25% which showed highest mortality in adults and nymphs population at 15 days after 1st spray, 15 days after 2nd spray followed by *M. anisopliae* Bilaspur isolate @ 25% during 2015-16 and 2016-17. In case of nymphs mortality, *M. anisopliae* Kawardha isolate @ 25% which showed higher mortality in nymph at 15 days after 1st spray, 15, 30, 45 days after 2nd spray, respectively during both the year followed by *M. anisopliae* Kawardha isolate @ 15%, *M. anisopliae* Bilaspur isolate @ 25% and *M. anisopliae* Bilaspur isolate @ 15%. It's indicated that higher concentration of *Metarhizium anisopliae* was found significantly superior over lower concentration against adult and nymph of Pyrilla population in sugarcane. However, both the isolates of *Beauveria bassiana* were not found much effective against the adults and nymphs population of Pyrilla during both the years.

Keywords: *Beauveria bassiana,* biological control, entomopathogenic fungi, *Metarhizium anisopliae*, *Pyrilla perpusilla,* sugarcane pyrilla

Introduction
Sugarcane (*Saccharum officinarum* L.) is important cash crop in India. It is generally used for manufacturing sugar and jaggary but it is also used for manufacturing of important chemicals and industrial products such as alcohol, paper and paper board. Sugarcane is a main source of sugar in the world. About 60 per cent sugar of the world production is obtained only from sugarcane. Largest producer of sugar is Asia followed by Europe but most of the sugar in produce in Asia which is obtained from sugarcane whereas in Europe it is obtained from sugarbeet. In India, sugurcane is cultivated an area of 4.95 million ha which produce 395.00 Million metric tons during 2017-18. Productivity of sugarcane has 79.80 metric tons per hactare during 2017-18 [1, 4]. Production and productivity have been affected by several insect pest and diseases which are major constraints and responsible for low productivity and production of sugarcane in India. These biotic stresses are also reduced the sugar recovery in sugarcane. Among the sugarcane plant hopper (*Pyrilla perpusilla* Walker) is the most destructive sucking pest in subtropical India and appears sporadically on sugarcane though out the sugarcane growing areas of India. It is a major insect pest of sugarcane which is responsible for low cane yield and low sugar recovery. In the World, *Pyrilla perpusilla* is found is India, Pakistan, Afghanistan, Bangladesh, Burma, Cambodia, Indonesia, Nepal, South China, Sri Lanka, Thailand and Vietnam. In India it is appear in Bihar, Delhi, Haryana, Punjab, Madhya Pradesh, Chhattisgarh, Uttar Pradesh, Maharashtra, Gujrat, and Orissa. *P. perpusilla* is a major pest of sugarcane but it also feed on a wide range of plant belonging to family Gramineae, Leguminae and Moraceae. This insect also occasionally feeds on maize, millets, rice, barley, oats, sorghum, bajra and wild grasses in India.
Sugarcane plant hoppers have been reported in different parts of India from time to time in the epidemic form and destroy the major areas of sugarcane [7, 8]. Sugarcane plant hoppers causes about 28 – 50 per cent of crop yield losses due to the poor growth of internodes and difficulties

in milling cane from affected plants. The syrup prepared from severely infested canes is not set well during processing of jaggery and reduced the 2.2-4.5 per cent jaggery production [2]. *P. perpusilla* suck of sap from the leaves and finally plant become weak. Heavy infestation of *P. perpusilla* reduces the sucrose contents up to 50% depending on the population of *P. perpusilla* and time of appearance. Both nymphs and adults' hoppers are suck the cell sap from the underside of the leaves, mainly near midribs resulting leaves turn yellowish in color with white spots. During heavy infestation of hoppers, leaves turn yellowish white and finally dry up due to continuous sucking of sap. These hoppers also secrete the fluid which is sweet and sticky called "honeydew". These honeydews are promoting growth of several fungus such as sooty mold which are affect the photosynthesis activity. In the recent years, it's appeared in severe form and become a major problem of sugarcane in Kabirdham district of Chhattisgarh due to heavy infestation.

The present investigation has been carried out on management of sugarcane Pyrilla (*Pyrilla perpusilla*) with *Beauveria bassiana* and *Metarhizium anisopliae* because *Beauveria bassiana* and *Metarhizium anisopliae* are most effective fungi under laboratory, green house and field conditions against many insect pests of economically important crops in India. *Beauveria bassiana* have been found naturally as entophytes in many plants while, *Metarhizium anisopliae* have been found naturally as soil inhabitant and on Pyrilla in this region. These fungi have capability to build up the population within the crop canopy if they are sprayed onto plants alternative intervals. Application of *B. bassiana* has been successful control the sucking insect pests in maize, cacao, date palm, coffee, banana, radiata pine, faba beans, cotton, common bean and tomato. *Metarhizium anisopliae* was also found affective against insect pest in tomato, faba bean, oilseed rape, and haricot bean. Therefore, present investigation has been conducted to find out the efficacy *Beauveria bassiana* and *Metarhizium anisopliae* isolates against *Pyrilla perpusilla* in sugarcane and optimization doses of *Beauveria bassiana* and *Metarhizium anisopliae* against *Pyrilla perpusilla* in sugarcane.

Materials and Methods

An experiment was conducted on performance of *Beauveria bassiana* and *Metarhizium anisopliae* against Pyrilla (*Pyrilla perpusilla*) in Sugarcane at Sant Kabir College of Agriculture and Research Station (Indira Gandhi Krishi Vishwavidyalaya), Kawardha (District-Kabirdham), Chhattisgarh, India during 2015-16 and 2016-17 consisting two isolates of *Beauveria bassianaI* and two isolates of *Metarhizium anisopliae* and three doses of formulation. Experiment was layout in Randomized Block Design (RBD) with seventeen treatments viz., T_1 – *Beauveria bassiana* Bilaspur isolate @ 5%, T_2 – *Beauveria bassiana* Bilaspur isolate @ 10%, T_3 – *Beauveria bassiana* Bilaspur isolate @ 15%, T_4 – *Beauveria bassiana* Bilaspur isolate @ 25%, T_5 – *Beauveria bassiana* Jagdalpur isolate @ 5%, T_6 – *Beauveria bassiana* Jagdalpur isolate @ 10%, T_7 – *Beauveria bassiana* Jagdalpur isolate @ 15%, T_8 – *Beauveria bassiana* Jagdalpur isolate @ 25%, T_9 – *Metarhizium anisopliae* Bilaspur isolate @ 5%, T_{10} – *Metarhizium anisopliae* Bilaspur isolate @ 10%, T_{11} – *Metarhizium anisopliae* Bilaspur isolate @ 15%, T_{12} – *Metarhizium anisopliae* Bilaspur isolate @ 25%, T_{13} – *Metarhizium anisopliae* Kawardha isolate @ 5%, T_{14} – *Metarhizium anisopliae* Kawardha isolate @ 10%, T_{15} – *Metarhizium anisopliae* Kawardha isolate @ 15%, T_{16} – *Metarhizium anisopliae* Kawardha isolate @ 25%, T_{17} – Control (Water only) and three replications. One isolate of *Metarhizium anisopliae* was isolated from the naturally infected Pyrilla (*Pyrilla perpusilla*) in Kawardha region (*Metarhizium anisopliae* Kawardha isolate). Another Isolate of *Metarhizium anisopliae* (*Metarhizium anisopliae* Bilaspur isolate) was obtained from State Biocontrol Laboratory, B.T.C. College of Agriculture and Research Station, Bilaspur (C.G.). Both isolates of *Beauveria bassiana* i.e., *Beauveria bassiana* Bilaspur isolate and Beauveria *bassiana* Jagdalpur isolate were also obtained from State Biocontrol Laboratory, B.T.C. College of Agriculture and Research Station, Bilaspur (C.G.). Both the fungus was mass multiply on Potato Dextrose Broth and different concentration formulation was prepared in talc powder.

Field experiment was layout with net plot size of 5.4m X 5.0m. Most popular variety of this region i.e., Co-86032 was taken for experiment purpose. Three budded sets of variety Co-86032 was planted in the plots by maintain row to row distance of 90cm. All recommended agronomical practices were performed to maintain the good crop canopy. Suspension of both isolates of *Beauveria bassiana* and *Metarhizium anisopliae* formulation were prepared in the bucket @ 10 g formulation per liter of water just prior to the spray. Observations were recorded on nymph population per leaf, adult population per leaf, parasitized nymph population per leaf and parasitized adult population per leaf population per leaf First spray was given at the Pyrilla population reached above ETL level and second spray was given 15 days after first spray at per treatment details. Plant canopy was fully covered with suspension using foot sprayer. In control plot water was spread instead of entomopathogenic fungi. Ten plants were marked for counting of nymphs and adult's population in each plot. Total number of nymphs, adult and number of parasitized and dead nymph and adult population were counted on upper, middle and lower leaf at before spray, 15 days after first spray, 15, 30 and 45 days after second spray from 10 plants of each replication of each treatment. Total, parasitized and dead nymphs and adult's population per leaf was calculated by making an average of total, parasitized and dead nymphs and adults' population of upper, middle and lower leaves. Percentage of parasitized/mortality of nymphs and adults was calculated using following formula:

$$\text{Parasitized/mortality nymphs or adults (\%)} = \frac{\text{No. of parasitized/dead nymphs or adults per leaf}}{\text{Total no. of nymphs or adults per leaf}} \text{X100}$$

Results and Discussion

Experimental data on adult and nymph population before spray and mortality (parasitized) in adult and nymph were recorded in all the treatments at 15 days after 1st spray, 15, 30, 45 days after 2nd spray.

Mortality and parasitized adults' population

Experimental data pertaining to mortality in adults have been presented in table 1 and 2 reveal that the highest mortality recorded was 23.83, 37.44, 61.38, 73.48 per cent at 15 days after 1st spray, 15, 30, 45 days after 2nd spray, respectively in

treatment T_{16}=*M. anisopliae* Kawardha isolate @ 25%. It was at par with treatment T_{12}=*M. anisopliae* Bilaspur isolate @ 25% at 15 days after 1st spray, 15 days after 2nd spray exhibited 22.91 and 34.51 per cent mortality in adult of *Pyrilla perpusilla* in sugarcane during 2015-16 and significantly superior over all the treatments. Same trend was found during 2016-17, highest mortality of 17.20, 31.02, 39.04 and 61.34 at 15 days after 1st spray, 15, 30, 45 days after 2nd spray, respectively in treatment T_{16}=*M. anisopliae* Kawardha isolate @ 25% followed by T_{16}=*M. anisopliae* Kawardha isolate @ 25% (17.20, 31.02, 39.04, 61.34%), T_{12}=*M. anisopliae* Bilaspur isolate @ 25% (12.97, 21.70, 32.52, 38.20%), T_{15}=*M. anisopliae* Kawardha isolate @ 15% (12.73, 22.01, 31.01, 43.33%), T_{11}=*M. anisopliae* Bilaspur isolate @ 15% (8.22, 17.75, 26.06, 30.97%), T_{14}=*M. anisopliae* Kawardha isolate @ 10% (9.32, 16.74, 25.75, 30.48%), T_{13}=*M.anisopliae* Kawardha isolate @ 5% (7.58, 14.43, 19.74, 23.80%), T_{10}=*M. anisopliae* Bilaspur isolate @ 10% (6.42, 13.58, 19.05, 24.10%), T_9=*M. anisopliae* Bilaspur isolate @ 5% (4.85, 11.12, 12.95, 17.92%), T_8=*B. bassiana* Jagdalpur isolate @ 25% (0.00, 8.85, 11.83, 20.06%), T_7=*B. bassiana* Jagdalpur isolate @ 15% (0.00, 6.02, 7.71, 16.80%), T_6=*B. bassiana* Jagdalpur isolate @ 10% (0.00, 3.20, 6.98, 13.07%), T_2=*B. bassiana* Bilaspur isolate @ 10% (0.00, 1.50, 4.97, 7.41%), T_4=*B. bassiana* Bilaspur isolate @ 25% (0.00, 5.00, 12.02, 15.50%), T_3=*B. bassiana* Bilaspur isolate @ 15% (0.00, 2.30, 8.00, 10.55%), T_5=*B. bassiana* Jagdalpur isolate @ 5% (0.00, 0.00, 4.50, 9.52%), T_1=*B. bassiana* Bilaspur isolate @ 5% (0.00, 0.00, 3.02, 5.73%) at 15 days after 1st spray, 15, 30, 45 days after 2nd spray, respectively during 2016-17 (Table 2).

Numbers of adults parasitized by *B. bassiana* and *M. anisopliae* have been illustrated in figure 1 and 2 reveal that the maximum parasitized adults was recorded in treatment T_{16}–*Metarhizium anisopliae* Kawardha isolate @ 25% which showed 6.09, 16.09, 28.09, 32.59 parasitized adult per leaf during 2015-16 at 15 days after 1st spray, 15, 30, 45 days after 2nd spray, respectively and 2.21, 6.19, 8.88, 10.48 parasitized adult per leaf during 2016-17 at 15 days after 1st spray, 15, 30, 45 days after 2nd spray, respectively. Second most effective treatment was T_{12}–*Metarhizium anisopliae* Bilaspur isolate @ 25% exhibited 5.57, 13.59, 20.34, 23.19 and 1.94, 5.20, 7.85, 9.49 parasitized adult per leaf at 15 days after 1st spray, 15, 30, 45 days after 2nd spray during 2015-16 and 2016-17, respectively followed by T_{11}–*Metarhizium anisopliae* Bilaspur isolate @ 15% (4.74, 11.31, 16.90, 19.54 and 1.37, 4.46, 7.10, 8.64 per leaf), T_{15}–*Metarhizium anisopliae* Kawardha isolate @ 15% (4.57, 12.75, 19.65, 24.49 and 1.41, 4.06, 6.37, 7.88 parasitized adults per leaf), T_{14}–*Metarhizium anisopliae* Kawardha isolate @ 10% (4.26, 9.78, 14.91, 17.60 and 1.39, 3.96, 6.20, 7.51 parasitized adults per leaf), T_{13}–*Metarhizium anisopliae* Kawardha isolate @ 5% (3.72, 9.23, 13.38, 15.59 and 1.02, 3.00, 4.51, 5.55 parasitized adults per leaf), T_{10}–*Metarhizium anisopliae* Bilaspur isolate @ 10% (3.44, 9.33, 14.14, 16.87 and 0.90, 3.03, 4.96, 6.38 parasitized adults per leaf), T_9–*Metarhizium anisopliae* Bilaspur isolate @ 5% (3.09, 7.76, 10.74, 12.47 and 0.62, 2.23, 3.46, 4.63 parasitized adults per leaf), T_4–*Beauveria bassiana* Bilaspur isolate @ 25% (0.00, 3.22, 8.28, 9.95 and 0.00, 0.68, 1.81, 3.07 parasitized adults per leaf), T_2–*Beauveria bassiana* Bilaspur isolate @ 10% (0.00, 2.48, 4.35, 5.95 and 0.00, 0.27, 0.82, 1.20 parasitized adults per leaf), T_8–*Beauveria bassiana* Jagdalpur isolate @ 25% (0.00, 4.62, 9.10, 10.50 and 0.00, 1.53, 2.79, 4.10 parasitized adults per leaf), T_7–*Beauveria bassiana* Jagdalpur isolate @ 15% (0.00, 3.65, 6.10, 7.50 and 0.00, 1.00, 1.81, 2.83 parasitized adults per leaf), T_3–*Beauveria bassiana* Bilaspur isolate @ 15% (0.00, 2.78, 5.35, 6.60 and 0.00, 0.33, 1.10, 1.81 parasitized adults per leaf), T_6–*Beauveria bassiana* Jagdalpur isolate @ 10% (0.00, 2.65, 5.19, 6.23 and 0.00, 0.41, 0.97, 1.92 parasitized adults per leaf), T_5–*Beauveria bassiana* Jagdalpur isolate @ 5% (0.00, 0.50, 1.43, 1.94 and 0.00, 0.00, 0.40, 0.99 parasitized adults per leaf), T_1–*Beauveria bassiana* Bilaspur isolate @ 5% (0.00, 0.00, 0.62, 1.92 and 0.00, 0.00, 0.31, 0.65 parasitized adults per leaf) at 15 days after 1st spray, 15, 30, 45 days after 2nd spray during 2015-16 and 2016-17, respectively (Figure 1, 2).

Mortality and parasitized nymphs' population

Results of experiments on efficacy *B. bassiana* and *M. anisopliae* against nymph population of *Pyrilla perpusilla* indicated that the highest mortality in nymph of *Pyrilla perpusilla* was recorded in T_{16}=*M. anisopliae* Kawardha isolate @ 25% which showed 36.55, 39.46, 64.10 and 72.31 per cent mortality in nymph at 15 days after 1st spray, 15, 30, 45 days after 2nd spray, respectively during 2015-16 followed by T_{15}=*M. anisopliae* Kawardha isolate @ 15% (26.79, 35.66, 44.08, 59.11%), T_{12}=*M. anisopliae* Bilaspur isolate @ 25% (25.38, 33.28, 48.43, 61.95%), T_{11}=*M. anisopliae* Bilaspur isolate @ 15% (20.65, 30.34, 36.81, 54.30%), T_{14}=*M. anisopliae* Kawardha isolate @ 10% (22.41, 28.05, 39.71, 46.23%), T_{10}=*M. anisopliae* Bilaspur isolate @ 10% (18.97, 27.50, 31.90, 41.04%), T_{13}=*M.anisopliae* Kawardha isolate @ 5% (19.08, 26.07, 28.80, 38.98%), T_9=*M. anisopliae* Bilaspur isolate @ 5% (12.56, 26.01, 26.73, 34.65%), T_8=*B. bassiana* Jagdalpur isolate @ 25% (0.00, 16.22, 25.53, 30.81%), T_4=*B. bassiana* Bilaspur isolate @ 25% (0.00, 14.71, 26.84, 27.69%), T_7=*B. bassiana* Jagdalpur isolate @ 15% (0.00, 11.57, 20.90, 23.80%), T_3=*B. bassiana* Bilaspur isolate @ 15% (0.00, 9.61, 16.22, 20.70%), T_6=*B. bassiana* Jagdalpur isolate @ 10% (0.00, 8.21, 17.00, 21.23%), T_2=*B. bassiana* Bilaspur isolate @ 10% (0.00, 5.68, 13.27, 18.73%), T_1=*B. bassiana* Bilaspur isolate @ 5% (0.00, 0.00, 10.30, 16.79%) and T_5=*B. bassiana* Jagdalpur isolate @ 5% (0.00, 0.00, 6.32, 10.18%) at 15 days after 1st spray, 15, 30, 45 days after 2nd spray, respectively during 2015-16 (Table 3). Same trend was observed during 2016-17 most effective treatment was found T_{16}=*M. anisopliae* Kawardha isolate @ 25% which showed highest mortality (18.17, 34.93, 48.28, 68.52%) at 15 days after 1st spray, 15, 30, 45 days after 2nd spray, respectively. It was found statistically significant over T_1=*B. bassiana* Bilaspur isolate @ 5% (0.00, 2.01, 4.53, 7.44%), T_2=*B. bassiana* Bilaspur isolate @ 10% (0.00, 5.03, 6.52, 9.83%), T_3=*B. bassiana* Bilaspur isolate @ 15% (0.00, 8.50, 9.51, 12.99%), T_4=*B. bassiana* Bilaspur isolate @ 25% (0.00, 13.03, 13.49, 16.84%), T_5=*B. bassiana* Jagdalpur isolate @ 5% (0.00, 3.53, 6.51, 12.50%), T_6=*B. bassiana* Jagdalpur isolate @ 10% (0.00, 7.25, 9.44, 16.03%), T_7=*B. bassiana* Jagdalpur isolate @ 15% (0.00, 10.23, 12.60, 20.76%), T_8=*B. bassiana* Jagdalpur isolate @ 25% (0.00, 14.36, 15.98, 25.97%), T_9=*M. anisopliae* Bilaspur isolate @ 5% (5.68, 11.10, 16.62, 20.48%), T_{10}=*M. anisopliae* Bilaspur isolate @ 10% (8.25, 16.79, 21.94, 28.04%), T_{11}=*M. anisopliae* Bilaspur isolate @ 15% (9.76, 18.28, 25.49, 38.63%), T_{12}=*M. anisopliae* Bilaspur isolate @ 25% (13.98, 22.48, 35.10, 47.06%), T_{13}=*M.anisopliae* Kawardha isolate @ 5% (9.15, 16.90, 22.30, 29.00%), T_{14}=*M. anisopliae* Kawardha isolate @ 10% (11.91, 19.84, 27.93, 40.81%) and T_{15}=*M. anisopliae* Kawardha isolate @ 15% (14.51, 23.72, 34.72, 47.59%) at 15

days after 1st spray, 15, 30, 45 days after 2nd spray, respectively during 2015-16 and 2016-17(Table 4).

Number of nymphs parasitized by *B. bassiana* and *M. anisopliae* have been deputed in figure 3 and 4 reveal that the most effective treatment was found T_{16}–*Metarhizium anisopliae* Kawardha isolate @ 25% with 8.76, 20.64, 37.37, 43.45 and 3.53, 6.96, 11.05, 13.67 parasitized nymphs per leaf at 15 days after 1st spray, 15, 30, 45 days after 2nd spray, respectively during 2015-16 and 2016-17 followed by T_{15}–*Metarhizium anisopliae* Kawardha isolate @ 15% (10.46, 16.44, 25.89, 30.39 and 3.02, 5.57, 9.32, 11.85 parasitized nymphs per leaf), T_{12}–*Metarhizium anisopliae* Bilaspur isolate @ 25% (9.60, 15.56, 24.48, 29.50 and 2.76, 5.15, 9.20, 11.62 parasitized nymphs per leaf), T_{14}–*Metarhizium anisopliae* Kawardha isolate @ 10% (9.17, 15.43, 23.09, 26.88 and 2.52, 4.73, 7.97, 10.21 parasitized nymphs per leaf), T_{11}–*Metarhizium anisopliae* Bilaspur isolate @ 15% (8.38, 13.78, 21.05, 23.93 and 2.29, 4.54, 7.79, 10.73 parasitized nymphs per leaf), T_{13}–*Metarhizium anisopliae* Kawardha isolate @ 5% (7.94, 11.88, 18.24, 20.59 and 2.03, 4.08, 7.09, 8.74 parasitized nymphs per leaf), T_{10}–*Metarhizium anisopliae* Bilaspur isolate @ 10% (7.18, 11.75, 17.55, 20.39 and 1.58, 3.42, 6.29, 7.86 parasitized nymphs per leaf), T_9–*Metarhizium anisopliae* Bilaspur isolate @ 5% (6.73, 9.44, 16.04, 18.69 and 1.31, 2.73, 5.15, 6.27 parasitized nymphs per leaf), T_4–*Beauveria bassiana* Bilaspur isolate @ 25% (0.00, 4.68, 10.22, 12.50 and 0.00, 1.19, 2.60, 4.06 parasitized nymphs per leaf), T_8–*Beauveria bassiana* Jagdalpur isolate @ 25% (0.00, 4.44, 10.17, 12.31 and 0.00, 1.17, 2.84, 5.04 parasitized nymphs per leaf), T_7–*Beauveria bassiana* Jagdalpur isolate @ 15% (0.00, 2.60, 6.89, 8.70 and 0.00, 1.08, 2.69, 4.17 parasitized nymphs per leaf), T_3–*Beauveria bassiana* Bilaspur isolate @ 15% (0.00, 2.26, 5.13, 6.61 and 0.00, 0.84, 1.96, 3.25 parasitized nymphs per leaf), T_6–*Beauveria bassiana* Jagdalpur isolate @ 10% (0.00, 2.21, 5.77, 7.71 and 0.00, 0.58, 1.36, 2.45 parasitized nymphs per leaf), T_2–*Beauveria bassiana* Bilaspur isolate @ 10% (0.00, 1.16, 3.88, 5.16 and 0.00, 0.56, 1.44, 2.20 parasitized nymphs per leaf), T_1–*Beauveria bassiana* Bilaspur isolate @ 5% (0.00, 0.00, 1.93, 3.17 and 0.00, 0.20, 0.75, 1.38 parasitized nymphs per leaf), T_5–*Beauveria bassiana* Jagdalpur isolate @ 5% (0.00, 0.00, 1.07, 1.67 and 0.00, 0.29, 0.92, 1.52 parasitized nymphs per leaf) at 15 days after 1st spray, 15, 30, 45 days after 2nd spray, respectively during 2015-16 and 2016-17.

In the investigations, application of *M. anisopliae* with higher concentration (Higher cfu values) was most effective in reducing the population of adults and nymphs of sugarcane pyrilla in sugarcane sprayed at regular intervals. This intomopathogenic fungi persist in the soil on dead organic matter and also can survive on crop residues for a longer long times and parasitize on insect when the insect appears in the fields. *M. anisopliae* has been commercially used to control several insects such as coconut rhinoceros beetle, groundnut cut worm, rice brown plant hopper, diamond back moth, stem borer, shoot borer and white grubs in many crops. *Beauveria* and *Metarhizium* are used commercially as biopesticide against several insects [9]. *Metarhizium anisopliae* as a microbial pesticide indicated that overwintering populations of *Pyrilla perpusilla* could readily be infected and that infected individuals were capable of spreading the infection and inducing an epizootic [13]. Entomopathogenic fungi such as *Metarhizium and Beauveri* were found better than *Bacillus thuringiensis* or nucleopolyhedrosis virus (NPV) [11]. *Beauveria bassiana, Fusarium oxysporum* and *Metarhizium anisopliae* var. *anisopliae* were evaluated against eleven different insect pests of sugarcane under laboratory and concluded that the *B. bassiana* was found most pathogenic to larvae of *Chilo auricilius, Chilo infuscatellus* and *Sesamia inferens*, nymphs and adults of *Cavelerius sweeti*, adults of *Phytoscaphus* sp. and *Astychus lateralis* and grubs of *Holotrichia consanguinea* whereas, *Metarhizium anisopliae* was found pathogenic to larvae of *C. auricilius, C. infuscatellus* and *S. inferens*, adults of *Phytoscaphus* sp. and *A. iateralis*, and adults and nymphs of *Pyrilla perpusilla* [12]. Isolated 16 different isolates of *Metarhizium anisopliae* (Metschnikoff) based from stem borer [5]. Two formulations - broken white rice and parboil rice of *Metarhizium anisopliae* were tested against rice-stem bugs, *Tibraca limbativentri* and reveal that the both formulations, the % G decreased from 97% to less than 87.32% and 85.11% at 6°C after 50 and 100 days of room storage, respectively. At 20°C the %G presented values below 51.42% and 16.47% after 50 and 100 days of storage, respectively [3]. In order to assess the effectiveness of *Metarhizium anisopliae* var. *anisopliae* (Metschnikoff) Sorokin isolates in controlling the sugarcane root spittlebug *Mahanarva fimbriolata* (Stal). Manisegaran *et al*. (2011) [6] reveal that the *Metarhizium anisopliae* was found effective against sugarcane white grub *Holotrichia serrata* at 4 x1 09 conidia ha^{-1} and reduced 92% of grub population at 60th DAT. M. anisopliae @ 5x1013 spores ha-1 mixed with farm yard manure (FYM) was found effective followed by *B. bassiana* @ 5x1013 spores ha^{-1} applied in FYM enriched field and registered 93.6% and 88.09% decrease in white grub damage and 77.22% and 74.08% decrease in white grub population. The highest cane yield was recorded when *M. anisopliae* @ 5x1013 spores ha-1 (81.44 t ha^{-1}) applied with FYM followed by *B. bassiana* @ 5x1013 spores ha-1 (76.6 t ha^{-1}) with FYM [6]. Differential pathogenicity of *Metarhizium anisopliae* against sugarcane root spittlebug, *Mahanarva fimbriolata* was observed [10]. Similar trend was observed by imposing treatments at one month after planting i.e., after the onset of monsoon in the month of july. *M. anisopliae* @ 5x1013 spores ha-1 (79.73 t ha^{-1}) recorded highest cane yield followed by *B. bassiana* @ 5x10 13 spores ha-1 (76.45 t ha^{-1}) when applied with FYM at one month after planting. However, highest percent yield increase was recorded in *M. anisopliae* @ 5x10 13 spores ha^{-1} (71.56%) applied with FYM at the time of planting [14].

Table 1: Efficacy of *B. bassiana* and *M. anisopliae* isolates against adult's population of Pyrilla in sugarcane during 2015-16

Treatment	Adults population before spray (No./leaf)	Mortality (Parasitized) of adults *Pyrilla perpusilla* (%)			
		15 Days after 1st Spray	15 Days after 2nd Spray	30 Days after 2nd Spray	45 Days after 2nd Spray
T_1=*B. bassiana* Bilaspur isolate @ 5%	16.51	0.00 (0.00)	0.00 (0.00)	3.72 (11.09)	10.19 (18.57)
T_2=*B. bassiana* Bilaspur isolate @ 10%	17.60	0.00 (0.00)	9.60 (18.01)	13.31 (21.28)	17.79 (24.81)
T_3=*B. bassiana* Bilaspur isolate @ 15%	18.40	0.00 (0.00)	12.86 (20.98)	16.26 (23.75)	20.35 (26.78)
T_4=*B. bassiana* Bilaspur isolate @ 25%	18.90	0.00 (0.00)	15.01 (22.78)	21.50 (27.61)	25.09 (30.04)
T_5=*B. bassiana* Jagdalpur isolate @ 5%	16.40	0.00 (0.00)	2.85 (9.71)	5.59 (13.67)	9.79 (18.22)
T_6=*B. bassiana* Jagdalpur isolate @ 10%	20.50	0.00 (0.00)	10.79 (19.14)	14.31 (22.15)	17.15 (24.39)
T_7=*B. bassiana* Jagdalpur isolate @ 15%	22.11	0.00 (0.00)	13.37 (21.44)	16.11 (23.66)	18.38 (25.38)
T_8=*B. bassiana* Jagdalpur isolate @ 25%	15.80	0.00 (0.00)	20.37 (26.79)	19.48 (26.09)	24.51 (29.57)
T_9=*M. anisopliae* Bilaspur isolate @ 5%	20.60	13.27 (21.33)	17.20 (24.46)	20.26 (26.69)	28.38 (32.12)
T_{10}=*M. anisopliae* Bilaspur isolate @ 10%	18.50	13.88 (21.86)	23.79 (29.18)	29.82 (33.05)	33.45 (35.29)
T_{11}=*M. anisopliae* Bilaspur isolate @ 15%	20.01	19.82 (26.40)	24.50 (29.63)	32.31 (34.55)	36.84 (37.29)
T_{12}=*M. anisopliae* Bilaspur isolate @ 25%	21.80	22.91 (28.57)	34.51 (35.94)	40.30 (39.35)	48.59 (44.19)
T_{13}=*M.anisopliae* Kawardha isolate @ 5%	18.10	18.00 (25.10)	27.12 (31.94)	29.27 (32.65)	34.35 (34.79)
T_{14}=*M. anisopliae* Kawardha isolate @ 10%	19.31	19.05 (25.84)	20.33 (26.77)	34.09 (35.52)	37.93 (37.83)
T_{15}=*M. anisopliae* Kawardha isolate @ 15%	16.90	19.58 (26.20)	32.45 (34.67)	40.71 (39.60)	47.68 (43.65)
T_{16}=*M. anisopliae* Kawardha isolate @ 25%	20.50	23.83 (29.18)	37.44 (37.70)	61.38 (51.75)	73.48 (59.74)
T_{17} = Control (Water only)	21.25	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
CV (%)		10.75	12.63	13.38	14.21
SEm±		0.75	1.66	2.10	2.53
CD at 5%		2.71	4.79	6.05	7.28

Figure () parentheses are Arcsine Transformation value

Table 2: Efficacy of *B. bassiana* and *M. anisopliae* isolates against adults population of Pyrilla in sugarcane during 2016-17

Treatment	Adults population Before spray (No./leaf)	Mortality (Parasitized) of adults *Pyrilla perpusilla* (%)			
		15 Days after 1st Spray	15 Days after 2nd Spray	30 Days after 2nd Spray	45 Days after 2nd Spray
T_1=*B. bassiana* Bilaspur isolate @ 5%	11.67	0.00 (0.00)	0.00 (0.00)	3.02 (9.98)	5.73 (13.81)
T_2=*B. bassiana* Bilaspur isolate @ 10%	12.40	0.00 (0.00)	1.50 (6.99)	4.97 (12.80)	7.41 (15.70)
T_3=*B. bassiana* Bilaspur isolate @ 15%	11.60	0.00 (0.00)	2.30 (8.71)	8.00 (16.41)	10.55 (18.93)
T_4=*B. bassiana* Bilaspur isolate @ 25%	14.60	0.00 (0.00)	5.00 (12.91)	12.02 (20.27)	15.50 (23.18)
T_5=*B. bassiana* Jagdalpur isolate @ 5%	11.60	0.00 (0.00)	0.00 (0.00)	4.50 (12.24)	9.52 (17.96)
T_6=*B. bassiana* Jagdalpur isolate @ 10%	11.00	0.00 (0.00)	3.20 (10.27)	6.98 (15.26)	13.07 (21.12)
T_7=*B. bassiana* Jagdalpur isolate @ 15%	12.07	0.00 (0.00)	6.02 (14.20)	7.71 (16.12)	16.80 (24.19)
T_8=*B. bassiana* Jagdalpur isolate @ 25%	12.53	0.00 (0.00)	8.85 (17.23)	11.83 (20.03)	20.06 (26.50)
T_9=*M. anisopliae* Bilaspur isolate @ 5%	13.73	4.85 (12.69)	11.12 (19.42)	12.95 (21.04)	17.92 (24.98)
T_{10}=*M. anisopliae* Bilaspur isolate @ 10%	16.33	6.42 (14.64)	13.58 (21.58)	19.05 (25.83)	24.10 (29.35)
T_{11}=*M. anisopliae* Bilaspur isolate @ 15%	14.67	8.22 (16.59)	17.75 (24.83)	26.06 (30.60)	30.97 (33.72)
T_{12}=*M. anisopliae* Bilaspur isolate @ 25%	13.20	12.97 (21.03)	21.70 (27.67)	32.52 (34.68)	38.20 (38.10)
T_{13}=*M.anisopliae* Kawardha isolate @ 5%	11.73	7.58 (15.91)	14.43 (22.24)	19.74 (26.28)	23.80 (29.10)
T_{14}=*M. anisopliae* Kawardha isolate @ 10%	10.87	9.32 (17.61)	16.74 (23.95)	25.75 (30.28)	30.48 (33.30)
T_{15}=*M. anisopliae* Kawardha isolate @ 15%	12.60	12.73 (20.85)	22.01 (27.92)	31.01 (33.78)	43.33 (41.13)
T_{16}=*M. anisopliae* Kawardha isolate @ 25%	11.00	17.20 (24.44)	31.02 (33.78)	39.04 (38.62)	61.34 (51.72)
T_{17} = Control (Water only)	14.07	0.00 (0.00)	0.00 (0.00)	0.00	0.00 (0.00)
CV (%)		17.50	13.68	12.98	13.37
SEm±		0.85	1.26	1.60	2.01
CD at 5%		2.46	3.64	4.62	5.79

Figure () parentheses are Arcsine Transformation value

Table 3: Efficacy of *B. bassiana* and *M. anisopliae* isolates against nymph population of Pyrilla in sugarcane during 2015-16

Treatment	Nymph population Before spray (No./leaf)	Mortality (Parasitized) of nymph *Pyrilla perpusilla* (%)			
		15 Days after 1st Spray	15 Days after 2nd Spray	30 Days after 2nd Spray	45 Days after 2nd Spray
T_1=*B. bassiana* Bilaspur isolate @ 5%	24.6	0.00 (0.00)	0.00 (0.00)	10.30 (18.68)	16.79 (24.14)
T_2=*B. bassiana* Bilaspur isolate @ 10%	21.88	0.00 (0.00)	5.68 (13.71)	13.27 (21.24)	18.73 (25.51)
T_3=*B. bassiana* Bilaspur isolate @ 15%	27.32	0.00 (0.00)	9.61 (18.03)	16.22 (23.72)	20.70 (27.03)
T_4=*B. bassiana* Bilaspur isolate @ 25%	33.2	0.00 (0.00)	14.71 (22.54)	26.84 (31.19)	27.69 (31.73)
T_5=*B. bassiana* Jagdalpur isolate @ 5%	24.02	0.00 (0.00)	0.00 (0.00)	6.32 (14.55)	10.18 (18.60)
T_6=*B. bassiana* Jagdalpur isolate @ 10%	30.38	0.00 (0.00)	8.21 (16.59)	17.00 (24.27)	21.23 (27.35)
T_7=*B. bassiana* Jagdalpur isolate @ 15%	31.74	0.00 (0.00)	11.57 (19.88)	20.90 (27.20)	23.80 (29.19)
T_8=*B. bassiana* Jagdalpur isolate @ 25%	28.64	0.00 (0.00)	16.22 (23.65)	25.53 (30.24)	30.81 (33.61)
T_9=*M. anisopliae* Bilaspur isolate @ 5%	21.2	12.56 (20.71)	26.01 (30.61)	26.73 (31.07)	34.65 (36.00)
T_{10}=*M. anisopliae* Bilaspur isolate @ 10%	25.9	18.97 (25.77)	27.50 (31.56)	31.90 (34.34)	41.04 (39.81)

T_{11}=*M. anisopliae* Bilaspur isolate @ 15%	23.24	20.65 (26.93)	30.34 (33.33)	36.81 (37.27)	54.30 (47.55)
T_{12}=*M. anisopliae* Bilaspur isolate @ 25%	29.92	25.38 (30.16)	33.28 (35.14)	48.43 (44.10)	61.95 (52.16)
T_{13}=*M.anisopliae* Kawardha isolate @ 5%	35.48	19.08 (25.80)	26.07 (30.48)	28.80 (32.36)	38.98 (38.56)
T_{14}=*M. anisopliae* Kawardha isolate @ 10%	20.2	22.41 (28.04)	28.05 (31.88)	39.71 (38.89)	46.23 (42.73)
T_{15}=*M. anisopliae* Kawardha isolate @ 15%	30.38	26.79 (31.11)	35.66 (36.61))	44.08 (41.57)	59.11 (50.32)
T_{16}=*M. anisopliae* Kawardha isolate @ 25%	22.96	36.55 (37.14)	39.46 (38.87)	64.10 (53.43)	72.31 (58.89)
T_{17} = Control (Water only)	32.50	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
CV (%)		18.61	12.98	13.60	14.78
SEm±		1.69	1.51	2.33	2.93
CD at 5%		4.86	4.34	6.70	8.43

Figure () parentheses are Arcsine Transformation value

Table 4: Efficacy of *B. bassiana* and *M. anisopliae* isolates against nymph population of Pyrilla in sugarcane during 2016-17

Treatments	**Nymph population Before spray (No./leaf)**	**Mortality (Parasitized) of nymph *Pyrilla perpusilla* (%)**			
		15 Days after 1st Spray	**15 Days after 2nd Spray**	**30 Days after 2nd Spray**	**45 Days after 2nd Spray**
T_1=*B. bassiana* Bilaspur isolate @ 5%	13.87	0.00 (0.00)	2.01 (8.13)	4.53 (12.26)	7.44 (15.79)
T_2=*B. bassiana* Bilaspur isolate @ 10%	19.67	0.00 (0.00)	5.03 (12.88)	6.52 (14.70)	9.83 (18.16)
T_3=*B. bassiana* Bilaspur isolate @ 15%	14.67	0.00 (0.00)	8.50 (16.93)	9.51 (17.94)	12.99 (21.10)
T_4=*B. bassiana* Bilaspur isolate @ 25%	21.87	0.00 (0.00)	13.03 (21.15)	13.49 (21.53)	16.84 (24.22)
T_5=*B. bassiana* Jagdalpur isolate @ 5%	17.00	0.00 (0.00)	3.53 (10.82)	6.51 (14.78)	12.50 (20.70)
T_6=*B. bassiana* Jagdalpur isolate @ 10%	22.40	0.00 (0.00)	7.25 (15.57)	9.44 (17.83)	16.03 (23.52)
T_7=*B. bassiana* Jagdalpur isolate @ 15%	18.60	0.00 (0.00)	10.23 (18.65)	12.60 (20.79)	20.76 (27.10)
T_8=*B. bassiana* Jagdalpur isolate @ 25%	15.13	0.00 (0.00)	14.36 (22.17)	15.98 (23.46)	25.97 (30.53)
T_9=*M. anisopliae* Bilaspur isolate @ 5%	13.33	5.68 (13.75)	11.10 (19.41)	16.62 (24.00)	20.48 (26.84)
T_{10}=*M. anisopliae* Bilaspur isolate @ 10%	21.53	8.25 (16.66)	16.79 (24.14)	21.94 (27.88)	28.04 (31.92)
T_{11}=*M. anisopliae* Bilaspur isolate @ 15%	20.53	9.76 (18.13)	18.28 (25.22)	25.49 (30.23)	38.63 (38.36)
T_{12}=*M. anisopliae* Bilaspur isolate @ 25%	20.20	13.98 (21.87)	22.48 (28.12)	35.10 (36.25)	47.06 (43.30)
T_{13}=*M.anisopliae* Kawardha isolate @ 5%	18.87	9.15 (17.53)	16.90 (24.18)	22.30 (28.08)	29.00 (32.48)
T_{14}=*M. anisopliae* Kawardha isolate @ 10%	17.07	11.91 (20.01)	19.84 (26.24)	27.93 (31.69)	40.81 (39.54)
T_{15}=*M. anisopliae* Kawardha isolate @ 15%	17.00	14.51 (22.34)	23.72 (29.08)	34.72 (36.05)	47.59 (43.60)
T_{16}=*M. anisopliae* Kawardha isolate @ 25%	15.47	18.17 (25.17)	34.93 (36.17)	48.28 (44.01)	68.52 (56.28)
T_{17} = Control (Water only)	17.07	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
CV (%)		17.68	12.19	12.92	14.13
SEm±		0.93	1.40	1.76	2.37
CD at 5%		2.69	4.04	5.08	6.82

Figure () parentheses are Arcsine Transformation value

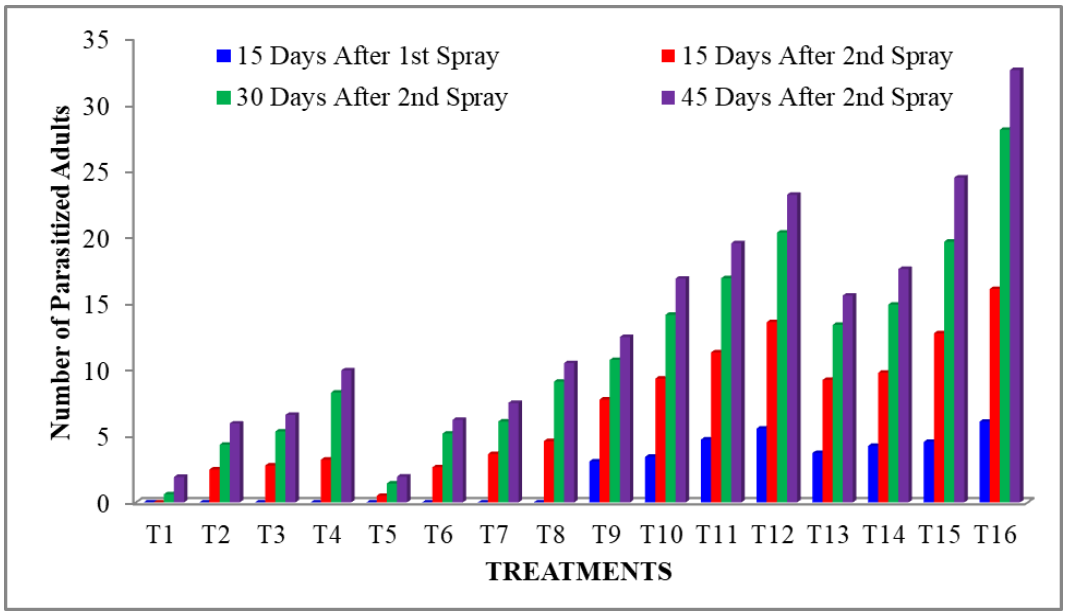

Fig 1: Parasitised adults population of Pyrilla with *Beauveria bassiana* and *Metarhizium anisopliae* in sugarcane during 2015-16

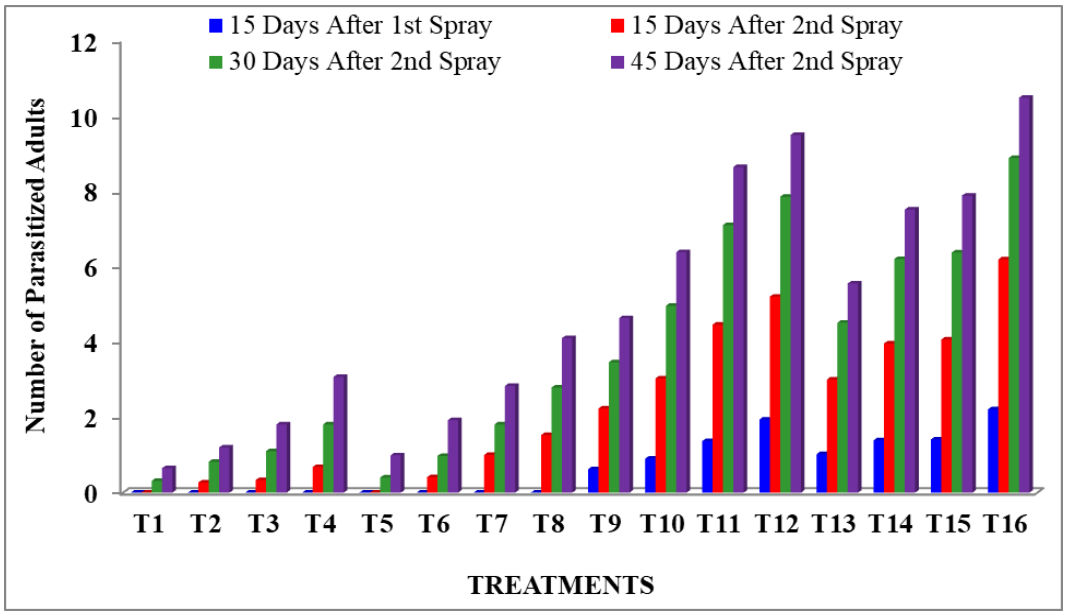

Fig 2: Parasitised adults' population of Pyrilla with *Beauveria bassiana* and *Metarhizium anisopliae* in sugarcane during 2016-17

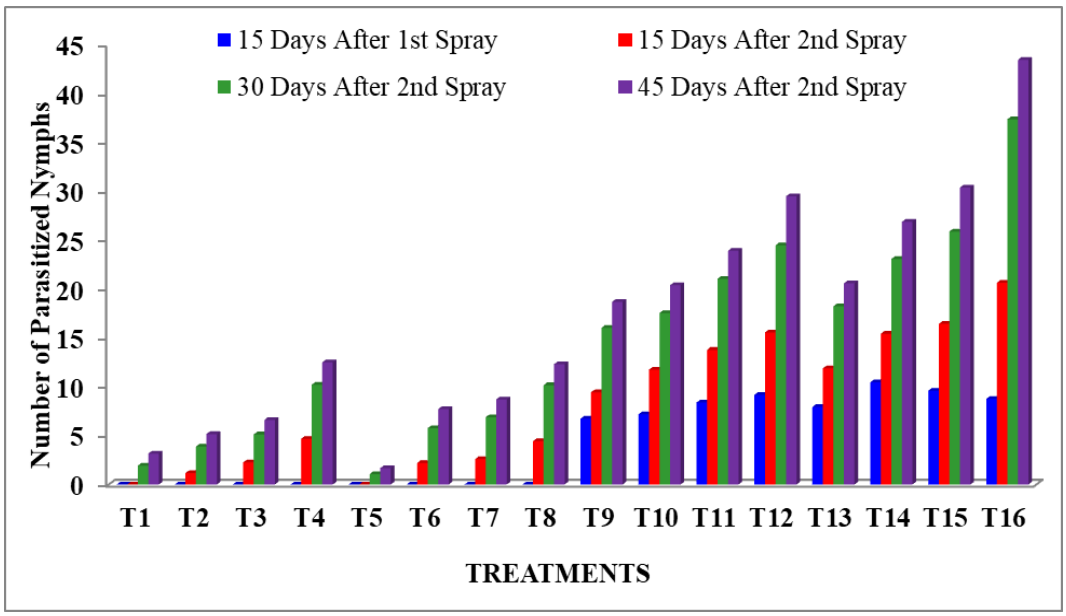

Fig 3: Parasitised nymphs' population of Pyrilla with *Beauveria bassiana and Metarhizium anisopliae* in sugarcane during 2015-16

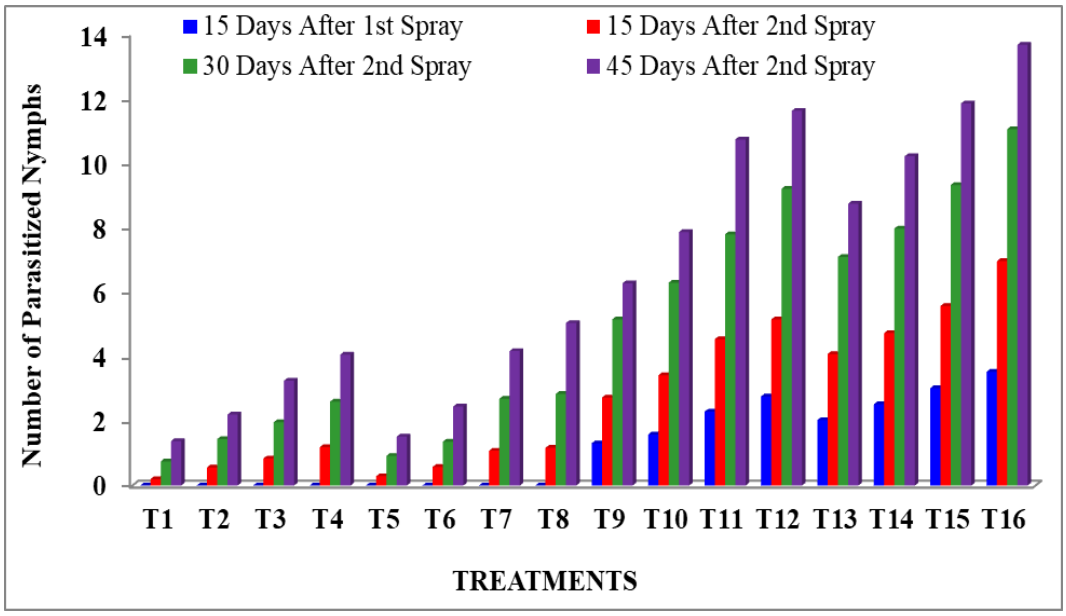

Fig 4: Parasitised nymphs' population of Pyrilla with *Beauveria bassiana and Metarhizium anisopliae* in sugarcane during 2016-17

Acknowledgements
We thank the director of the Research, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India for providing financial support on this program. We thank Head, Department of Plant Pathology, *Indira Gandhi Krishi Vishwavidyalaya*, Raipur, Chhattisgarh, India for their helpful guiding in conducting experiment.

References

1. Anonymous. Pocket Book of Agricultural Statistics. Government of India Ministry of Agriculture & Farmers Welfare Department of Agriculture, Cooperation & Farmers Welfare Directorate of Economics & Statistics New Delhi 2018,1-122.
2. Gupta BD. Control of sugarcane leaf hopper (*Pyrilla* spp.) in the U.P. Indian Farming, 1948;9:401-406.
3. Kruger RD, Posadas JB, Lewylle MA, Mini JI, Lecuona RE. Solid substrate production and formulation of an isolate of Metarhizium anisopliae for biological control of stem bug Tibraca limbativentris. World Applied Sciences Journal 2014;32(7):1242-1251.
4. Landry T, Aradhey A. Global Agricultural Information Networks. India Sugar Annual Report 2018;IN8047:1–12.
5. Liu L, Zhan R, Yang L, Liang C, Zeng D, Huang J. Isolation and identification of *Metarhizium anisopliae* from *Chilo venosatus* (Lepidoptera: Pyralidae) cadaver. African Journal of Biotechnology, 2012;11(30):7609–7617.
6. Manisegaran S, Lakshmi SM, Srimohanapriya V. Field Evaluation of *Metarhizium anisopliae* (Metschnikoff) Sorokin against *Holotrichia serrata* (Blanch) in sugarcane. Journal of Biopesticides, 2011;4(2):190-193.
7. Pawar SV, Patil SC, Jambhale VM, Naik RM, Mehetre SS. Rapid multiplication of commercial sugarcane varieties through tissue culture. Indian Sugar 2002;11:183-186.
8. Rajak DC. Colonization and redistribution of Epiricania mealanoleuca Fletcher against Pyrilla perpusilla Walker. Annals of Plant Protection Science 2007;15:83-86.
9. Shahid AA, Rao AQ, Bakhsh A, Husnain T. Entomopathogenic fungi as biological controllers: New insights into their virulence and pathogenicity. Archives of Biological Science, Belgrade 2012;64(1):21-42.
10. Tiago PV, Souza HMde L, Moyses JB, Oliveira NTde, Lima EÁ de LA. Differential pathogenicity of *Metarhizium anisopliae* and the control of the sugarcane root spittlebug *Mahanarva fimbriolata*. Brazilian Archives of Biology and Technology 2011;54(3):1516-8913.
11. Tupe SG, Pathan EK, Deshpande MV. Development of *Metarhizium anisopliae* as a Mycoinsecticide: From Isolation to Field Performance. J Vis. Exp 2017;125:e55272.
12. Varma A, Tandan, BK. Pathogenicity of three entomogenous fungi against insect pests of sugarcane. Journal of Biological Control 1996;10:87-91.
13. Varma A, Singh K. *Metarhizium anisopliae* (Metschnikoff) Sorokin in the management of *Pyrilla perpusilla* Walker, the sugarcane leaf hopper. Ento. Newsletter 1987;18(12):20-24.
14. Visalakshi M, Bhavani B, Rao SG. Field evaluation of entomopathogenic fungi against white grub, *Holotrichia consanguinea* Blanch in sugarcane. Journal of Biological Control 2015;29(2):103-106.