Evaluation of the *Beauveria bassiana* Grown under Nanomaterial Enriched Media for its Relative Efficacy against *S. litura* under Laboratory Conditions

M. Gayathri¹*, N.C. Venkateswarlu¹, T. Murali Krishna² and K. Devaki¹

¹Department of Entomology, S.V. Agricultural College, Tirupati 517502, India
²KVK, Kalyandurg, Ananthapur district, 515761, India

*Corresponding author

**A B S T R A C T**

*Beauveria bassiana* (Balsamo) Vuillemin (Ascomycota: Hyphocreales) is a facultative pathogen with wide host range. The bioefficacy of entomopathogens in relation to number of conidia in *B.bassiana* were chance to increase the bioefficacy with respect to the mortality of lepidopteran larvae by adding minerals. These minerals are namely calcium, magnesium, iron and zinc were added to SDAY media at 10, 20, 50, 100 and 500 ppm. As a result the efficacy of entomopathogens will increase. The cumulative per cent mortality with nano enriched *B. bassiana* was ranged between 16.67 and 90.00 per cent in different treatments. The highest per cent mortality (90.00) was recorded with MgO at 50 ppm which is on par with CaO 20 ppm and FeO 10 ppm based *B. bassiana*, followed by ZnO at 10 ppm (83.33). Where as in control it was 16.67 per cent during 2016. Similarly during 2017 also the same treatments have given the highest per cent mortality compare to other treatments.

**Keywords**

Nanomaterials, *Beauveria bassiana*, *S. litura* relative efficacy

**Introduction**

The tobacco caterpillar, *Spodoptera litura* (F.), has been reported as one of the major insect pest of groundnut and feed on 112 cultivated food plants all over the world (Mousa *et al.*, 1980) of which 40 are grown in India (Basu, 1981, Muthukrishnan *et al.*, 2005). It passes through 5-6 overlapping generations annually (Sasidharan and Varma, 2005; Kumar and Chapman, 2006) and if not controlled timely, it may causes in huge crop losses ranging from 25.8-100 percent in various parts of India (Ahmad *et al.*, 2005).

The management of *S. litura* using insecticides has become difficult because of the development of resistance and effect to non-target organisms *viz.*, natural enemy population as well as frequent use of these insecticides increasing problems of human health and environmental pollution.

Biological control of insect pests is one of the most important component of Integrated Pest Management (IPM), wherein entomopathogens such as bacteria, viruses and fungi are exploited against insect pests.
Although 700 to 750 species of EPF have been reported as pathogenic to insects but only about a dozen have been exploited for insect control (Stark and Banks, 2003). Among these Beauveria bassiana (Balsamo) Vuillemin (Ascomycota: Hyphocreales) is a facultative pathogen with wide host range (Armes et al., 1997; Sahayaraj et al., 2007). This fungus has potential to control over 70 insect pests belonging to different orders particularly lepidopteran pests, infesting various crops and appears to be innocuous to most non target organisms.

The bioefficacy of entomopathogens in relation to number of conidia in B. bassiana were chance to increase the bioefficacy with respect to the mortality of lepidopteran larvae by adding minerals. These minerals are namely calcium, magnesium, iron and zinc will enhance the conidial count in B. bassiana. As a result the efficacy of entomopathogens will increases. The nanoparticles of these minerals will increase the conidial count in B. bassiana and also chance to decrease the dose of biopesticides. Nanoparticles are atomic or molecular aggregates characterized by size less than 100 nm. These are actually modified form of basic elements derived by altering their atomic as well as molecular properties of elements (Suchea, et al., 2006).

To enhance the biopesticides efficacy interms of increasing the number of conidial in B. bassiana the mineral salts viz., Calcium, magnesium, iron and zinc were added to the media before inoculation (Valicente et al., 2010).

By considering all these issues, to know the impact of nanobased material on bio pesticides to enhance their efficacy for longer periods and their combined effect on S. litura management, the present study has been taken up.

**Materials and Methods**

**Preparation of nanoparticulate solutions**

Oxide nanoparticles of Zn, Ca, Mg and Fe weighing 250 mg was added to 500 ml of distilled water (500 ppm) and from this solution different concentrations (100, 50, 20 and 10 ppm) of nanoparticulate solutions were prepared by adding the respective volumes of distilled water.

From the prepared nanoparticulate solutions Zn, Fe, Ca and Mg at 10 ppm, 20 ppm, 50 ppm, 100 ppm and 500 ppm in 1:9 ratio (1ml of nanoparticulate solution to 9ml of LBA media) was added to the Sabouraud Dextrose Agar media (SDAY) media before sterilisation to study the relative efficacy of B. bassiana against S.litura.

**Mass multiplication of S. litura**

For multiplication and maintenance of S. litura population in the laboratory equipment like wire cages for oviposition, plastic troughs for larval maintenance, plastic boxes for pupae were cleaned with ethanol and were dried under solar radiation. The mother culture of S. litura egg masses were collected from field and surface sterilized with 4 per cent formaldehyde, washed 3-4 times with distilled water and kept in plastic transparent covers tied with rubber band. Castor leaves were provided to freshly emerged Spodoptera larvae. After three days, the larvae were segregated based on size into transparent plastic rearing troughs and covered with muslin cloth. The food material was changed twice in a day till pupation. Before pupation, larvae were transferred to another plastic container containing sterilized soil and allowed them for pupation. The emerged moths were transferred to oviposition cages. Cotton swab dipped in 10 per cent honey solution was kept in cage as food for the
adults. For oviposition by the female moths fresh castor plant with tender twigs were arranged in conical flasks containing $\frac{3}{4}$th of water and kept in cages. Egg masses were collected every day and later sterilized. After hatching, the larvae were reared up to third instar for further laboratory bioassay studies.

**Bioassay of B.bassiana grown on Nanomaterial based media against S. litura**

To know the efficiency of *B.bassiana* grown on nanomaterial based media, bioassay studies were conducted in laboratory against *S.litura*. The spore suspension was prepared from 15 days old culture of *B.bassiana* along with added nanomaterials viz., Zn, Ca, Mg and Fe at 10, 20, 50, 100 and 500 ppm concentration and without nanomaterials was evaluated against *S.litura* on 3rd instar larvae at 10 days interval. Sterilized plastic troughs (20 cm x 20 cm) were taken into which one groundnut compound leaf containing four leaflets (quadrate leaf) was dipped for 10 minutes into culture broth (1x10$^8$ to 1x10$^5$ spores 1mL$^{-1}$), later leaflets were taken out and kept for air drying till leaf surface free from moisture. After drying, the petiole of leaf was swabbed with wet cotton to maintain leaf succulence and turgidity. One compound leaf was used for one replication. which was placed in a Petri plate. Ten larvae were released per each treatment which was replicated thrice. In control treatment the leaflets (quadrat leaf) were dipped in distilled water and served as control. The larval mortality was assessed after 120 h at regular intervals.

For each treatment ten third instar *S.litura* larvae were released to crawl on the treated leaf and daily observations were recorded on post treatment changes of larvae, larval mortality, pupal mortality, malformed pupae and adults until to death. Each treatment was replicated thrice along with an untreated control (Hafez *et al.*, 1994). The per cent larval mortality was expressed by using the following formula.

The larval mortality was converted to percentage before subjecting to statistical analysis by using the formula.

\[
\text{Per cent larval mortality} = \frac{\text{No. of larvae dead due to infection}}{\text{Total number of larvae treated}} \times 100
\]

The per cent mortality was analysed statistically after transforming into angular values.

**Results and Discussion**

**Evaluation of B. bassiana grown in nanomaterial enriched media against S. litura**

*B. bassiana* (SGB strain) culture was maintained in the laboratory and 5 mm discs were made from four days old culture and inoculated in to SDAY plates which were added with different nanomaterials at different concentrations. Then the culture was allowed to grow for 15 days. Then spore suspension was prepared by mixing with 10 ml of sterile distilled water. A series of bioassays were conducted by providing groundnut leaves which were dipped into spore suspensions containing *B.bassiana*. Then the mortality rate was recorded daily up to pupation and results are presented in the table 1 and 2.

During 2016, the mortality of *S.itura* after 120 hours of treatment was ranged from 6.67 to 76.67 per cent. The maximum mortality of 76.67 per cent was recorded with MgO based *B.bassiana* at 50 ppm and 73.33 with CaO based *B.bassiana*, at 20 ppm and 56.67 with ZnO based *B.bassiana* and 20.00 and 43.33 per cent with FeO based *B.bassiana*. 
Table 1 Influence of different nanoparticles on the efficacy of B. bassiana against S. litura at different concentrations during the year 2016

| S.No. | Name of the Treatment | S. litura Per cent mortality |
|-------|------------------------|-----------------------------|
|       |                        | 120h | 144h | 168h | 192h | Cumulative |
| 1     | Magnesium oxide (MgO) 10 ppm | 36.67 (33.21)cdef | 23.33 (28.88)bcde | 6.67 (14.96) | 0.00 (0.00) | 66.67 (54.74)ab |
| 2     | Magnesium oxide (MgO) 20 ppm | 33.33 (43.09)def | 40.00 (3923)abc | 10.00 (18.43) | 0.00 (0.00) | 83.33 (65.91)ab |
| 3     | Magnesium oxide (MgO) 50 ppm | 76.67 (58.91)a | 13.33 (21.42)de | 0.00 (0.00) | 0.00 (0.00) | 90.00 (71.57)ab |
| 4     | Magnesium oxide (MgO) 100 ppm | 43.33 (41.17)cd | 30.00 (33.21)abcd | 6.67 (14.96) | 0.00 (0.00) | 80.00 (63.43)ab |
| 5     | Magnesium oxide (MgO) 500 ppm | 33.33 (35.26)def | 40.00 (39.22)ab | 3.33 (10.52) | 0.00 (0.00) | 76.67 (61.12)ab |
| 6     | Calcium oxide (CaO) 10 ppm | 23.33 (28.88)efg | 46.67 (49.09)a | 6.67 (14.96) | 0.00 (0.00) | 76.67 (61.12)ab |
| 7     | Calcium oxide (CaO) 20 ppm | 73.33 (58.91)a | 16.67 (24.09)cde | 0.00 (0.00) | 0.00 (0.00) | 90.00 (71.57)ab |
| 8     | Calcium oxide (CaO) 50 ppm | 23.33 (28.88)efg | 36.67 (37.27)ab | 16.67 (24.09) | 0.00 (0.00) | 76.67 (61.12)ab |
| 9     | Calcium oxide (CaO) 100 ppm | 30.00 (33.21)def | 33.33 (35.26)abc | 10.00 (18.43) | 0.00 (0.00) | 73.33 (58.91)ab |
| 10    | Calcium oxide (CaO) 500 ppm | 26.67 (31.09)def | 33.33 (35.26)abc | 10.00 (18.43) | 0.00 (0.00) | 70.00 (56.79)ab |
| 11    | Zinc oxide (ZnO) 10 ppm | 43.33 (41.17)cd | 33.33 (35.26)abc | 6.67 (14.96) | 0.00 (0.00) | 83.33 (65.91)ab |
| 12    | Zinc oxide (ZnO) 20 ppm | 53.33 (46.91)bc | 16.67 (24.09)cde | 10.00 (18.43) | 0.00 (0.00) | 76.67 (61.12)ab |
| 13    | Zinc oxide (ZnO) 50 ppm | 26.67 (31.09)def | 36.67 (37.27)ab | 6.67 (14.96) | 0.00 (0.00) | 70.00 (56.79)ab |
| 14    | Zinc oxide (ZnO) 100 ppm | 30.00 (33.21)def | 33.33 (35.26)abc | 13.33 (21.42) | 0.00 (0.00) | 83.33 (65.91)ab |
| 15    | Zinc oxide (ZnO) 500 ppm | 20.00 (26.57)fg | 33.33 (35.26)abc | 13.33 (21.42) | 0.00 (0.00) | 80.00 (63.43)ab |
| 16    | Ferrous oxide (Fe$_2$O$_3$) 10 ppm | 63.33 (52.73)ab | 23.33 (28.88)bcde | 0.00 (0.00) | 0.00 (0.00) | 86.67 (68.58)a |
| 17    | Ferrous oxide (Fe$_2$O$_3$) 20 ppm | 36.67 (37.27)cddef | 33.33 (35.26)abc | 10.00 (18.43) | 0.00 (0.00) | 80.00 (68.43)ab |
| 18    | Ferrous oxide (Fe$_2$O$_3$) 50 ppm | 33.33 (35.26)def | 33.33 (35.26)abc | 6.67 (14.96) | 0.00 (0.00) | 73.33 (58.91)ab |
| 19    | Ferrous oxide (Fe$_2$O$_3$) 100 ppm | 40.00 (39.23)cde | 16.67 (24.09)cde | 10.00 (18.43) | 0.00 (0.00) | 73.33 (58.91)ab |
| 20    | Ferrous oxide (Fe$_2$O$_3$) 500 ppm | 30.00 (33.21)def | 23.33 (28.88)bcde | 13.33 (21.42) | 0.00 (0.00) | 73.33 (58.91)ab |
### Table 2: Influence of different nanoparticles on the efficacy of *B. bassiana* against *S. litura* at different concentrations during the year 2017

| S.No. | Name of the Treatment | *S. litura* Per cent mortality |
|-------|-----------------------|-------------------------------|
|       |                       | 120h | 144h | 168h | 192h | Cumulative |
| 1     | Magnesium oxide (MgO) 10 ppm | 43.33 (41.17) bcd | 23.33 (28.88) bcd | 6.67 (14.96) abc | 0.00 (0.00) | 73.33 (58.91) bcde |
| 2     | Magnesium oxide (MgO) 20 ppm | 43.33 (41.17) bcd | 30.00 (33.21) abcde | 6.67 (14.96) abc | 0.00 (0.00) | 80.00 (63.43) abcd |
| 3     | Magnesium oxide (MgO) 50 ppm | 80.00 (63.43) a | 13.33 (21.42) ef | 0.00 (0.00) c | 0.00 (0.00) | 93.33 (75.04) abcd |
| 4     | Magnesium oxide (MgO) 100 ppm | 46.67 (43.09) bc | 30.00 (33.21) abcde | 10.00 (18.43) abc | 0.00 (0.00) | 86.67 (68.58) ab |
| 5     | Magnesium oxide (MgO) 500 ppm | 33.33 (35.26) cdef | 30.00 (33.21) abcde | 13.33 (21.42) abc | 0.00 (0.00) | 76.67 (61.12) abcd |
| 6     | Calcium oxide (CaO) 10 ppm | 26.67 (31.09) def | 43.33 (41.17) a | 10.00 (18.43) abc | 0.00 (0.00) | 80.00 (63.43) abcd |
| 7     | Calcium oxide (CaO) 20 ppm | 76.67 (61.12) a | 16.67 (21.09) cdef | 0.00 (0.00) c | 0.00 (0.00) | 93.33 (75.04) a |
| 8     | Calcium oxide (CaO) 50 ppm | 33.33 (35.26) cdef | 40.00 (39.23) ab | 10.00 (18.43) abc | 0.00 (0.00) | 83.33 (65.91) abc |
| 9     | Calcium oxide (CaO) 100 ppm | 30.00 (33.21) cdef | 30.00 (33.21) abcde | 16.67 (24.09) ab | 0.00 (0.00) | 76.67 (61.12) abcd |
| 10    | Calcium oxide (CaO) 500 ppm | 33.33 (35.26) cdef | 30.00 (33.21) abcde | 0.00 (0.00) c | 0.00 (0.00) | 63.33 (52.73) def |
| 11    | Zinc oxide (ZnO) 10 ppm | 36.67 (37.27) bede | 20.00 (26.57) cdef | 10.00 (18.43) abc | 0.00 (0.00) | 83.33 (65.91) abc |
| 12    | Zinc oxide (ZnO) 20 ppm | 36.67 (37.27) bede | 36.67 (37.27) abc | 3.33 (10.52) bc | 0.00 (0.00) | 76.67 (61.12) abcd |
| 13    | Zinc oxide (ZnO) 50 ppm | 40.00 (39.23) abcde | 26.67 (31.09) abcde | 10.00 (18.43) abc | 0.00 (0.00) | 76.67 (61.12) abcd |
| 14    | Zinc oxide (ZnO) 100 ppm | 30.00 (33.21) cdef | 26.67 (31.09) abcde | 20.00 (26.57) a | 0.00 (0.00) | 76.67 (61.12) abcd |
| 15    | Zinc oxide (ZnO) 500 ppm | 30.00 (33.21) cdef | 23.33 (28.88) bcd | 10.00 (18.43) abc | 0.00 (0.00) | 63.33 (52.73) def |
| 16    | Ferrous oxide (Fe₂O₃) 10 ppm | 53.33 (46.91) bd | 33.33 (35.26) abcd | 10.00 (18.43) abc | 0.00 (0.00) | 80.00 (63.43) abcd |
| 17    | Ferrous oxide (Fe₂O₃) 20 ppm | 36.67 (37.27) bede | 20.00 (26.57) cdef | 10.00 (18.43) abc | 0.00 (0.00) | 66.67 (54.74) cdef |

Figures in parentheses are arcsine transformed values.

Alphabets indicating Duncan Multiple Range Test (DMRT)

*Int. J. Curr. Microbiol. App. Sci* (2018) 7(12): 2017-2024
Ferrous oxide (Fe$_2$O$_3$) 50 ppm

|   |   |   |   |   |
|---|---|---|---|---|
| 18 | Ferrous oxide (Fe$_2$O$_3$) 50 ppm | 36.67 (37.27)bcde | 23.33 (28.88)bcdef | 6.67 (14.96)abc | 0.00 (0.00) | 66.67 (54.74)bcdef |
| 19 | Ferrous oxide (Fe$_2$O$_3$) 100 ppm | 23.33 (28.88)ef | 33.33 (35.26)abcd | 0.00 (0.00)c | 0.00 (0.00) | 56.67 (58.83)ef |
| 20 | Ferrous oxide (Fe$_2$O$_3$) 500 ppm | 16.67 (24.09)fg | 33.33 (35.26)abcd | 6.67 (14.96)abc | 0.00 (0.00) | 56.67 (58.83)ef |
| 21 | Bb without nano | 23.33 (28.88)ef | 20.00 (26.57)abcd | 0.00 (0.00)c | 0.00 (0.00) | 53.33 (46.91)f |
| 22 | Control | 3.33 (10.52)g | 6.67 (14.96)f | 3.33 (10.52)bc | 0.00 (0.00) | 13.33 (21.42)g |

C.D. | 9.089 | 8.859 | 7.604 | - | 9.532 |
SE(m) | 3.178 | 3.098 | 2.659 | - | 3.333 |
SE(d) | 4.495 | 4.381 | 3.761 | - | 4.714 |
C.V. | 14.89 | 20.007 | 58.456 | - | 8.056 |

Figures in parentheses are arcsine transformed values
Alphabets indicating Duncan Multiple Range Test (DMRT)

The highest $S$.itura mortality of 76.67 per cent was recorded with MgO at 50 ppm, followed by 73.33 per cent with CaO at 20 ppm, 63.33 per cent with FeO 10 ppm and 56.67 per cent with ZnO 10 ppm. Where as in B. bassiana without nanomaterial based it was recorded as 43.33 per cent and in control it was 6.67 per cent.

The mortality per cent after 144 hours of the treatment ranged from 6.67 to 46.67 per cent in different treatments. The highest per cent mortality 46.67 per cent was recorded with CaO at 10 ppm. The per cent mortality 168 hours after treatment was ranged between 3.33 and 16.67 per cent, and the mortality per cent was gradually decreased.

The cumulative $S$.itura larval mortality was ranged between 16.67 and 90.00 per cent in different treatments. The highest per cent mortality (90.00) was recorded with MgO based B. bassiana at 50 ppm which is on par with CaO 20 ppm and FeO 10 ppm based N. rileyi, followed by ZnO at 10 ppm (83.33). Where as in control it was 16.67 per cent.

During 2017, the mortality of $S$.itura after 120 hours of the treatment recorded was ranged from 33.33 to 80.00 with MgO based B. bassiana, 26.67 to 76.67 with CaO based B. bassiana, 16.67 and 53.00 with FeO based B. bassiana and 30.00 and 40.00 per cent with ZnO based B. bassiana. The highest mortality per cent 80.00 was recorded with MgO at 50 ppm, followed by 76.67 per cent with CaO at 20 ppm, 53.33 per cent with FeO 10 ppm and 40.00 per cent with ZnO 50 ppm. Where as in B. bassiana without nanomaterial based it was recorded as 23.33 per cent and in control it was 3.33 per cent.

The mortality $S$.itura after 144 hours of the treatment ranged from 6.67 to 43.33 per cent in different treatments. The highest $S$.itura mortality of 43.33 per cent was recorded with CaO at 10 ppm. The S.itura mortality 168 hours after treatment was ranged between 0 and 20.00 per cent and later the mortality per cent was gradually decreased.

The cumulative $S$.itura mortality was ranged from 13.33 per cent to 93.33 per cent in different treatments. The highest $S$.itura mortality (93.33) was recorded with CaO based B. bassiana at 20 ppm and MgO 50 ppm, followed by (80.00) FeO 10 ppm based B. bassiana and followed by ZnO 10 ppm (83.33) based B. bassiana. Where as in B. bassiana without nanoparticles was 53.33 per cent and in control it was 13.33 per cent.
The results revealed that, highest *S. litura* mortality was recorded with MgO @ 50 ppm, CaO 20 ppm fortified growth media for *Bt* similarly MgO @ 50 ppm, CaO 20 ppm was effective for enhancing the activity of *B. bassiana* against *S. litura*. The *B. bassiana* grown in nanoparticles enriched media were tested against 3rd instar larvae of *S. litura* under laboratory conditions.

The results revealed that the significant highest per cent mortality was observed at 120h with *B. bassiana* grown under nanoparticles fortified CaO at 20 ppm, MgO at 50 ppm, FeO at 10 ppm and ZnO at 20 ppm enriched biopesticide when compared with biopesticide without nanoparticles as well as control. The studies of Valicente *et al.*, (2010) on the influence of mineral salts of FeSO$_4$, ZnSO$_4$, MnSO$_4$ and MgSO$_4$ when added to LBA media at a concentration of 0.002g, 0.02g, 0.02g and 0.03g respectively and these resulted in an increased number of viable spores 2 x 10$^8$ cells/ml of *Bt* compared to control and as well as reported higher efficacy of 60 per cent mortality against first instar larvae of *S. frugiperda* under laboratory conditions. Similarly Namasivayam *et al.*, (2013) observed the nano sized copper coated chitosan showed the distinct effect on the growth of *N. rileyi* under field conditions.

**Summary**

The *B. bassiana* grown under nano enriched media was tested against 3rd instar larvae of *S. litura* under laboratory conditions. The results revealed that the significant highest per cent mortality of *S. litura* was observed at 120h after treatment with *B. bassiana* grown under CaO at 20 ppm, MgO at 50 ppm, FeO at 10 ppm and ZnO at 20 ppm nanomaterial enriched media when compared with biopesticides without nanoparticles as well as control.

**References**

Ahmad, M., Saleem, M. A and Ahmad, M. 2005. Time oriented mortality in leaf army worm, *Spodoptera litura* (Fab.) (Lepidoptera: Noctuidae) by some new chemistry insecticides. *Pakistan Entomology*. 27 (1): 67-70.

Armes, N. J., Wightman, J.A., Jadhav, D.R. and Ranga Rao, G.V. 1997. Status of insecticide resistance in *Spodoptera litura* in Andhra Pradesh, India. Pesticide Science, 50: 240-248.

Basu, A. C. 1981. Effect of different foods on the larval and post larval development of moth of *Prodenia litura* (Fab.). *Journal of Bombay Natural History Society*. 44: 275–288.

Hafez, M., Zaki, F.N., Moursy, A and Sabbour, M. 1994. Biological effects of the entomopathogenic fungus, *Beauveria bassiana* on the potato tuber moth, *Phthormaea operculella* (Seller). *Journal of Islamic Academy Sciences*. 57: 167-168.

Kumar, K and Chapman, R. B. 2006. Sublethal effects of insecticides on the diamondback moth *Plutella xylostella* (L.). *Pesticide Science*. 15: 344-352.

Mousa, M. A., Zaker, M. A and Koppy, F. 1980. Abundance of cotton leaf worm, *Prodenia litura* (Fab.) in relation to host plants Host plants and their effect on biology. *Bulletin of Entomological Society, Egypte*. 44: 241–251.

Muthukrishnan, N., Ganapathy, N., Nalini, R and Rajendran, R. 2005. Pest Management in Horticultural Crops. New Madura Publishers, Madurai. PP. 325.

Namasivayam, K.R., Bharani, R.S.A and Ansari M.R. 2013. Natural Occurrence of Potential Fungal Biopesticide *Nomuraea rileyi* (Farlow) Samson Associated with Agriculture Fields of Tamil Nadu, India and it’s Compatibility with Metallic
Nanoparticles. *Journal of Biofertilizers & Biopesticides*. 4: 132.

Sahayaraj, K., Selvarj, P. and Balasubramanian, R. 2007. Cell mediated immune response of *Helicoverpa armigera* Hubner and *Spodoptera litura* Fabricius to Fern Phytoecdysterone. *Journal of Entomology*. 4: 289-298.

Sasidharan, K. R and Varma, R.V. 2005. Laboratory evaluation of *Beauveria bassiana* (Balsamo) Vuillemin against *Indarbela quadrinotata* Walker (Lepidoptera: Metarbelidae) - a key pest of *Casuarina equisetifolia* L. in Tamil Nadu. *Journal of Biological Control*. 19: 197-200.

Stark, J. D. and Banks, J. E. 2003. Population-level effects of pesticides and other toxicants on arthropods. *Annual Review of Entomology*. 48: 505-19.

Suchea, M., Christoulakis, S., Moschovis, K., Katsarakis, N and Kiriakidis, G. 2006. ZnO transparent thin films for gas sensor applications. *Thin Solid Films*. 515: 551–554.

Valicente, F.H., Tuelher, E.D.S, Liete, M.I.S, Freire, F.L and Vieira, C.M. 2010. Production of *Bacillus thuringiensis* biopesticide using commercial lab medium and agricultural by-products as nutrient sources. *Revista Brasileira de Milho e Sorgo*. 9 (1): 1-11.

---

**How to cite this article:**

Gayathri, M., N.C. Venkateswarlu, T. Murali Krishna and Devaki, K. 2018. Evaluation of the *Beauveria bassiana* Grown under Nanomaterial Enriched Media for its Relative Efficacy against *S. litura* under Laboratory Conditions. *Int.J.Curr.Microbiol.App.Sci.* 7(12): 2017-2024. doi: [https://doi.org/10.20546/ijcmas.2018.712.232](https://doi.org/10.20546/ijcmas.2018.712.232)