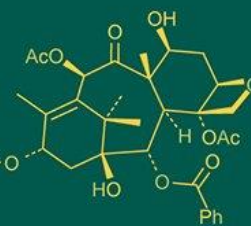
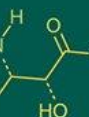
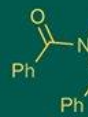


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## Evaluation of entomopathogenic fungi for management of white grub and termite and their impact on groundnut growth under pots & field conditions

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### Abstract

A study was conducted to evaluate the efficacy of entomopathogenic fungi *Metarhizium anisopliae* and *Beauveria bassiana*, applied individually and in combination, against white grub and termite infestation in groundnut under pot and field conditions. The results revealed that both fungi significantly reduced pest-induced losses compared to the untreated control (15.7%), with *M. anisopliae* (2.9%) performing slightly better than *B. bassiana* (3.1%) at the highest concentration ( $1 \times 10^9$ /ml), while their combined application showed a strong synergistic effect, minimizing losses to 1.3% (over 90% reduction). Field observations at 90 DAS indicated significant improvement in growth parameters, with the combined treatment recording the highest plant population (30 plants/m<sup>2</sup>), plant height (12.3 cm), tillers (15.6 per plant) and fresh leaves (112 per plant). Pod damage at harvest was also drastically reduced, with the combined treatment showing the lowest damage (0.5% by termite and 0.7% by white grub), representing over 95% reduction compared to control. Furthermore, the combined application resulted in the highest yield (19.2 q/ha), net return (Rs. 68,574) and cost-benefit ratio (3.98), clearly demonstrating that the integrated use of these fungi is an effective, eco-friendly and economically viable strategy for managing soil insect pests and enhancing groundnut productivity.

**Keywords:** Groundnut, insect pest, entomopathogenic fungi

### Introduction

Groundnut or Peanut (*Arachis hypogaea* L.) is an important legume nut as well as one of the most important cash crops of our country. It is a low-priced commodity but a valuable source of all nutrients. In the farming of groundnut, India is the world leader with 4.12 million hectares of cultivated area with 3.77 million tonnes production during 2018-19 (Acc. to SEA report). It has been reported that the groundnut is native of Brazil to Peru, Argentina & Ghana. It was introduced into India during the first half of the 16<sup>th</sup> century from one of the Pacific Islands of China

Groundnut (*Arachis hypogaea* L.) is a member of subfamily-Papilionaceae of family Leguminosae. It is a self-pollinated annual legume. At the locations where bee activity is high, some cross pollination can occur. Groundnut is called as "King of oilseeds" and the 6<sup>th</sup> most important oilseed crop in the world. It contains 48-50% of oil and 26-28% of protein, and is a rich source of dietary fibre, minerals and vitamins. It is also used in soap making, and manufacturing cosmetics and lubricants, olein stearin and their salts. Kernels are rich in protein and vitamin A, B and some members of B<sub>2</sub> group. Their calorific value is 349/100gm. The Hand-Picked Selection (HPS) types of kernels are exported to foreign. Its oil is extensively used as a cooking medium as both refined oil and *Vanaspatti Ghee*. The residual oilcake after extraction of oil, contains 7-8% of N, 1.5% of P<sub>2</sub>O<sub>5</sub> and 1.2% of K<sub>2</sub>O making it useful as a fertilizer.

Groundnut cultivating farmers face the huge loss due to the major destructive pest White grub (*Holotrichia consanguinea*) and Termites (*Odontotermes* spp. and *Microtermes* spp.) with wide distribution especially in the dry & sand-rich soils.

White grubs cause the damage by eating the nodules, the rootlets and may also girdle the main root ultimately killing the plants. Termite is another important pest of groundnut. These are widely distributed in sand rich soils having areas. Mainly *Odontotermes spp.* and *Microtermes spp.* can cause damage to groundnut crop. They cause damage by entering the root system and burrow inside the root as well as stem. They bore holes in pods and damage the seed and remove the soft corky tissues from between the veins of pods. (ICRISAT)

For the control of white grub and termites in groundnut, farmers are using heavy and repeated dose of chemical pesticides in injudicious manner which is deteriorating the natural soil flora and fauna. Biopesticides generally affect only the target pest and closely related organisms, when used as a component of Integrated Pest Management (IPM) programs, biopesticides can greatly reduce the use of conventional pesticides, while crop yields remain high

### Material and method

The variety of groundnut HGN-123 was chosen for experimental purpose. This is Virginia Bunch high yielding variety with Salmon colored Kernels and high Shelling turnover.

### Collection of white grub and termite colonies-

*Holotrichia species* of white grub is majorly habitual species of this region. The grubs were collected and graded (stage wise) in laboratory. As the attack of termite was very common in this area so the colonies of termite were collected very easily.

### Soil Testing

The soil sample was taken from the experimental field by following the standard method of soil sampling. The taken soil was tested in the laboratory of Krishi Vigyan Kendra-II, Katiya, Sitapur, Uttar Pradesh.

### Treatment in Pots

To check the best concentration of *Metarhizium anisopliae* and *Beauveria bassiana* individually and also in combined form, we conducted a pot experiment a few days earlier than the main (plot) experiment. The sterilized soil of the constant weight was filled in each pot. The same *spp.* of white grub and same amount of termite colonies were released in the pots after sowing.

In pots, four doses  $2 \times 10^5$ ,  $2 \times 10^6$ ,  $2 \times 10^7$ ,  $2 \times 10^8$  and  $2 \times 10^9$  in Colony Forming Unit (CFU) per millilitre were examined of *Metarhizium anisopliae* and *Beauveria*

*bassiana* individually and the combination of both. Yubak Dhoj G.C. 2006 used  $1 \times 10^7$ /ml concentration of entomopathogenic fungi *Metarhizium anisopliae* in his experiment against White grub and got 67.5% mortality. Three replications  $R_1$ ,  $R_2$  and  $R_3$  were used for each treatment. The above treatments and replications were applied for *Metarhizium anisopliae*, *Beauveria bassiana* and for the combination of both fungi.

### Observation of growth parameters

The growth parameters of each plot were recorded at different crop growing stages of groundnut for the observation.

### Plant Height

The average height of groundnut plant was measured by selecting the plants. The plants were chosen randomly with square meter quadrat from every replication of the relevant treatment at 90 days after sowing (DAS).

### No. of leaves

At 90 days after sowing of crops, we counted the average number of leaves from each replication of the treatments by selecting the plants in random manner by using square m quadrat.

### No. of nodes/plant

At 90 days after sowing the crop in plots, the average number of nodes were recorded from each replication of all treatments. To record this data some plants randomly selected from every plot.

### No. of pods/plant

At the stage of harvesting, we recorded the data of pods. The average numbers of pods were counted from some randomly selected plants after harvesting.

### No. of damaged pods/plant

On harvesting, the average number of damaged pods by white grub and termite were also recorded from all the replicated plots.

### Yield

Yield per plot was recorded among the all-experimental plots randomly selected in square meter quadrates. The average mean yield/plot was recorded per replication plot.

### Results and Discussions

**Table 1:** Total losses% by white grub and termite on application of *metarhizium anisopliae* and *beauveria bassiana* individually and in combine manner under pot experiment.

| Treatment      |                     | Losses%              |                    |                                           |
|----------------|---------------------|----------------------|--------------------|-------------------------------------------|
|                |                     | <i>M. anisopliae</i> | <i>B. bassiana</i> | <i>M. anisopliae</i> + <i>B. bassiana</i> |
| T <sub>0</sub> | Control             | 15.7                 | 15.7               | 15.7                                      |
| T <sub>1</sub> | $1 \times 10^5$ /ml | 4.2                  | 4.7                | 3.5                                       |
| T <sub>2</sub> | $1 \times 10^6$ /ml | 4.0                  | 4.4                | 3.0                                       |
| T <sub>3</sub> | $1 \times 10^7$ /ml | 3.6                  | 3.9                | 2.8                                       |
| T <sub>4</sub> | $1 \times 10^8$ /ml | 3.1                  | 3.3                | 1.9                                       |
| T <sub>5</sub> | $1 \times 10^9$ /ml | 2.9                  | 3.1                | 1.3                                       |

**Table 2:** Effect of entomopathogenic fungal application on external growth parameters in groundnut experimental plot

| Treatments     |                                           | No. of plants/m <sup>2</sup><br>area at 90 DAS | Av. Height of plant<br>(cm) at 90 DAS | No. of tillers/plant<br>at 90 DAS | No. of av. Fresh<br>leaves/plant at 90 DAS |
|----------------|-------------------------------------------|------------------------------------------------|---------------------------------------|-----------------------------------|--------------------------------------------|
|                |                                           | M                                              | M                                     | M                                 | M                                          |
| T <sub>0</sub> | Control                                   | 23.6                                           | 9.3                                   | 11.6                              | 99                                         |
| T <sub>1</sub> | <i>Metarhizium anisopliae</i>             | 26.3                                           | 10.6                                  | 14                                | 106                                        |
| T <sub>2</sub> | <i>Beauveria bassiana</i>                 | 24.3                                           | 11.6                                  | 15.3                              | 109                                        |
| T <sub>3</sub> | <i>M. anisopliae</i> + <i>B. bassiana</i> | 30                                             | 12.3                                  | 15.6                              | 112                                        |

**Table 3:** Average pod damaged percentage/plot by termite and white grub at harvesting

| Treatments     |                                           | Av. Pod damaged%/plot By termite | Av. Pod damaged%/plot By white grub |
|----------------|-------------------------------------------|----------------------------------|-------------------------------------|
| T <sub>0</sub> | Control                                   | 11.3                             | 16.2                                |
| T <sub>1</sub> | <i>Metarhizium anisopliae</i>             | 0.7                              | 1.2                                 |
| T <sub>2</sub> | <i>Beauveria bassiana</i>                 | 1.1                              | 1.3                                 |
| T <sub>3</sub> | <i>M. anisopliae</i> + <i>B. bassiana</i> | 0.5                              | 0.7                                 |

**Table 4:** Effect of Entomopathogenic fungal application on yield of groundnut in plots

| Treatments     | Yield q/ha | Gross cost/ha (Rs) | Gross return/ha (Rs) | Net return/ha (Rs) | C:B ratio |
|----------------|------------|--------------------|----------------------|--------------------|-----------|
| T <sub>0</sub> | 12.4       | 19,970             | 59,148               | 39,178             | 2.96      |
| T <sub>1</sub> | 18.3       | 22,960             | 87,291               | 64,331             | 3.80      |
| T <sub>2</sub> | 17.6       | 22,530             | 83,952               | 61,422             | 3.72      |
| T <sub>3</sub> | 19.2       | 23,010             | 91,584               | 68,574             | 3.98      |

T<sub>0</sub>-control, T<sub>1</sub>-*Metarhizium anisopliae*, T<sub>2</sub>-*Beauveria bassiana*, T<sub>3</sub>-*Metarhizium anisopliae* + *Beauveria bassiana*. The efficacy of *Metarhizium anisopliae* and *Beauveria bassiana*, applied individually and combination, was evaluated under pot experiments against white grub and termite infestation. The data presented in Table 1 clearly indicate that both entomopathogenic fungi significantly reduced losses compared to the untreated control, with the combined application consistently outperforming individual treatments.

In the untreated control (T<sub>0</sub>), the percentage loss was recorded at 15.7%, representing the natural damage in the absence of fungal inoculation. Application of *M. anisopliae* alone resulted in a progressive reduction in losses from 4.2% at  $1 \times 10^5$ /ml (T<sub>1</sub>) to 2.9% at  $1 \times 10^9$ /ml (T<sub>5</sub>). Similarly, *B. bassiana* alone reduced losses from 4.7% at  $1 \times 10^5$ /ml to 3.1% at  $1 \times 10^9$ /ml. Between the two, *M. anisopliae* exhibited slightly higher efficacy at equivalent concentrations. The combined application of *M. anisopliae* and *B. bassiana* demonstrated a synergistic effect, producing the lowest losses across all treatments. At the lowest concentration ( $1 \times 10^5$ /ml), losses were reduced to 3.5%, while at the highest concentration ( $1 \times 10^9$ /ml), losses were minimized to 1.3%. This represents a reduction of more than 90% compared to the control, highlighting the superior effectiveness of the combined inoculation strategy. The application of entomopathogenic fungi significantly influenced the external growth parameters of groundnut plants under field conditions at 90 days after sowing (DAS). The data presented in Table 2 reveal clear improvements in No. of plants/m<sup>2</sup>, height, tiller number, and leaf production compared to the untreated control. In the control plot (T<sub>0</sub>), the number of plants per m<sup>2</sup> was 23.6, with an average plant height of 9.3 cm, 11.6 tillers per plant, and 99 fresh leaves per plant. Application of *Metarhizium anisopliae* (T<sub>1</sub>) enhanced growth, recording 26.3 plants per m<sup>2</sup>, 10.6 cm average height, 14 tillers per plant, and 106 fresh leaves per plant. Similarly, *Beauveria bassiana* (T<sub>2</sub>) treatment resulted in 24.3 plants per m<sup>2</sup>, 11.6 cm average height, 15.3 tillers per plant, and 109 fresh leaves per plant.

The combined application of *M. anisopliae* and *B. bassiana* (T<sub>3</sub>) produced the most pronounced effect, with 30 plants per m<sup>2</sup>, 12.3 cm average height, 15.6 tillers per plant and 112 fresh leaves per plant. This treatment consistently outperformed individual applications, indicating a synergistic effect of the two fungi in promoting plant growth and vigor.

The application of entomopathogenic fungi significantly reduced pod damage caused by termite and white grub at harvest compared to the untreated control. The data presented in Table 3 clearly demonstrate the effectiveness of both *Metarhizium anisopliae* and *Beauveria bassiana*, with the combined application producing the lowest damage percentages.

In the control plots (T<sub>0</sub>), average pod damage was 11.3% by termite and 16.2% by white grub. Application of *M. anisopliae* (T<sub>1</sub>) reduced pod damage to 0.7% by termite and 1.2% by white grub. Similarly, *B. bassiana* (T<sub>2</sub>) treatment lowered pod damage to 1.1% by termite and 1.3% by white grub.

The combined application of *M. anisopliae* and *B. bassiana* (T<sub>3</sub>) was most effective, reducing pod damage to 0.5% by termite and 0.7% by white grub. This represents a reduction of more than 95% compared to the control, highlighting the synergistic effect of the two fungi in minimizing pest-induced losses at harvest.

The application of entomopathogenic fungi had a significant impact on the yield and economic returns of groundnut under field conditions. The data presented in Table 4 show that both *Metarhizium anisopliae* and *Beauveria bassiana*, when applied individually, improved yield and profitability compared to the untreated control, while their combined application produced the highest yield and economic benefit.

In the control plots (T<sub>0</sub>), the yield was 12.4 q/ha, with a gross cost of Rs. 19,970, gross return of Rs. 59,148, net return of Rs. 39,178 and a cost-benefit (C:B) ratio of 2.96. Application of *M. anisopliae* (T<sub>1</sub>) increased yield to 18.3 q/ha, resulting in a gross return of Rs. 87,291 and a net return of Rs. 64,331, with a C:B ratio of 3.80. Similarly, *B. bassiana* (T<sub>2</sub>) treatment produced a yield of 17.6 q/ha, gross

return of Rs. 83,952, net return of Rs. 61,422, and a C:B ratio of 3.72.

The combined application of *M. anisopliae* and *B. bassiana* (T<sub>3</sub>) was most effective, recording the highest yield of 19.2 q/ha. This treatment achieved a gross return of Rs. 91,584, net return of Rs. 68,574, and the maximum C:B ratio of 3.98. These results clearly demonstrate that the combined fungal application not only enhanced yield but also provided superior economic returns compared to individual treatments. Francisco Hernández-Rosas *et al.* (2019), reported that *B. bassiana* and *M. anisopliae* both having contact mode of action, the former has a toxic strategy using oosporeins and invades the host while the latter has a growth strategy with the formation of appressoria and invasion of the host, this makes the effect for the biological control of pests greater. Although other studies revealed that when adult of *Tetranychus ogmophallos* females were treated with *B. bassiana* and *M. anisopliae*, at 7 d after treatment under laboratory condition. *B. bassiana* resulted in 100% mortality and *M. anisopliae* almost 100% mortality (Barbosa *et al.*, 2018) <sup>[1]</sup>, as well as their combinations with some insecticides (Rivero-Borja *et al.*, 2018) <sup>[20]</sup>, with various chemical compounds, such as thymol, and application methods (Sinia and Guzmán-Novoa, 2018) <sup>[19]</sup> showed pest control significantly. In general, the research deals with formulations, mortality and virulence (Oliveira *et al.*, 2018) <sup>[21]</sup>, laboratory bioassays, field evaluation, and their evaluation for the control of various pests.

## Conclusion

The present study clearly demonstrates that the application of entomopathogenic fungi, *Metarhizium anisopliae* and *Beauveria bassiana*, plays a significant role in reducing pest incidence and improving growth and yield of groundnut. Both fungi, when applied individually, effectively reduced losses caused by white grub and termite and enhanced plant growth parameters as well as yield attributes compared to the untreated control.

However, the combined application of *M. anisopliae* and *B. bassiana* proved to be the most effective treatment across all parameters. It showed a synergistic effect by minimizing pest-induced losses to the greatest extent, significantly reducing pod damage and improving both external and internal plant growth characteristics. This combined treatment also resulted in the highest yield and maximum economic returns, indicating its practical feasibility and profitability for farmers.

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