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ANTAGONISTIC/SYNERGISTIC EFFECTS OF ENTOMOPATHOGENIC FUNGI *BEAUVERIA BASSIANA* AND BACTERIA *BACILLUS THURINGIENSIS* SPECIES AGAINST INSECT PESTS OF RICE

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Abstract: *The rice crop is one of the most vital cereal crop. It provides food for nearly half of the world's population. It is attacked by numbers of insect pests which cause serious damage to the crop. Generally synthetic pesticides are used to control insect pests but these pesticides have serious impacts on the environment and human health. Keeping in view, the present study was conducted to determine the efficacy of microbial pesticides against insect pests of rice. The entomopathogenic fungi and Bacillus species were used for experimentation. The rice plants were grown in pots and in the field. The experiments were done in pots with three experiments as well as in the field by using the entomopathogens alone and in combinations. At the emergence of plants different concentrations of entomopathogens were applied against rice pests. After the application the population reduction percentage data in pots was noted after 24, 48 and 72 hours and in field the population reduction percentage data was noted after 48 and 72 hours. The field data was collected after every three days of application for the evaluation of long term efficacy of entomopathogens until the second application. The highest population reduction of rice leaf folder and sugarcane pyrilla was caused by pure formulation. The fungal isolate alone produced 45.62 and 81.73% reduction of rice leaf folder population after 48 and 72 hours respectively after the application of pure formulation. Bacillus thuringiensis alone produced 45.69% and 81.98% reduction of rice leaf folder after 48 and 72 hours respectively after application of pure formulation while the combination of both fungal and bacterial pure formulation produced 75.23% and 89.93% reduction in population of rice leaf folder after 48 and 72 hours respectively. Pure formulation of fungus also caused the population reduction percentage of Sugarcane pyrilla and produced 42.93% and 64.40% reduction in population after 48 and 72 hours while the pure formulation of bacteria alone produced 66.26% and 76.95% reduction in population of Sugarcane pyrilla. The combinations of both formulations produced 72.96% and 82.59% population reduction percentage after 48 and 72 hours respectively. The highest population reduction percentage was produced by Bacillus thuringiensis alone in pots experiment is 47.19%, 81.54% and 90.29% after 24, 48 and 72 respectively, while Beauveria bassiana produced 45.64%, 62.39% and 79.44% population reduction percentage after 24,48 and 72 hours of application. The combination of both formulations provided 52.64%, 90.31% and 90.39% population reduction percentage after 24, 48 and 72 hours. So it is concluded that microbial pesticides can be used as potential biocontrol agent against insect pests of rice with no harmful effect on our ecosystem.*

Key words: *Entomopathogenic fungi and bacteria, Beauveria bassiana and Bacillus thuringiensis, Population reduction percentage, Rice leaf folder, Sugarcane pyrilla*

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INTRODUCTION:

Rice (*Oryza sativa* L.) crop is grown all over the world and about 11% of cultivated land of the world is occupied by rice. It provides staple diet to more than 1/3 of world's population [1]. Nearly of the world half of the world's populations use it as food [2]. It also provides food having dietary importance to large number of population [3]. It has been considered that 20% of dietary protein and 27% of dietary energy is provided by rice to 3rd world countries [4]. It provides income and employment to people living in developing countries. More than 110 countries grow rice on over 145 million hectares. About 90 % of the rice crop is grown and used in Asia. More than two billion people in developing countries of Asia used it as the staple food [2,5]. Rice is the second important cash crop after cotton and it also provides basic nutrients after wheat [6]. It has good impact on economy of Pakistan. It also provides foreign exchange. The share by rice in total foreign exchange is about 18% [7,8]. It can provide more foreign exchange to the country.

In Pakistan rice is grown mainly in Sindh and Punjab with 88% of total production. About 100% of Basmati rice is grown in Punjab due to the favorable soil and climatic conditions. In Punjab, it is cultivated in Gujranwala, Sheikhupura, Sialkot, Gujrat, Sargodha, Faisalabad, Kasure, Mandi Bahaudin Din, Hafizabad and Jhang districts. In Sindh, it is cultivated in Jacobabad, Shikarpur, Larkana, Badin, Thatta, and Dadu districts while rice is also growing in Nasirabad district of Balochistan [9].

Rice crop is attacked by large numbers of insects from nursery to harvesting stage and cause serious damage. Herbivorous insects are considered most damaging pests of rice crops and it was estimated that about 80 percent yield of rice can be increased with the control of insect pests [10]. Globally more than one hundred species of insects attack on the rice crop in the world among them twenty can cause economic damage [11]. More than seventy species of insect pests have been subjected to attack rice crop in Pakistan. They attack all the parts of plants, at all growth stages. About twenty four species of pests have been commonly observed in Sindh. [12]. The leaffolder, white backed plant hopper, stem borers and grasshoppers are the major economic pests[13]. The stem borer is considered as destructive pest that cause financial crop losses in Pakistan [14] (Mahar and Hakro, 1979). Yellow stem borer, *Scirpophaga incerulas* (Walker) of rice is considered the most damaging pests of rice crop [15]. Globally 10 million tones yield losses is caused by this pests and about 50% of insecticides are used against this pest [16]. The rice crop is attacked by stem borer from seedling stage to the harvesting stage and cause serious losses of tillers [17]. These insects attack at the vegetative stage and produce "Dead heart" and produce white heads when they attack at heading stage [18]. In Pakistan the insect pests cause 15-17% yield loss [19] while 10-15% yields losses are caused by yellow stem borer (*S. incertulas*) annually. Leaffolder, *Cnaphalocrosis medinalis* also causes server damage on paddy crop. It was first reported in 1989 [20]. It is one of the serious major rice pests and can normally cause 15-25% yield losses in Pakistan [21].

The control of insect pests is mostly dependent on synthetic insecticides. The chemical pesticides usage has created many difficulties such as resistance in target species, residues in fruits/vegetables and adverse effects on environment, human health [22] and it also produces heavy loss to the budget of a country. Nowadays one of the important mechanisms in pest management is biological control of insect pests by using insect pathogens like viruses, protozoa fungi, bacteria, and nematodes as biocontrol agents.

The entomopathogenic fungus *Beauveria bassiana* (Bal) and *Bacillus thuringiensis* (Berliner) are broadly observed as the most encouraging species as biocontrol agents against many insects pests of rice. [23,24] . *Beauveria bassiana* is used for controlling Lepidoptera pests[25].

MATERIALS AND METHODS:

Culture of *Beauveria bassiana* and *Bacillus thuringiensis*

The culture of entomopathogenic fungus (*Beauveria bassiana)* and bacteria (*Bacillus thuringiensis*) was obtained by using the Indian product taken from Agri-life Telangana, India in Soil Microbiology and Biochemistry laboratory and mass cultured in Soil Microbiology and Biochemistry laboratory, Institute of Soil and environmental Science, University of Agriculture Faisalabad.

Isolated culture of *Beauveira bassiana* and *Bacillus thuringiensis*

The isolated culture of *Beauveria bassiana* and *Bacillus thuringiensis* was further used for formulation preparation.

Formulation preparation of *Beauveira bassiana*

Potato dextrose broth (PDB) media was used for the multiplication of fungus. About 1000 ml of distilled water was taken in a conical flask. Potato dextrose broth at the rate of 24g was added to 1000 ml of distilled water. After adding of PDB the mouth of conical flask was covered with aluminum sheet and shake well. After shaking the conical flask was autoclaved at 121^0C for 20-30 minutes at 15 psi. The autoclaved conical flask was removed from autoclave and was cooled at room temperature. The conical flask was placed under the laminar flow hood. Scalpel was taken dip it into the ethanol and was heated on the sprite lamp until it became red hot. This process was carried out to remove contamination. The petri dishes of colonies of fungus was taken and brought under the laminar flow hood. Small piece from the fungal colony was cut with red hot scalpel and inoculated in to the autoclaved Potato dextrose broth (PDB) and stored at 28^0C for 5-6 days.

Formulation preparation of *Bacillus thuringiensis*

Tryptic Soy Broth (TSB) was used for the multiplication of bacteria. About 1000 ml of distilled water was taken in a conical flask. Tryptic Soy Broth at the rate of 5 g was added to 1000 ml of distilled water. After adding of TSB the mouth of conical flask was covered with aluminum sheet and shake well. After shaking the conical flask was autoclaved at 121^0C for 20-30 minutes at 15 psi. The autoclaved conical flask was removed from autoclave and was cooled at room temperature. The conical flask was placed under the laminar flow hood. Scalpel was taken dip it into the ethanol and was heated on the sprite lamp until it became red hot. This process was carried out to remove contamination. The petri dishes of colonies of bacteria was taken and brought under the laminar flow hood. Small piece from the bacterial colony was cut with red hot scalpel and inoculated in to the autoclaved Tryptic Soy Broth (TSB) and stored at 28^0C for 2-3 days.

Experimental design

The experiment was conducted in two phases and each phase is further divided into three experiments

- Phase I Field trial
- Phase II Pots trial

The pots and field experiment was conducted in the research area of Department of Entomology, University of Agriculture Faisalabad, in Randomized Complete Block Design (RCBD), having 3 replications and 4 treatments.

Phase I Field trial

The field trail was conducted out with three experiments

The rice plants were grown in field by using the nursery plants. The incidence of rice pests was checked regularly in each experimental unit. When the population of any of the rice pest reached to ETL level, the 1st application of treatments was applied. Both *B. bassiana* and *B. thuringiensis* at the rate of 10^7-10^8 spore/ml and 10^6-10^7 cfu/ml respectively was applied alone as well as in combination with the help of hand sprayer to suppress the population of targeted insect pest. Two applications were carried out in field trial as only one application was on pot trail was enough for pest control. Before and after both applications the data was collected.

Phase II. Pots trial

Pots trail was also carried out with three experiments and the rice plants were also grown in the pots. The larvae and pupae of leaffolder and Sugarcane pyrilla were carefully transferred to each rice plant. The numbers of larvae and pupae were 12 and 12 respectively. The larvae and pupae were checked daily after application. After the transfer of larvae and pupae when the insects were establish on the rice plant, the rice plants were treated with the different treatments of fungus *Beauveria bassiana* and the bacteria *Bacillus thuringiensis* alone as well as in combination. After the application of treatments population reduction percentage data of larvae and pupae was noted after 24, 48 and 72 hours.

Number of insects per plant was recorded form each plot a day before, 48 and 72 hours of application of both treatments. Number of insects per pot was also recorded after 24, 48 and 72 hours of application. Percent population change (increase or decrease) was

$$\%\,\text{Pop. change} = 1 - \frac{\text{Post treatment populaion in treatment}}{\text{Pre treatment populaion in treatment}} \times \frac{\text{Pre treatment populaion in treatment}}{\text{Post treatment populaiton in treatment}} \times 100$$

calculated by using Abbot's formula [26] as below:

Statistical analysis

All the data from field and pot was collected and analyzed by statistical software Statistix 8.1 using Tukey HSD for mean at 5% of level of confidence.

RESULTS:

Highly significant difference was observed between time and dose (spores/ml) both alone and in combination of the entomopathogens. The population reduction percentage of the target insects was observed after 48h of treatment application in the field while the insects showed population reduction percentage after 24h in pots treatment. The difference may be due to the effective application of biopesticides in pots [27]. Another observation revealed that only single application of entomopathogens were applied on pots while in field two applications were applied which also confirm the effective application and efficacy of pathogens in pots against both insect pests. The difference between two applications in field was 25-30 days which may be due to the density of crop in the field that may help insect survival.

The *Bb* alone showed more than 45% and 47% population reduction percentage of RLF after 48h in 1st and 2nd application respectively in the field at highest concentration used (10^7 spore/ml). Similarly, the population reduction percentage reduced to 41% with reduced concentration (10^6 spore/ml) after 48h of application. These finding are similar with the previous studies of Dhuyo *et al*. 2008 [28]. The population reduction percentage of RLF increases with the passage of time. After 72h of application, the population reduction percentage was 75% and 69% after 1st and 2nd application of *Bb* respectively as highest concentration. The population reduction percentages were 47% and 41% reduces in a similar manner as observed after 48h of exposure with reduced concentration (10^6spore/ml). The population reduction percentage was also observed at very lowest concentration of (10^5 spore/ml) and significant results were observed after 72h but not after 48h of application [29, 30] (Sivasundaram *et al.* 2007, Loc *et al.* 2010). The important finding of this study was sugarcane pyrilla (SP) shifting on rice as a pest in Pakistan as does in India (Pawar, 1981). The SP appear to be resistant than the RLF against *Bb* because the observed population reduction percentage was 42% and 44% after 48h at highest concentration used[29]. This may be due the reason that rice is not the major host of SP. This observation also confirmed with population reduction percentage data (64% and 69%) after 72h of application. The population reduction percentage was reduced 37% and 32% at reduced concentration (10^6 and 10^5 spore/ml) respectively after 48 hours, while it were 46% and 48% after 72h in 1st and 2nd application at 10^6 and it were 42% and 43% at 10^5 spore/ml after 72h [30].

Bt has been also used as biopesticide against different insect pests [31]. The *Bt* has been found more toxic to insect pests than *Bb* in different studies. Similarly, the data revealed that the *Bt* is more effective against the target insect pests than *Bb* after both 48h and 72 h of treatment both at highest (10^9 cfu/ml) concentration as well as at reduced concentrations (10^8 and 10^7 cfu/ml). The population reduction percentage of RLF was 65% and 63% after 48h of 1st and 2nd application while after 72h the population reduction percentage increase to 81% and 74% after 1st and 2nd application respectively. These observations shows that the population of RLF decreases with the increase of exposure time against *Bt [32]*. In contrast to *Bb*, the susceptibility of the SP against *Bt* was quite similar as RLF after 48h and 72 of treatments application. The population of SP reduces to around 66% after 48h in both 1st and 2nd application of *Bt*. Similarly, the non-significant population reduction difference (76% and 79%) was observed after 72h of exposure to SP in the field. *Bt* is actually effective against the chewing insect pests but interestingly, in present study both insect pests were exposed to *Bt*. [29]. There could be different factors involved in the population reduction of these insects. The population reduction may be due the metabolites production in plants after *Bt* application or the due the activation of plant defense system triggered by the application of *Bt* after the attack of insect pest. The presence of *Bt* spore on plants may make difficult for insects to feed on the plants. The reduced concentration (10^8 cfu/ml) of *Bt* showed a significant reduction in its efficacy (54 and 50%) against RLF after 48h of application while after 72h there is significant difference (78% and 76%) in the population reduction of RLF with reduced concentration of (10^8 cfu/ml). Therefore, the *Bt* can be used effectively at reduced concentration (10^8 cfu/ml) against RLF. The significant different was observed in population reduction of SP after 48h of application when used at highest concentration (66%) and with reduced concentration (56%). In contrast to RLF, significant difference was observed after 72h of application between highest concentration (76%) and reduced concentrations of 10^8 and 10^7 cfu/ml the percentage reduction percentage were 68% and 56% respectively in 1st application in the field and 2nd application, the population reduction of RLF was 63% and 50% at highest and reduced concentration of *Bt* after 48h respectively. The difference of population reduction between two pests could be due to the higher concentration of spores [33] and it was 74% and 66% at highest and lowest concentration respectively.

The combination of *Bt* and *Bb* provided maximum population reduction percentage of insect pests as observed in previous studies [34]. Their combination showed the maximum population reduction percentage of RLF 75% after 48h at highest concentration (10^9 cfu/ml of *Bt*+ 10^7 spore/ml *Bb*) after 1st and 2nd applications. After the 72h the maximum population reduction percentage of RLF was 89% and 84% after 1st and 2nd applications. The combination of *Bt* and *Bb* also provided population reduction percentage of SP after 48h in 1st (72%) and 2nd (74%) applications. It was increased after 72h to 82% and 84% after 1st and 2nd applications respectively. The population reduction percentage was reduced to 64% and 58% at reduced concentrations of 10^8 cfu/ml of *Bt*+ 10^6 spore/ml of

Bb and 10^7 cfu/ml of *Bt*+ 10^5 spore/ml of *Bb* respectively in 1^{st} application after 48h while it was 64% and 50% in 2^{nd} application. The 10^8 cfu/ml of *Bt*+ 10^6 spore/ml of *Bb* concentration produced 78% and 79% after 72h in 1^{st} and 2^{nd} applications while the lowest concentration 10^7 cfu/ml of *Bt*+ 10^5 spore/ml of *Bb* produced 71% and 78% population reduction percentage after 72h in 1^{st} and 2^{nd} application. The results were not similar to Wraight and Ramos 2005 results where the effect of *B. bassiana* and *B. thuringiensis* alone and in combination observed against the Colorado potato beetle, *Leptinotarsa decemlineata*. The combination of both *B. bassiana* and *B. thuringiensis* did not cause the high population reduction percentage of Colorado potato beetle as beetles have more hard outer membrane so it was difficult for biopesticides to penetrate into their body. Their combinations also increased the population reduction percentage of *Ostrina nubilalis* Hubner (Lepidoptera: Pyralidae) [35].

In pots experiment only single application was applied and significant results have been observed *Bb* was used in potted plant experiments and it produced 45%, 62% and 79% population reduction of RLF at highest concentration of 10^7 spore/ml after 24, 48 and 72h. It reduced to 34%, 65% and 78% in reduced concentration of 10^6 spore/ml and 28%, 52% and 69% at lowest concentration of 10^5 spore/ml after 24, 48 and 72h. *Bb* also produced population reduction percentage of SP 29%, 58% and 79% at highest concentration of 10^7 spore/ml after 24, 48 and 72h. Similarly population reduction percentage was reduced at lower concentration of 10^6 spore/ml to 32%, 56% and 79% after 24, 48 and 72h, while population reduction percentages were 20%, 50% and 69% after 24, 48 and 72h at lowest concentration of 10^5 spore/ml.

Bt showed 47%, 81% and 90% population reduction percentage of RLF after 24, 48 and 72h of application at highest concentration of (10^9 cfu/ml) and it reduced to 43%, 74% and 87% in reduced concentration of 10^8 cfu/ml after 24, 48 and 72h it was further reduced to 31%, 67% and 82% after 24, 48 and 72h in lowest concentration of (10^7 cfu/ml). *Bt* also produced population reduction of SP to 43%, 71% and 91% after 24, 48 and 72h of application at highest concentration of (10^9 cfu/ml) and 39%, 62% and 89% at reduced concentration of (10^8 cfu/ml) and it was further reduced to 34%, 63% and 80% at lowest concentration of (10^7 cfu/ml) after 24, 48 and 72h.

The combination of *Bt* and *Bb* was also applied on potted plant experiment as it was previously studied in previously studies (Wraight and Ramos 2005). The combination of both biopesticides gave significant result in population reduction percentage of RLF after 24, 48 and 72h (52%, 90% and 99%) at highest concentration (10^9 cfu/ml of *Bt*+ 10^7 spore/ml of *Bb*). The results were also significant at reduced concentration of 10^8 cfu/ml of *Bt*+ 10^6 spore/ml of *Bb* the population reduction percentages were 52%, 79% and 97% after 24, 48 and 72h of application. The population reduction percentages were reduced to 34%, 69% and 89% after 24, 48 and 72h of application at lowest concentration of 10^7cfu/ml of *Bt*+ 10^5 spore/ml of *Bb*.

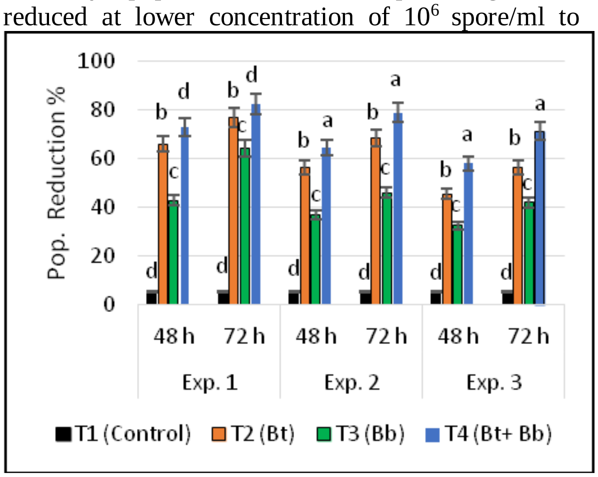


Fig 1: Graphical presentation of percentage population reduction percentage of Rice leaf folder in field after 1^{st} application after 48 and 72 hours in Experiment No. 1, 2 and 3

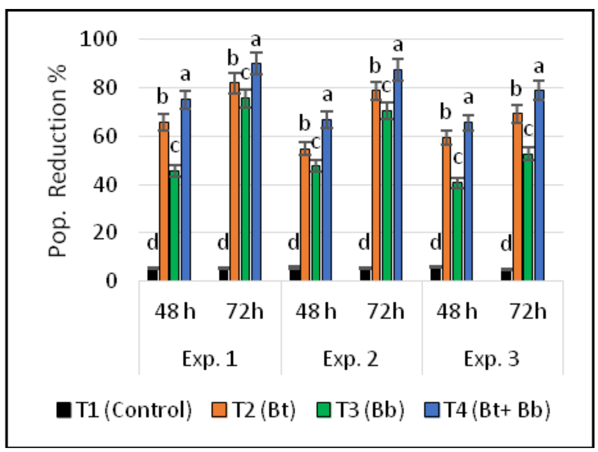


Figure 2: Graphical presentation of population reduction percentage of Sugarcane pyrilla in field after 1^{st} application after 48 and 72 hours in Experiment No. 1, 2 and 3

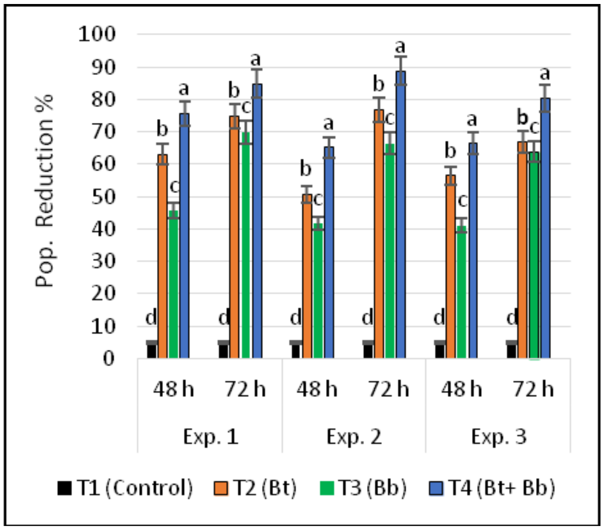


Figure 3: Graphical presentation of population reduction percentage of Rice leaf folder in field after 2nd application after 48 and 72 hours in Experiment No. 1, 2 and 3

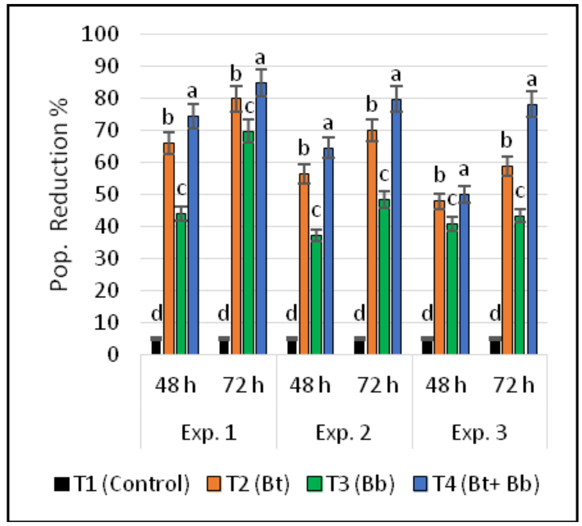
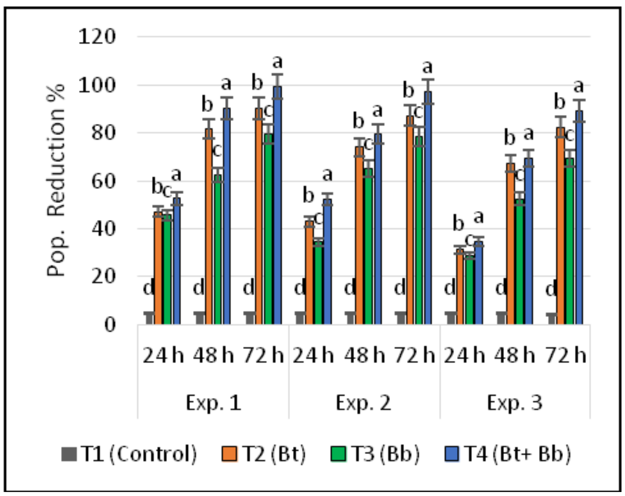
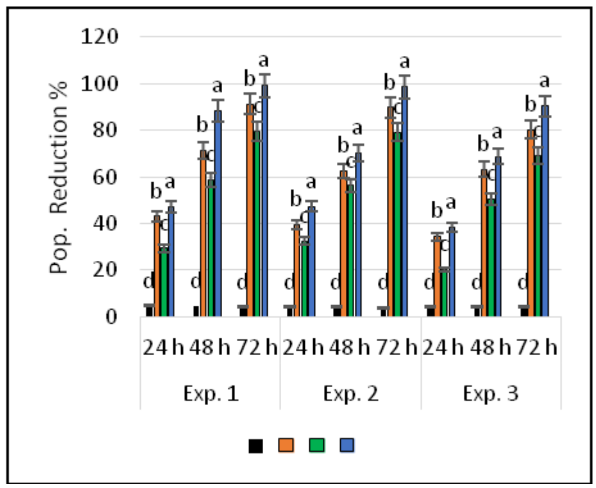


Figure 4: Graphical presentation of population reduction percentage of Sugarcane pyrilla in field after 2nd application after 48 and 72 hours in Experiment No. 1, 2 and 3



Graph 5: Graphical presentation of population reduction percentage of Rice leaf folder in pots after treatments application after 24, 48 and 72 hours in Experiment No. 1, 2 and 3



Graph 6: Graphical presentation of population reduction percentage of Sugarcane pyrilla in pots after treatments application after 24, 48 and 72 hours in Experiment No. 1, 2 and 3

CONCLUSION:

It may be concluded that the combination of both *B. bassiana* and *B. thruingeinsis* showed synergistic/additive effect and give the better control of RLF and SP, while their individual formulation may also provide significant results to control RLF and SP. So these microbial pesticides can be used as alternative to synthetic pesticides which have adverse effects and can be used as potential biocontrol agent against insect pests of rice with no adverse effect on human health and environment.

DISCUSSION:

In present study, mostly all the treatment showed the significant results against insect pests of rice and it was observed that entomopathogenic fungi and bacteria have great capacity to control lepidopterns defoliators [36] carried out an experiment to control lepidopteran defoliators by using *Bacillus thuringiensis* var. *kurstaki*, *Verticilium lecanii*, *Metarhizium anisopliae* and *Beauveria bassiana* along with typical used chemicals such as Spinosad 45%SC and Quinalphos 25 EC. The results of their findings supported our results as the more pure concentration (10^8-10^9 spore/ml) of *B. bassiana* (Bb), *B. thuringiensis* (Bt) provided excellent results to control rice leaf folder and sugarcane pyrilla. Pure concentration (10^8-10^9 spore/ml) of *B. bassiana* and *B. thuringiensis* provided the highest mortality of rice leaf folder *i-e* 75.73% and 81.98% respectively. This result was supported by Kirubakaran *et al* 2014 [37] revealed that *B. bassiana* produced 83% mortality.

B. bassiana can cause significant reduction in the population of rice leaf folder [29] (Sivasundaram *et al*. 2007). An important relationship is that as the fungal formulation is more concentrated more mortality was observed. The combination of *B. thuringiensis* and *B. bassiana* provided maximum mortality of insect pests as observed in previous studies [34], where the effect of *B. bassiana* and *B. thuringiensis* alone and in combination observed against the larvae of Colorado potato beetle, *Leptinotarsa decemlineata* [34]. The combination of both *B. bassiana* and *B. thuringiensis* did not cause the high mortality of Colorado potato beetle as beetles have more hard outer membrane so it was difficult for biopesticides to penetrate into their body. Their combinations also increased the mortality of *Ostrina nubilalis* Hubner (Lepidoptera: Pyralidae) [35].

Furthermore it was also confirmed that the mortality of rice leaf folder and sugarcane pyrilla was increased by using the fungal and bacterial biopesticides. These results have been supported by Sivasundaram *et al*. 2007 isolated thirteen strains of *Beauveria spp.* from infected insects and soil. These isolates were taken from the soil and infected insects and used against the rice leaf folder (*Cnaphalocrosis medinalis*).The results of this study showed that *Beauveria spp* strain change the feeding behavior, decreased the pupal body weight and pupal period. The percentage mortality of rice leaf folder caused by *Beauveria spp* was 73.3% that supported our results. So it was concluded that the conidial concentration which contains 1×10^8 spore/ml caused the maximum percentage death of 76.7%. Similarly Shalaby *et al*. (2013) [33] checked the efficacy of three biopesticides *B. thuringiensis* var. *kurstaki* (Btk), *B. bassiana* and *Metarhizium anisopliae* against 2nd and 3rd instar larvae of tomato borer, *Tuta absoluta*. Sivasundaram *et al*. (2007) [29]

Results also demonstrated that *B. bassiana* has potential to reduce the pest population. These findings have been confirmed by Loc *et al*. (2010) [30] exploited the potential of *B. bassiana* and *M. anisopliae* showed high efficiency to citrus pyrilla and citrus aphid in screen house tests. These two isolates were also effective in field conditions. The results of demonstrated garden, which was applied with biopesticides compared with the control garden, which was applied with chemical insecticide. The net profit of demonstrated garden was more than the control garden.

It was also confirmed that the *B. bassiana* and *B. thuringiensis* show the synergistic effect. Our results were same as Ali *et al*. (2015) [38] who assessed the efficacy of *B. bassiana* and *B. thuringiensis* to control three field population of *Earias vittella* under laboratory conditions. The results indicated that highest mortality was obtained through the combination of both microbial insecticides against Faisalabad field population of *E. vittella*, while lowest mortalities were noted in population of Pakpattan region. So it was concluded that both fungal and bacterial isolates provided significant control of *E. vittella* and they could be used in IPM program for control of spotted bollworm (*E. vittella*).

Dhuyo *et al*. 2008 [28] study also favor the present study as their findings explored that the spore of entomopathogenic fungus *B. bassiana* (Bal.) with concentrations ranging from 10^5 to 10^9 spores ml^{-1} were effective against the juvenile stages of yellow rice stem borer, *Scirpophaga incertulas* (Walker) under lab condition. The results observed that the *B. bassiana* caused the highest rate of mortality of *S. incertulas* and reduction in the fecundity of yellow rice stem borer.

CONCLUSION:

On the bases of the results of experiments it may be suggested that the combination of both *B. bassiana* and *B. thruingeinsis* showed synergistic effect and give the better control of rice pests, while their individual formulation may also provide significant results to control rice leaf folder and sugarcane pyrilla. So these microbial pesticides can be used as alternative to synthetic pesticides which have adverse effects and can be used as potential biocontrol agent against insect pests of rice with no adverse effect on human health and environment.

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