Comparative Effect of Entomopathogenic Fungus (Beauveria Bassiana) and Botanical Insecticide in the Management of Gram Pod Borer (Helicoverpa Armigera)

Vachaspati Mishra[1], Suchi Modi[2]

[1,2]Rabindranath Tagor University, Bhopal (M.P.) India.

ABSTRACT

The goal of the study is to compare the effectiveness of an entomopathogenic fungus and a botanical insecticide in the control of Gram pod Borer. The most effective spray material as Beauveria bassiana which reduced H. armigera pod damage by 14.18 percent while Metarhizium anisopliae reduced pod damage by 15.37 percent. Pod infestation was lowest in the test plots of Beauveria bassiana and highest in the control plots. Beauveria bassiana was selected as the recommended technique for controlling Gram pod borer infestations because it was most successful in reducing pod damage and consequently increasing chickpea yields. It was an extremely hazardous chemical and synthetic pesticide mixture. Metarhizium anisopliae, EPN, Custard apple leaf extract, sweet flag rhizome oil and clove oil extract all outperformed control in terms of pest reduction while remaining environmentally friendly. This botanical and bio-agent combination must be implemented into an IPM method to successfully combat H. armigera in the context of chickpea production.

Keyword- Bio-Agents, Botanical Insecticide, Entomopathogenic Fungus and Gram pod borer

I INTRODUCTION

The bio control of plant diseases was initially studied in the middle of the 20th century and in the recent years scientists, business, and academia have been actively researching the methods associated with plant pathology. "Decreasing the density or disease-causing acts of pathogen in its dynamic or static state, by one or more organisms, performed naturally by change of the environment, host, or antagonist" is how bio control is defined (definition taken from the NIH). As molecular technology advances, molecular techniques for natural control are becoming increasingly potent, broadly applicable, and simple to use. In order to increase control rates and success rates of the associated biological management plan a number of molecular techniques and studies can illustrate and annotate information on the target pests. These details are presented in addition to taxonomic categorization “hybridization and ambiguous species, population structure, and invasion origin”. Additionally, it is possible to discover new species of fungi or arthropods clarify taxonomy show genetic heterogeneity in the agents, and peacefully document host association using a more effective method for evaluating the biocontrol agent after it has been released into the environment. Current molecular methods and examples of molecular technology for biological pest management are presented. **(Raina 2017)**

(a) Host range of entomopathogenic fungi - Ectoparasitic fungi have the ability to regulate insect populations in the wild by causing lethal infections in insects. Too far, more than 400 different species of entomopathogenic fungi have been discovered. Numerous persons and animals are infected by fungi that are dangerous to humans. A total of 1800 relationships between various fungi and insects were discovered. All the species within a pathogen's host range that can support and spread the infection are considered part of the host range. The group of species with which an organism can develop symbiotic connections and successfully produce parasite progeny is known as the host range. The host range is solely dependent on the outcomes of laboratory tests. In the wild several species that have been discovered to be hosts in the lab may not be hosts. There is a connection between the pathogen and the insect when it infects the host in the field or laboratory and the infectious propagule is created. If an infection has been attempted but not observed, no correlations can be formed.

Source: Slide Share

(b) Entomopathogenic fungi as bio pesticides - The ancient Chinese understood the significance of fungi in controlling insect populations early in recorded history due to the frequency of natural epileptics and the conspicuous symptoms that are related with fungus-induced mortality. EPF can be used for biological control, augmentation, and conservation. Since EPF is less hazardous to people, the environment and non-target animals it is a safer solution for IPM than the use of chemical pesticides.

Although they have many similarities, fungus and other dangerous insect microbes differ greatly from each other. The way they propagate infection is where they differ most from one another. Contrary to most entomophagy infections, which spread through the digestive system, it is the only significant pathogen known to infect insects with sucking mouthparts in the Hemiptera and Homoptera that is transmitted through the gut. Instead of completely eliminating a particular pest, insecticides like EPF are best used to maintain populations below a given economic threshold with some crop loss considered acceptable. There are numerous species of Lecanicillium (Isaria), Beauveria (Metarhizium), and Lecanicillium that are developed for commercial purposes (Metarhizium). With the help of fungi like B. bassiana, Vuillemin, Isaria fumosorosea Wize, and M. anisopliae, it is currently being studied for use against agricultural and urban insect pests. Many Isoptera, Lepidoptera, and Diptera species, together with Coleoptera and Hemiptera, are susceptible to various fungus. EPF has been used by some people to try and manage pests, but it hasn't always been successful.**(Kidanu 2020)**

(c) **Gram pod Borer -** Although the insect is active all year long, the most hazardous times for gramme are from November through March. The damage is initially caused by the larvae, which consume the seedlings and feed on the leaves. It is found feeding on the growing grain at the time of pod formation after drilling a hole in the pod and inserting its heads inside. When the sun is out, it prefers to hide in the foliage rather than the ground. In its lifetime, a single caterpillar is expected to destroy 30–40 gram pods. The act of caterpillars consuming their own larvae is known as cannibalism. Infestations that are extremely nasty are frequent to cause damage between 20 and 50 percent.**(Awaneesh 2010)**

(d) **Botanical Insecticide -** The second-largest edible legume in the world is Cicer arietinum L also referred to as chickpea. The largest producer of chickpeas worldwide is India. Between 1978 and 2010, India's farmland for chickpeas barely increased, while during that time, the world's annual production increased by 65 percent ("from 4.8 to 6.8 million metric tons") The grame crop suffers substantial harm during the fruiting stage from a bug called Helicoverpa armigera (Hubner). The pest's vengeance is most severely felt on green pods. The growing usage of pesticides has led to H. armigera developing resistance to a variety of insecticides. Eco-friendly pest management places a strong emphasis on using a variety of non-chemical or biological pest control methods in order to minimize the negative effects of chemical overuse. Botanical insecticides are employed far more frequently when it comes to crop protection techniques. Botanicals are unlikely to harm the environment because they are environmentally non-permanent. Indigenous agriculture systems are agricultural systems that have developed over time based on the knowledge and experience of indigenous peoples.**(Shekhara 2017)**

(e) **Current botanicals in use -** The four most popular botanical pesticides currently in use are pyrethrum, rotenone, neem, and essential oils, with three others being used infrequently ("ryania, nicotine, and sabadilla"). Other plant oils and extracts, such as garlic oil and capsicum oleoresin, are occasionally used in some countries, but they are not considered in this study. When detailing the extent to which certain important botanical insecticides are used, I frequently quote annual records from the State of California's Pesticide Regulation Department. 80,000 tonnes of pesticides were used in California in 2003, which is greater than the 175 million pounds or tonnes used in other jurisdictions. Approximately 6% of all pesticides were used in agriculture, which accounted for 91 percent of global pesticide usage. Given that California registers the use of pesticides by crop, use, and active ingredient, the state's data are among the most precise and comprehensive in the world.**(Isman 2006)**

II LITERATURE REVIEW

(Kammara 2022) Using the Randomize Block Design, the Rabi Season of this year was utilised to investigate the effectiveness of biological remedies and botanical extracts against the H. armigera pest in the field (RBD). The examined bio-agents and botanical extracts were equally efficacious when compared to the control group. Among the spray materials tested, Beauveria bassiana and Metarhizium anisopliae were shown to be the most successful at reducing H. armigera pod damage. Pod infestation was lowest in the Beauveria bassiana test plots and greatest in the control plots. The largest yields were produced by the Beauveria bassiana-treated plots (14.48 q/ha) and the control plot (8.0 q/ha). Beauveria bassiana was shown to be the most effective at controlling the

Gram pod borer infestation, which led to a decrease in chickpea production. It was a dangerous blend of synthetic insecticide and chemicals. Furthermore, in terms of pest reduction, Metarhizium anisopliae, EPN, Custard apple leaf extract, Sweet flag rhizome oil, and clove oil extract all outperformed control and were significantly less hazardous to the environment than the standard treatment. Therefore, it is advised to use these botanicals and bio-agents in an IPM programme to suppress H. armigera in chickpea crops.

(Kammara 2022) Using the Randomize Block Design, the Rabi Season of this year was utilised to investigate the effectiveness of biological remedies and botanical extracts against the H. armigera pest in the field (RBD). The effectiveness of the tested bio-agents and botanical extracts compared to the control group did not differ significantly. Beauveria bassiana was the most effective spray material, reducing H. armigera pod damage by 14.18 percent, while Metarhizium anisopliae decreased pod damage by 15.37 percent. Pod infestation was lowest in the Beauveria bassiana test plots and greatest in the control plots. The largest yields were produced by the Beauveria bassiana-treated plots (14.48 q/ha) and the control plot (8.0 q/ha). Beauveria bassiana was shown to be the most effective in eradicating the Gram pod borer infestation, which decreased chickpea yield. It was a dangerous blend of synthetic insecticide and chemicals. In terms of pest reduction, Metarhizium anisopliae, EPN, Custard apple leaf extract, Sweet flag rhizome oil, and clove oil extract all outperformed controls and were quite eco-friendly. IPM programmes should therefore include these botanicals and bioagents to aid in the management of H. armigera, a pest connected to the chickpea crop.

(Iqbal Et.al 2021) In low-income countries, transitional and subsistence farms frequently employ botanical insecticides. Because these compounds are expensive or scarce, industrial insecticides are also used. Botanical pesticides are also recommended by various development organisations, agricultural initiatives, and development programmes. Some people have questioned whether or not insecticidal evidence of their effectiveness and protection is enough or useful. There has been extensive research on biopesticides that work effectively in the field and during storage, but no organised attempt has been made to synthesise them domestically. This chapter focuses on botanical insecticides, including those manufactured from neem, garlic, and essential oils. This chapter goes into considerable length on essential oil-based insecticides. The quantity, ratio, and dosage of the active ingredients employed in biological insecticides based on vegetables may have an effect. As a last resort, we may utilise homemade insecticides to stop food losses and employ pest management strategies that are kind to the environment.

(Litwin Et.al 2020) A microorganism called an EPF can kill arthropods and cause disease. Each stage of the infection requires direct contact between the fungus and the insect's cuticle. EPF's lytic enzymes, secondary metabolites, and adhesins all help the infection process work effectively. These fungi are frequently used as biopesticides in organic farming due to their exceptional insecticidal qualities. Recent studies have concentrated on how EPF are harmed by pesticides and other manmade substances, as well as how they might survive in such a toxic environment. One type of the many substances that contaminate the environment and farmlands is pesticides. This study investigates the efficacy of EPF in the removal of dangerous pollutants like “alkylphenols, organotin compounds, synthetic estrogens, pesticides, and hydrocarbons”. These fungi also create a wide range of secondary metabolites, some of which have therapeutic or antibacterial characteristics. Due to a lack of knowledge of EPF's capabilities, bio control activities have so far used it insufficiently. Based on the information that is now accessible, our study has looked into a different application for these bacteria.

(Selvam 2018) The biological efficacy of botanicals was assessed against a variety of pests, such as the spotted pod borer complex, Maruca vitrata, gramme blue butterfly, and Euchrysops cnejus. Field testing for the black gramme crop were conducted in 2017 and 2018 under rainfed circumstances. Azadirachtin treatment reduced floral damage by more than 50.63 percent and pod damage by more than 66.8 percent in M. vitrata compared to the untreated control (0.03 percent). Neem oil applied in a 2 percent concentration also reduced E. cnejus-caused “flower and pod damage by 57.8 and 62.22%”. Beauveria bassiana and Metarhizium anisopliae were shown to be less active than botanicals in a variety of metrics. Most coccinellids “(2.14 beetles/plant) and spiders (0.97 spiders/plant)” were observed in adhatoda leaf extract up to 10%, which was determined to be the safest concentration. Crop yields improved after application of a neem mixture containing 0.03 percent azadirachtin, going from 433 kg/ha to 750 kg/ha.

(Campos Et.al 2018) In order to fulfil the demands of a rapidly rising human population, agrochemical usage has substantially expanded in recent decades throughout the world. Pests have become resistant as a result of the widespread and negligent administration of pesticides and other herbicides, which has contaminated the environment. The important regulators of soil quality, soil enzymes, are likewise impacted by pesticides. To meet the demands for food security in an area with declining arable land and declining water resources, more food must be produced in a responsible and safe manner. In light of the current situation, alternatives to synthetic agrochemicals that improve food safety while posing less of a risk to the environment and human health are gaining popularity. In the management of agricultural pests, substances derived from aromatic plants have demonstrated promising usefulness. They can be highly effective, have a variety of modes of action, and be relatively nontoxic to creatures other than the target. These chemicals are not suitable for widespread pest control application due to their limited stability and other technical issues. The current research also discusses the usage of plant-based compounds and approaches that can be used to farming operations that are sustainable in this context.

(Patil 2017) Helicoverpa armigera Hubner (Lepidoptera: Noctuidae), a pod borer, is thought to be responsible for up to 90% of the damage to chickpeas and is consistently present from the vegetative growth stage until the stage of pod formation. The temptation for growers to use more pesticides to combat the issue has resulted in residues from pesticides in food, a resurgence of pests, pesticide resistance, harm to the environment and other useful organisms, all of which are detrimental to the ecosystem. An integrated approach comprising host plant resistance, adequate agronomic practises, and cautious application of chemical and biological treatments was investigated here in order to decrease the occurrence of pod borer in chickpea production systems. Good agronomic practises have been demonstrated to limit pod borer survival and damage, including early sowing with optimal planting density, fertiliser levels, and inter/trap crops ("coriander, mustard, linseed, sunflower, and marigold") ("which is also necessary to understand the major factors influencing pest population and to make the pest control programme more effective"). All of these treatments, along with biological control, have been combined to produce long-term pod borer management and good chickpea yields. Both farmers and researchers have used effective management techniques. These techniques can be used in areas where the pest H. armigera is a concern. We come to the conclusion that an integrated approach works best for long-term sustainable management objectives.

(Hikal et.al 2017) One of the most urgent global challenges is protecting crops from pests. Regular use of insecticides endangers the health of farm workers, animals, and food consumers. Due of their low cost and minimal environmental impact, botanical pesticides have gained favour again despite the risks they pose to human health. Flavonoids, alkaloids, and glycoside fatty acids, among other plant compounds, have anti-insect properties and can be used as an alternative to chemicals that are used to get rid of insects in a variety of ways, including repellents, feeding deterrents, toxicants, growth retardants, chemosterils, and attractants. Because botanical pesticides do not eliminate natural enemies, there are no pesticide residues in food or the environment. The use of synthetic insecticides can be greatly reduced by incorporating botanical insecticides into an integrated insect management programme.

III METHODOLOGY

(a) "Materials and methods"

(i) "Botanicals and Entomogenous Fungi Used" - A ground test was carried out at the Regional Research Station in Praygraj to learn more. A randomised block design was used to replicate 12 treatments three times each. During the rabi season, the black gramme variety VBN 6 (Vamban 6) was cultivated in a 17-meter plot with a 35-centimeter x 15-centimeter spacing. Rain was necessary for the crop's growth. Agronomic techniques were meticulously adhered to in accordance with the crop's set of protocols. The details of the therapy strategy are as follows. During the flowering and pod-forming phases, respectively, sprays were used, while water was used on the control regions.

(ii) "Assessment of Pod Borer" - Data on the number of larvae per plant were collected from five randomly selected plants per plot one day before, 3rd, 5th, and 9th day after spraying.

(iii) "Assessment of Flower Damage" - Prior to spraying, a sample of 25 randomly selected flowers from each plot were counted and recorded to ascertain the degree of spotted pod borer infestation on the blossoms. The silky tunnels were used to identify the spotted pod borer, while the gramme blue butterfly observations were based on little holes on the blooms.

$$\text{Flower infestation (\%)} = \frac{\text{Number of infested flowers}}{\text{Total number of flowers}} \times 100$$

(iv) "Assessment of Pod Damage" - Along with the overall number of healthy pods, the amount of spotted pod borer and gramme blue butterfly infestations were also counted. The existence of a small hole on the pod was thought to be hazardous to the blue butterfly, and the development of webbing and a damaged hole on the pods were considered signs of damage by the spotted pod borer. The following formula was used to determine the damage.

$$\text{Pod damage (\%)} = \frac{\text{Number of infested pods ods}}{\text{Total number of pods}} \times 100$$

(v) "Assessment of Natural Enemies" - It was demonstrated that the entomogenous fungus and botanicals were protected in the field from predatory coccinellids and web spiders. Prior to the application of entomogenous fungi and botanicals, the number of five randomly selected plants per plot was counted to determine the impact of insecticides on coccinellids and spiders, as well as three, five, and nine days following treatment.

(vi) **"Assessment of Yield" -** For each treatment and replication, the pod yield for each plot was measured and statistically analysed. The yield on average per hectare as well as the variance between the treated and control plots were calculated. The methodology below was used to conduct a final cost-benefit analysis.

IV OBJECTIVES

To Compare the Effect of an Entomopathogenic Fungus and Botanical Insecticide in the Management of Gram pod Borer

(a) Hypothesis

(i) **Null Hypothesis:** There is no significant Effect of an Entomopathogenic Fungus and Botanical Insecticide in the Management of Gram pod Borer.

(ii) **Alternative Hypothesis:** There is significant Effect of an Entomopathogenic Fungus and Botanical Insecticide in the Management of Gram pod Borer.

V RESULT

(a) **Efficacy against Spotted Pod Borer -** Tests on the spotted pod borer were done to see how effective entomogenous MOUS fungus and plants are. An average of 2.1 to 3.1 larvae were present on each plant. Findings that are statistically insignificant imply that the black Gram-spotted pod bore population was evenly distributed over the experimental plot before the application of treatment.

During the flower initiation stage, azadirachtin (0.05 percent spray) was the most efficient and considerably superior to all other treatments, with the lowest mean number of larvae (1.56 larvae plant). The second-best treatment, neem oil 2.5 percent spray, had an average larval density of 1.95 per plant. Neem seed kernel extract 5.5 percent, which was similar to pungam oil 2.5 percent (2.00 per plant) and Madhuca oil 2.5 percent (1.99 larvae/plant), came in third. Following a 3.0 mL/L treatment with chlorpyrifos 21 percent EC, the lowest number of larvae per plant was observed.

The results also shown that azadirachtin (0.05 percent spray) consistently outperformed all other treatments at the pod initiation stage, with the lowest mean number of larvae (0.64 larval plant) and a longer residual efficacy up to the pod initiation stage in contrast to other treatments. The next-best treatment contained 2.5 percent neem oil and had 0.80 larvae per plant; it was followed by treatments containing 5.5 percent neem seed kernel extract, 2.5 percent pungam oil, and 2.5 percent Madhuca oil and had 0.90, 1.05, and 1.09 larvae per plant, respectively. One x 108 spores per mL are present in Metarhizium anisopliae, one percent are present in Notchi leaf extract, and one x 108 spores per mL are present in B. bassiana. 10% leaf extracts from Calotropis and Adhatoda were shown to be less effective, yielding "1, 15, 1, 25, 1, 30, 1, 49, and 1, 69" larval plants, respectively.

In comparison to the untreated control, larval survival ranged from 0.72 to 2.16 larva plants under treatment circumstances (3.41 larva plant). Clinical experiments revealed that azadirachtin, at a concentration of 0.05 percent, outperformed neem oil, 2.5 percent treatment, with mean larval survival of 1.5 larvae plant (1.7 larvae plant). The Adhatoda leaf extract therapy with a 10% concentration was shown to be the most ineffective ("2.20 larvae/plant"). The application of azadirachtin (68.6 percent) resulted in the greatest reduction over control, Neem oil came in second, then neem seed kernel extract(63.1 percent) (60.01 percent). Adhatoda leaf extract treatment resulted in the lowest reduction over control (35.8 percent).

(b) **"Efficacy against Gram Blue Butterfly" -** Before the application of botanicals and Entomogenous fungus, There were 1.80 to 2.16 larvae for every five plants. The statistical significance of these observations was low, showing that the gramme blue butterfly population was uniformly dispersed in the experimental plot prior to treatment application.

Neem oil 2.5 percent was found to be the most efficient and vastly better to all other treatments at the flower initiation stage, with the lowest mean number of larvae (1.50) per plant. M. anisopliae and Beauveria bassiana 1 x 108 spores/mL sprays, the second and third-best treatments, generated 1.64 larvae per plant, which each produced 1.67 larvae. An observation rate of 1.83 larvae/plant was obtained with an azadirachtin spray concentration of 0.05 percent, which is comparable to the 5.5 percent treatment rate of neem seed kernel extract. 1.85 larvae plants, roughly. The standard control, chlorpyrifos 20.5 percent EC at a concentration of 2.6 mL/L, only included 0.97 larvae plants.

Additionally, the results demonstrated that at the pod initiation stage, a second spray of neem oil at a concentration of 2.5 percent was consistently the best treatment, significantly superior to all other treatments (only 0.95 larvae plants were recorded), and demonstrated prolonged residual efficacy up to the pod initiation stage when compared to others. The second-best treatment, B. bassiana 1 x 108 spores/mL, generated an average of 1.5 larvae per plant. The next three treatments, azadirachtin 0.05 percent, metarhizium aniosopliae 1 x 108 spores/mL, and neem seed kernel extract 5.5 percent, each yielded a mean of 1.20, 1.30, and 1.50 larvae per plant.

"The overall efficacy of various treatments against E. cnejus". In comparison to the untreated control (3.40 larvae/plant), per plant, there were 0.82 to 2.25 larvae that survived. The larval population was 1.25 after a 2.5

percent neem oil spray, followed by 1 x 108 spores/mL B. bassiana (1.40), 5.45 percent neem seed kernel extract (1.52), 0.5 percent azadirachtin (1.60), and 1 x 108 spores/mL M. anisopliae (1.60). (1.40). (1.60). "While pungam oil 2.5 %, madhuca oil 2.5%, Adhatoda leaf extract 10%, Notchi leaf extract 10%, and Calotropis leaf extract 10% were significantly less active", with "1.80, 1.95, 2.15, and 2.25 larva/plant, respectively".

Following Beauveria bassiana at 1 x 108 spores/mL (59.80 percent) and neem seed kernel extract at 5.5 percent, the injection of neem oil at 2.5 percent led to a reduction above control of 64.30 percent (55.99 percent). The Notchi leaf extract 10% treatments had the lowest reduction over control (34.10 percent).

(c) **Flower Damage Due to M. vitrata -** It was determined that azadirachtin 0.05 percent was the most efficient herbal remedy, producing a minimum amount of floral damage of 10.08 percent, which was comparable to the use of 2.5 percent neem oil(10.35 percent damage) and the 5.7 percent neem seed kernel extract treatment (10.35 percent damage) (11.60 percent damage). In comparison to untreated flowers, flowers treated with 10 percent Calotropis leaf extract or Adathoda leaf extract suffered more damage (14.20 and 14.57 percent, respectively). The application of chlorpyrifos 20 percent EC at 2.7 mL/L during the flowering stage was the most efficient strategy to reduce flower damage (66.10 percent), followed by azadirachtin 0.05 percent (50.67 percent) and neem oil 2.5 percent (49.80 percent). The 10% Adhatoda leaf extract therapy resulted in the lowest percent reduction (27.95 percent).

(d) **"Pod Damage Due to M. vitrata" -** 11.60 percent of the herbal remedies containing azadirachtin (0.05%) caused pod damage, which was comparable to neem oil 2.5 percent (11.54 percent) therapy. The treatments with the maximum pod damage were those with 10% Calotropis leaf extract (16.95%) and 10% Adhatoda leaf extract (17.75%).

The percent reduction in pod damage was greatest when 3.0 mL/L of chlorpyrifos 20 percent EC was administered during the pod maturation stage (74.76 percent). The following two most widely used substances were neem oil (66.00 percent) and azadirachtin (0.5 percent). 65.89 percent Treatment with 10% Adhatoda leaf extract reduced mortality less than the untreated control, albeit by a smaller margin (46.80 percent).

(e) **"Flower Damage Due to E. cnejus" -** The best botanical treatment was 2.5% neem oil, which caused 3.12 percent floral damage. Beauveria bassiana 1 x 108 spores mL was the most effective entomogenous fungal, causing 3.57 percent floral damage. The most detrimental treatments employed 10% Adhatoda leaf extract (5.90%) and 10% Calotropis leaf extract (6.2 percent). Overall, positive control treatments of chlorpyrifos 20 percent EC reduced floral damage (68.50 percent), followed by neem oil 2.5 percent (58.1 percent) and Beauveria bassiana 1 x 108 spores/mL. (51.85 percent). The treatment using Adhatoda leaf extract (10%) resulted in the least reduction in symptoms (19.23 percent).

(f) **"Pod Damage Due to E. cnejus" -** Neem oil 2.5 percent spray caused 2.87 percent pod damage. Pod damage after Beauveria bassiana 1 x 108 spores/ mL administration was 3.53 percent on average, very similar to using neem seed kernel extract (3.73 percent). Treatments including 10% Notch leaf extract and 10% Aadhatoda leaf extract were much less effective (pod damage of 5.75 percent and 5.55 percent, respectively).

The chlorpyrifos treatment resulted in the greatest reduction in pod damage (72.05 percent) compared to the control, Neem oil, however, at a 2.5 percent concentration, reduced harm by 62.27 percent. When compared to the untreated control group, the reduction brought about by treatment with 10% Adhatoda leaf extract was less (23.70).

(g) **"Effect on Predatory Coccinellids" -** When I sprayed during the flowering stage, the coccinellid population ranged from 0.27 to 2.57/plant, while it was 2.57/plant in control conditions. Adhesive and calotropis leaf extracts appeared to be less toxic to coccinellids (2.27 and 2.00/plant, respectively). Chlorpyrifos 20 percent EC treatment was exceedingly fatal to these natural enemies, with only 0.27/plant reported. During the second spray of pod development, coccinellids ranged in size from 0.57 to 2.35. The untreated control had the highest population of coccinellids (2.35 plants), which was followed by extract from adhatoda leaves (2.10), which was equivalent to extract from calotropis leaves ("2.10/plant"). Following chlorpyrifos treatment, an estimated 0.60 coccinellid population was discovered per plant.

Notchi leaf extract (0.75 spiders per plant) and Despite the fact that chlorpyrifos is harmful to spiders, only 0.14 spider plants were observed.

During the second spray, "the spiders ranged from 0.25 to 3.00 per plant" (pod maturation period). The untreated control had the highest spider population (3.00 spiders/plant). Following that, a leaf extract of Adhatoda (1.27 spiders/plant) and a leaf extract of Calotropis were used (1.14). The least amount of spiders were seen in plots treated with chlorpyrifos (0.25 spiders per plant).

(h) **"Impact on Crop Yield" -** "Chlorpyrifos-treated plots gave the highest yield of 825 kg/ha", While azadirachtin-treated plots produced 750 kg/ha, which was the second-best natural product yield. The yield in treated plots was significantly higher than in controls. Both neem seed kernel extract (700 kg/ha) and neem oil (716 kg/ha) treated plots generated equal yields. The plots treated with Adhatoda and Calotropis leaf extract yielded 500 and 516 kg/ha less, respectively. The untreated control had a minimum yield of 433 kg/ha of black grame seed.

VI DISCUSSION

Two treatments, one during bloom and the other during pod start, were applied to the crop to avoid a pod borer infestation. The use of botanicals like azadirachtin, NSKE, fungi like B. bassiana or M. anisopliae, as well as oils from neem, madhuca, and pungam was found to be useful in the treatment of the pod borer. Pongamia has been shown in the past to be toxic to insects. Similarly, how neem leaf extracts effect M. vitrata is unknown. Although the efficiency of NSKE against pulse pests has been proved, several of the items presented here have yet to be field tested. Most studies on the pigeon pea spotted pod borer have focused on neem compounds such neem oil, neem seed extract, and neem cake. Neem oil works better against chilli bugs than the herbicides that growers typically use, the current study's findings that chlorpyrifos outperforms environmentally friendly alternatives appear to be a general phenomenon for chemical pesticides applied in the field. Endosulfan 0.12 percent and dichlorvos 0.13 percent, two popular insecticides, were more effective than neem oil 3.5 percent and NSKE 5.5 percent in suppressing Helicoverpa armigera larvae in pigeon pea. To treat M. vitrata, which attacked cowpea and pigeon pea, natural compounds such as NSKE (5.5%) and garlic extract (1.5%) as well as various doses of pepper were utilised. Maruca testulalis was the most effective entomopathogenic fungus for controlling M. anisopliae pod borers in field-grown cowpeas. The current study's findings are consistent with the mild effect of notchi leaf extract against on.

The use of NSKE in conjunction with cow urine, garlic extract in conjunction with cow urine, or NSKE alone reduced floral and pod damage. In a lab research, however, foliar treatment of neem seed kernel extract dramatically reduced M. vitrata damage to the flowers. This study's results, which are comparable to a 5% neem seed kernel extract, reveal a reduction in flower and pod damage. However, neem oil spray outperformed mahua oil spray in terms of dramatically reduced mean pod damage on pigeon pea. Pungam oil considerably reduced pod damage caused by H. armigera. Although endosulfan was the most effective, this study revealed that biopesticides NSKE 5 percent reduced pod damage more than endosulfan (0.12 percent).

Compared to treatments using dichlorovos, the effects of botanicals and fungi on natural enemies differed substantially. According to research, botanicals and entomopathogens can be used to control a wide range of sucking pests safely and effectively. Despite the fact that few research have been conducted to investigate the potential detrimental effects of botanical insecticides, neem-based pesticides have been routinely used against a wide range of agricultural pests. Even neem treatments have been said to be much less dangerous to spiders and coccinellid predators than chemical pesticides.

An integrated pest management approach must prioritise crop output. It was exciting to see such a high output after using azadirachtin and other neem compounds. When compared to monocrotophos, the NSKE 5 percent, which was used on green grame to control M. distalis and L. boeticus, had the highest mean cost-benefit ratio after utilising neem seed extract at a rate of 3-10% in field settings.

VII CONCLUSION

All interventions were shown to be significantly more successful than the control group. Beauveria bassiana was the most effective at reducing the larval population. In terms of pod damage, all treatments outperformed the control group. The plots that got Beauveria bassiana treatment had the least amount of pod damage. The highest rate of pod damage observed on plots treated with clove oil. Beauveria bassiana generated the highest grain yield in the fully treated plot, whereas clove oil produced the lowest. Beauveria bassiana had the least amount of yield loss, whereas clove oil had the highest percentage of yield loss. Clove oil produces the largest production loss in Beauveria bassiana, although yield increases in treated plots over control.

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