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NON-CHEMICAL PEST MANAGEMENT: BIO-EFFICACY OF A PLANT-BASED SOLUTION AGAINST COWPEA APHID

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ABSTRACT

Aphis craccivora, the cowpea aphid, is a severe problem for cowpeas. The pest cannot be controlled by using only the cowpea–cereal intercrop. Intercrop pesticide use is hazardous to human health and the environment. Alternatives like fungus-based biopesticides are preferable due to the fact that they are safe for both the environment and the end user. An intercrop of cowpea and maize was used in conjunction with Metarhiziumanisopliae ICIPE 62 to see how well it worked against A. craccivora. There were six treatments: untreated cowpea monocrop, untreated cowpea–maize intercrop, treated cowpea monocrop, treated cowpea–maize intercrop, treated cowpea monocrop, treated cowpea monocrop, treated cowpea For cold and dry season, ICIPE-62-treated cowpea–maize intercrop yielded similar leaf yields to cowpea monocrop treated with ICIPE-62 in cold and dry season. This intercrop of cowpea and maize was the most resistant to pests and disease in the short wet season, but the leaf yield was comparable to that of the same intercrop in the cold and dry season. Aphid infestation/cowpea damage levels were not reduced by Duduthrin in monocrop or intercrop crops in any of the seasons. Several insect pests attack the cowpea (Vignaunguiculata), including the cowpea aphid (Aphis craccivora), which damages the plant's vulnerable leaves and decreases its production. The Chemistry Lab created two plant-based formulations. Tobacco Nicotianatabacum leaf and Polygonumhydropiper flower components were employed for safe management.

INTRODUCTION

Originally cultivated in Africa, cowpeas have now spread around the world. As an intercrop with cereals, farmers can harvest the crop even if their cereal crops fail owing to lack of rain because the crop is drought-tolerant. In rural areas, the crop is a vital source of protein, vitamins, and cash for families. Cowpea is one of the most widely grown and consumed indigenous vegetables. Native vegetable cultivation has seen an increase in land use. The hunt for new plant-based pesticides continues to develop, but the results and advantages are not always evident. However, there are a number of plant species with recognized pesticide qualities that might be easily turned into novel products in the laboratory.[3]Isman has argued that increasing farmer use of natural pesticides needs research directed at the practical application of such products under complex agro-ecological conditions, particularly understanding how different pesticidal plant species perform when applied to different crops under different growing conditions. Aside from these issues, the overall socioeconomic and agroecological advantages of their use must also be examined in greater detail. As natural pesticides aren't as successful as their synthetic counterparts, field trials are the only way to determine whether or not they should be used more widely. Pesticide resistance can be prevented by using unprocessed plant extracts for pest management since they include a wide range of bioactive chemicals, their low environmental persistence, and their low cost of application, especially for smallholder farmers with little money. Bio-active chemicals, for example by photodegradation, are quickly broken down and readily washed away when it rains,[1] resulting in inconsistent efficacy and poor toxicity and persistence against target pests. To meet the demands of consumers and policymakers, methods that enable agroecological intensification as well as pesticidal plant products may be well-suited to this goal.

Trade-offs must be made when employing plant secondary metabolites to combat arthropod agricultural pests, such as the effect of crop protection measures on ecosystem services. Insect pollination and natural pest control are negatively influenced by pesticide usage. Therefore, the environmental and economic advantages of pest management by natural means may be quantified. Ecosystem services like pest control can be improved and sustained by natural or modified agricultural ecosystems and local land management techniques that affect the abundance of pollinators for legume crops like pigeon pea. There are several possible reasons for the reduction of pollinators, but one of the most important is the increased use of synthetic pesticides.[4] In order to ensure a more ecologically friendly approach to agriculture, legislation that encourage it will be necessary. Although little study has been done on the impact of pesticide usage on non-target arthropods, this remains a neglected field of research that needs greater exploration in order to understand the trade-offs of utilizing more plant-based pest control products.

Insect pests are susceptible to several entomopathogenic fungus (EPF), which can be used as biological control agents to lessen the need for chemical pesticides. To combat A. cracivora, which can be controlled using EPF-based biopesticides, synthetic insecticides aren't a viable option, especially when growing green vegetables like cowpea, because the pest is vulnerable to many different entomopathogenic fungus.[2] Both in the lab and in the field, several Metarhizium species have been identified as pathogenic to A. craccivora. In addition, it has recently been established that EPF-based biopesticides, such as Metarhiziumanisopliae ICIPE 62, decrease aphid populations in cowpea under field circumstances. Most aphid pesticides in Europe and the United States are EPF-based, but they are rare in Africa and none have been approved for use against A. craccivora.

Although biopesticides generated from EPF have the benefit of being compatible with integrated pest management (IPM), their limited potency in field circumstances slows down their widespread application. As a result, combining EPF-based biopesticides with other pest management methods like cultural control can improve their effectiveness.[3] There have been no prior studies evaluating the efficacy of EPF-based biopesticides when used in conjunction with intercropping cowpea and maize for control of A. craccivora, despite their recommendation in IPM. Accordingly, we looked at the effectiveness of using M. anisopliae ICIPE 62 treatment in conjunction with the cowpea–maize intercrop in the control of A. craccivora in the field.

Researchers investigated whether crude extracts from six pesticidal plant species from around the world might be used as a foundation for biopesticides on various legume crops and the effects of utilizing pesticidal plants on non-target arthropods.[5]

METHODS AND MATERIALS

Preparation of Fungal Cultures and Inoculums

The Arthropod Pathology Unit Germplasm Centre at icipe provided the isolate ICIPE 62 of the fungus Metarhiziumanisopliae, which is known to be harmful to A. craccivora.A 60 cm x 35 cm bag of long grain rice was autoclaved for one hour at 120°C and utilized as a substrate for mass generation of fungal conidia before the tests. For this experiment we used 35 () x 25 (width) x 15 (depth) plastic buckets to chill the autoclaved substrate to room temperature before introducing a 3-day-old culture of blastopores (50 mL). Ambient temperatures of 20–26 °C and 40%–70% RH were maintained for 21 days for the infected substrate culture. Drying at room temperature for five days after removal from the incubator was completed. In order to employ conidia in field research, they were first gathered and kept in the refrigerator (4–6 °C, 40–50 percent RH) after being sifted from the substrate with a sieve (295 m mesh size). In order to determine whether or not the therapy would be effective in the field, 100 L of conidial suspension was placed over Sabouraud dextrose agar (SDA) plates, and the vitality of the fungus was assessed. As a final step, the plates were incubated at 26 2°C in complete darkness for 18 hours, at which point the percentage of fungal spore germination was evaluated by counting 100 conidia using a light microscope (400x). To determine viability or germination, only conidia germ tubes that were at least twice the conidium's diameter in length were considered. In the field test, conidial germination was >90% after 18 h on SDA, and this was regarded satisfactory. In order to estimate the concentration of conidia per gram, the solution was first diluted serially to 100 times with sterile Triton water (0.05 percent Triton X-100), then vortexed for 5 minutes at 700 rpm to break up conidial clumps and ensure a homogeneous suspension. Spore counts were carried out under light microscopes using Neubauerhemocytometers after vortexed suspension was pipetted into hemocytometers. 0.1 mL of spores yielded the number of conidia in grams needed to create a concentration of 1,000,000 conidia/ml. [6]

Invention in the making

In advance of planting, the field trial site had been disc harrowed and ridged. Lyamungo 90 and Kalima were the most common bean seeds used for planting in Tanzania and Malawi, respectively. Within each 5-by-5-foot plot in Tanzania, the seeds were planted every 50 centimeters, and the rows were spaced 20 centimeters apart. Each ridge was planted with two rows of beans 75 cm apart, with rows 10 cm apart and ridges 30 cm away, and plants were arranged in 5 x 5 m plots that were 1 m apart.[6] In Tanzania, the seeds were of the Raha1 type, whereas in Malawi, they were of the Mkanakaufiti kind. Within each 5-by-5-foot plot in Tanzania, the seeds were planted every 50 centimeters, and the rows were spaced 20 centimeters apart. A row of 20 cm-spaced cowpeas was planted in Malawi on 75 cm-apart ridges in 1 meter-apart plots of 5 m by 5 m, one row on each ridge. Pigeon pea seeds of the Mali and Mthawajuni varieties were utilized for planting in Tanzania and Malawi, respectively. Pigeon pea seeds were sown in 5 x 5 m plots spaced 2 meters apart in Tanzania at a 75 cm row spacing and a 30 cm row spacing. Pigeon peas were grown in Malawi in 5-by-5-meter plots spaced 2 meters apart, with a 75-centimeter row spacing and a 60-centimeter row spacing.[7] When the seedlings were planted, the manufacturer's recommendations for diammonium phosphate fertilizer were followed. Each week, the trials were inspected and ad hoc hand weeding was performed as needed. In the experiment, the treatments were reproduced on four blocks in a randomized full block design.

Biopesticides are a big business.

Biopesticides account for just 1% to 2% of the global crop protection market, although sales were expected to climb by 4.2 percent in 2010 to reach. Bt-based goods account for the majority of the market's sales. More than half of all biopesticides are used in the orchard business, accounting for 55% of all applications. Biopesticide sales are likely to rise as organic farming becomes an increasingly important market for this business. While biopesticde use is not limited to organic markets, synthetic pesticide sales are dropping as the industry responds to customer concern about pesticide residues and increased environmental consciousness.. As a result, the biopesticide sector is focusing on research and development in the face of pesticide resistance, environmental pollution and contamination and human and animal safety issues, as well as the danger of exotic insect pests that necessitate innovative management strategies. Numerous new biopesticide products are being created to fulfill the rising demand for biopesticides, but the business is relatively new and confronts many problems in the process of research, implementation, and marketing of these pesticides.[8] A few of the roadblocks include: the need to identify effective strains of pathogens and their host range, problems with production and formulation, a lack of understanding on how these organisms can fit into an

IPM program and their interactions with the environment, a too-simple pesticide paradigm that compares biopesticides with synthetic chemical pesticides without regard for their attributes, and acceptance by growers and the general public.[1] A healthy biopesticide sector is unlikely unless these issues are resolved, and this has been evidenced by the industry's troubled past. Biopesticide research and development, as well as the important firms, agencies, and organizations participating in this field, will be discussed in this section. The elements that contribute to successful product commercialization will also be discussed.

Lambdacyhalothrin was the active component of a pesticide called Duduthrin, which was obtained from a local Nairobi, Kenya, agrochemical business. This pesticide is extensively used in Kenya to control aphids. It was necessary to fully mix the pesticide with 20 L of clean water in a knapsack sprayer before applying it, and 65 mL of the solution was used in the process.[4]

Three seasons were spent doing the experiment. There are four growing seasons: hot and dry (March–June), long rainy (July–August), cold and dry (July–August), and short rainy (October–December). Each has its own advantages and disadvantages. When the rainy season lasted from March to June of 2016, the experiment was carried out.[5] Annual rainfall in the lengthy wet season was 130 mm, with temperatures ranging from 20 °C to 25.2 °C and relative humidity between 60 and 70 percent. Rainfall averaged 60 millimeters throughout the cold and dry season; lowest and maximum temperatures were 23.7°C and 29.5°C, respectively; and relative humidity was 60-65%. It rained on average 80 mm throughout the brief rainy season, with lows of 25.8°C and highs of 29.3°C, with a relative humidity of 65-70% throughout.[8]

Biopesticide regulations and definitions differ from institution to university, and to avoid confusion, the relevant vocabulary must be established prior to discussion.

The Environmental Protection Agency (EPA) oversees biopesticides and classifies them into three categories. This includes (1) microbial pesticides, (2) PIPs (plant-integrated-protectants), and (3) biochemical pesticides.[9]

It is defined as a "agent microbiologically intended for the prevention, destruction, repell or mitigation of any pest or intended for use as a regulator, defoliant or desiccant of plants, that: is a eukaryotic microorganism including, but not limited to protozoa, algae and mushrooms; is a prokaryotic microorganism including, but not limited to Eubacterium and Archebacterium, or is a parasitically replicating microscopic element PIPs are "pesticidal compounds that plants create from genetic material that has been introduced to the plant," according to the National Institutes of Health. The Bt toxin protein and its genetic material are managed in transgenic plants, but the plant itself is not controlled. In the words of the EPA, biochemical pesticides are "naturally occurring compounds that manage pests through non-toxic processes. Some examples of these include sex pheromones and plant extracts intended to arouse. [10]

Comprehensive approaches to pest control are referred to as integrated pest management (IPM) or integrated pest control (IPC). The goal of IPM is to keep insect numbers at or below the level of economic harm (EIL) Improving the health of crops is the primary goal of integrated pest management, which supports the use of natural pest control methods. For example, physical, cultural, biological,[4] mechanical and chemical pest management approaches can all be utilized to keep pest populations under the EIL. Many studies and farmers have stressed the use of insecticides exclusively on the basis of chemicals, which do not perform as well as predicted in the latter year in both production and consumer health aspects as they were supposed to.. Our research has focused on evaluating various IPM-based pesticides, such as chemical bug zappers, on the basis of production, aphid count, and cost efficiency. The biological approach of IPM makes use of plant extracts like Neem extract and Cannabis sativum extract, as well as biological pesticides, whereas the chemical method makes use of chemicals like Chlorpyrifos and Cypermethrin.[3,6]

Species of Soil Found at the Research Facility

Every season, a new experiment was conducted in a different area of the same farm using the same crop rotation procedures. It is non-sodic, relatively well drained, dark, deep to extremely grey solid layered highly calcareous, cracking, sandy clay to clay loam soil in the field. Authors have validated that soil type and feature variability is non-existent in the research region they chose based on mapping done at the field station. [10]

Crop

After plowing and harrowing, the field was ready to be sown. The experiment employed a cowpea landrace sensitive to aphids from the icipegermplasm collection. A local agro-vet business provided the PHB 3253 type of maize for this investigation. After emergence, cowpea was trimmed to one plant per hole, with two seedlings per hole sowed in a spacing of 20 cm intra-row by 75 cm inter-row; two seeds were sown each hole. For maize, the recommended spacing was 30 cm between rows and 90 cm between rows. Six different treatments were tested in each plot, resulting in a total area of 600 m2 each block. Overhead irrigation was employed for the first three weeks of planting because the weather was relatively dry in January, and irrigation was stopped when the rains started. Prior to the crop's establishment, weeding was done twice a month; once the crop took hold and buried the weeds, weeding was lowered to once per month.[2] The crop was left open to aphid infestation by the natural process.

A fungus that is harmful to insects

Entomophthorales and Hypocreales are the two most common phyla of entomopathogenic fungus to be found in the world's insects. Asexual azygospores and sexual zygospores can be produced by Entomophthoralean fungus, which are obligate parasites with limited host ranges. Entomophaga, Entomophthora, and Zoophthor are three of the most prevalent genera of organisms that reduce insects by epizootics. They can be employed in inoculation biological control, but their usage is limited due to the high cost and difficulty of mass production, since they must be collected and raised on insect hosts; in addition, epizootics require a crucial threshold level of hosts to develop.[9] As a result, the development of mycoinsecticides based on Hypocrealean fungus has received greater attention recently. Beauveria, Metarhizium, and Isaria previously Paecilomyces are three of the most important fungi in this order since their compounds are now approved for use in the control of a wide range of insect pests.

A polymorphic species complex with variable selectivity has been discovered in these fungi that exhibits a greater host range than previously considered possible for certain of their strains. The use of Beauveria, Metarhizium, and Isaria in commercial goods is discussed.[6]

Currently, Beauveriabassiana is the most widely used biopesticide in greenhouse/nursery and vegetable, ornamental, and turf production. Mycotrol, BotaniGard ES and BotaniGard 22WP are all licensed for use in greenhouse/nursery and vegetable, ornamental, and turf production. Orthoptera, Thysanoptera, Hemiptera, Lepidoptera, and Coleoptera are among the insect orders for which these products can be used, while the label for Naturalis L also lists Diptera and Acari. There is no agronomic or field crop registration for either BotaniGard label.

As a vector for more than 30 plant viruses, Acyrthosiphonpisum is a severe problem for commercial pulse growers. It can hurt crops directly by taking sap from leaves, stems, and pods, and indirectly by acting as a host for a wide range of plant diseases. Seedling stems, terminal shoots, and petioles are the primary targets of the pea aphid, but as the plant grows, it also turns its attention to flowers and pods. Chlorotic damage, leaf bending and withering, nutritional deficits, and plant stunting are among symptoms of Acyrthosiphonpisum infestations on various host plants. Furthermore, by injecting saliva that is phytotoxic to plants through its needle-shaped stylus, these aphids cause indirect and catastrophic harm. In addition, aphid honeydew causes sooty mold to grow on the leaves of the host plant, which inhibits photosynthesis. A. pisum on pea has resulted in yield losses of up to 35.7% in India.[7]

Life's Cycle and the Science of Evolution

As pods developed, Acyrthosiphonpisum numbers rose in July, peaking in late July or early August. Peas affected up to the time of blossoming recovered and yielded normally. According to Pickering and Gutierrez, A. pisum multiplies asexually on a variety of legumes throughout the year and that pest outbreaks often occur in April to May or September to October. They also found that from September to October, A. pisum was particularly active on pigeon pea.

A. pisum's biology and life cycle. hemimetabolousAcyrthosiphonpisum has an incomplete metamorphosis. Known as reproductive polyphenism, the A. pisum is capable of both apomictic parthenogenesis and sexual reproduction. In the spring, overwintered fertilized eggs hatch into a wingless fundatrix, which gives birth to nymphs, which begin the A. pisum lifecycle. It is only in nymphs that the next generations of aphids go through the stages of oogenesis and embryonic development.[5] At high temperatures, parthenogenesis occurs in the pea aphid and the aphid produces identical offspring through four stages of development. A parthenogenetic female A. pisum produced an average of 83.7 nymphs each day on field pea at 20°C in a greenhouse, according to a study. Within 7–15 days of giving birth, females begin producing young, which may or may not be wingless (alate). Crowding and the quality of the host plant can both cause these prenatal morphological alterations.

Environmental Factors Affect Pea Aphid Development and Survival

As poikilotherms, insects have temperature-dependent life cycles that can be threatened by extremes of low and high temperatures. Pest outbreaks and aphid-induced losses on spring-sown grain legumes in the Pacific Northwest may rise as a result of higher winter temperatures, according to the latest research. For A. pisum, high temperatures can lower fertility, lifespan, and generation time. At 22°C, the intrinsic growth rate of A. pisum was maximum, and the ideal temperature for growth and development is between 18–24°C Aphid population growth and survival were negatively impacted by a temperature of 25°C, while reproduction and fecundity were negatively impacted by a temperature of 30°C. This aphid's maximal development threshold in Taiwan is 35°C, according to a study published in the Journal of Applied Entomology. According to this study, the optimal temperature range for the growth of A. pisum is between 26°C and 30°C.[8]

Development of A. pisum in the United Kingdom lasted between 9 and 10 days. The optimum temperature for A. pisum in the UK was 23.1°C, whereas 26.7°C had a detrimental effect on development and took longer for aphids to complete all their nymphal instars. As temperature rose, the number of nymphs per female increased from 11.9 to 19.6°C, while the number of mature nymphs per female decreased from 23.1 to 26.7°C.[9]

Pisum outbreaks are influenced by a variety of environmental conditions in addition to temperature. A. pisum's life cycle can be influenced by a variety of biotic and abiotic variables, such as natural enemies, agricultural techniques, and plant quality. In the Pacific Northwest, rain and windstorms in spring were able to lower the density of A. pisum by washing or knocking individuals from host plants.[10] A. pisum population development is influenced by host plant moisture maintenance, which is aided by autumn and spring rains. Winged A. pisum migrations are influenced by winds, as are following outbreaks in the UK, where harsh winters can cause high A. pisum mortality and delay aphid population development, while also delaying the sowing of pea crops, leading to larger A. pisum numbers throughout the growing season. In the United Kingdom, however, the same trend was not found, despite the fact that the amount of hectares planted to pea crops in a region differed. This suggests that the food supply is not the only factor that influences the quantity of A. pisum in a given location.

Coccinellids, parasitoids and fungus can all have an impact on A. pisum development, survival and population increase in pulse fields, depending on the location in where they are found.[3]

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