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PLANT-BASED BIOPESTICIDES: POTENTIAL ALTERNATIVES TO CHEMICAL PESTICIDES

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EXECUTIVE SUMMARY

With the rising concern for environmental safety and human health, regaining interest and attention to the development of alternative control methods, amongwhich is the use of biopesticide, should be given proper prioritization. In depth, research is needed in many areas such as production formulation, delivery and commercialization of these products.

Ilocos Region is one of the major producers of high value crops which include vegetables such as garlic, tomato, eggplant, sweet and finger pepper. These are grown and planted usually after rice. Aside from cash, they are good source of vitamins and minerals. However, good production is always constrained by the attack of insect pest and diseases. In spite of the concerted effort of the national government on the use of Integrated Pest Management (IPM) as an approach in controlling pest populations, most farmers still resort to the use of synthetic chemical pesticides as an immediate control, which is hazardous to human health and environment. As such, searching for new alternative control methods using plants with pesticidal properties can be exploited in order to develop a formulation and application method that is effective, reliable, consistent, and economically feasible.

This paper highlights activities carried out in research on the use of the developed promising biopesticide products of Mariano Marcos State University (MMSU) funded by Department of Science and Technology, DOST- Philippine Council for Agriculture and Aquatic Research and Development (PCAARRD), for the control of common insect pest like tomato fruitworm, thrips and mites for pepper, and epilachna beetles in eggplant and for diseases like early blight in tomato, tangle top, purple blotch, and cercospora leaf spot for garlic. The products were derived from plants with pesticidal properties available in the locality and was found effective as preventive and control measures or limits the organism to become pest status of the target vegetables in an organic farm. The different products were coded as MMSU Bio-In 3, MMSU Bio-In 6 and MMSU Bio-In 8 for insect pest and for diseases such as MMSU DFTm4 for tomato and MMSU DF4Ga for garlic.

Potential Plant Materials with Pesticidal Property

Biopesticide Formulated Products

The effectiveness of developed MSU Biopesticide products is comparable with chemical pesticide regardless of fertilizer management. Lower pest incidence was noted and comparable to the chemical pesticide. The effectiveness of the biopesticide for the control of pest of selected vegetable was further enhanced when used as an alternate to chemical pesticide as further indicated by the higher yield obtained in all the crops evaluated. With the above findings, the use of biopesticide presents a promising future for consumer demands for safer and lesser, if not pesticide-free, vegetable. In addition, the developed products has the potential to be included in the Integrated Pest Management (IPM) program of the government so that the total dependence of farmers to chemical pesticide alone is reduced.

INTRODUCTION

In the Ilocos region, tomato, garlic, eggplant, sweet and finger pepper are vegetables usually planted after rice. In addition to being considered as cash crops, they are rich sources of vitamins and minerals. However, like any other crop, they are being attacked by insect pests and diseases, a major constraint in production. For example, tomato is attacked by the tomato fruitworm *(Helicoverpa armigera* Hubn.*). A*lthough foliage feeding of the newly hatched larvae in tomato may not cause any significant damage, boring may result in yield loss up to 70%. Thrips and mites which are known vectors of viruses likewise cause damage to sweet and finger peppers. High population of these pests produces leaf curl, distortion of plant growth, leaves deformation and wilting. *Epilachna* beetle (*Epilachna vigintioctpucntata F*), is now becoming a major pest in eggplant and the most prevalent pest especially toward the onset of the rainy seasons. Both the larva and the adult damage the plant by eating the leaf tissues between the veins and skeletonized leaves dry out. Also, tangle top infestation due to mites

(*Aceria tulipae)* can reduce production by as much as 40-50% (Ahmed 1981) and thrips by as much as 50% (Ligsay et al. 1984).

Additionally, the industry of the Ilocos white garlic, a much preferred one over the imported Taiwan variety due to its pungency and aroma, is slowly collapsing due to low yield. This low yield is accounted to disease attack particularly purple blotch caused by *Alternaria porri* (Ellis) Cif and cercospora leaf spot caused by *Cercospora duddiae* Welles. Tomato production, on the other hand, is being beseeched by the early blight caused by *Alternaria solani* (Ellis and Martin) Jones and Grout. This disease is favored by hot and humid condition and, if not controlled, can cause 90-100% yield loss.

In general, farmers use synthetic chemical pesticides to abate pest incidence in the absence of alternatives. Its use has been an important part of pest management for many years. However, with known disadvantages and risks, some synthetic pesticides leave unwanted residues in food, water and the environment. Some are suspected carcinogens and low doses of many insecticides and fungicides are toxic to mammals.

This predicament results in the search for less hazardous alternatives to conventional synthetic insecticides. Among the recent efforts is the exploitation of natural products from plants that contain toxic metabolites to control pests. Botanicals degrade more rapidly than most chemicals pesticides and are, therefore, considered relatively environmentally-friendly and less likely to kill beneficial pests than synthetic pesticides with longer environmental retention. It is, therefore, an utmost urgency to identify alternative to chemical pesticide in plant protection. Hence, different plant materials with potential pesticidal activity, specifically insecticidal and fungicidal action, were investigated and formulated as biopesticide on pests of selected crops such as tomato, garlic, eggplant finger and sweet pepper.

APPROACHES AND RESULTS

Extraction of plant materials and formulation of bio-pesticides

Plants with insecticidal properties were extracted using either wine, vinegar and goat manure tea. Extraction method was done following the effective ratio and proportion of the plants and extractants. These were filtered and packed in storage bottles.

Bio-pesticides were formulated into powder and liquid form. The products were tested against the target pests, like tomato fruit worm in tomato, epilachna beetle in eggplant, thrips, mites for garlic, and pepper, early blight, purple blotch, and cercospera leaf spots.

The following plant materials for the formulations of the bio-pesticides were:

a. MMSU Bio-In 3 is a mixture of *Cleome viscosa, Argemona mexicana, Euphorbia hirta, Tabernaemontana pandacaqui* + goat manure tea (GMT);
b. MMSU Bio-In 6 is a mixture of *Euphorbia hirta, Curcuma longa, Piper betle, Tabernaemontana pandacaqui, Ocimum sp.;*
c. MMSU Bio-In 8 is a mixture of garlic waste and Neem tree leaves;
d. MMSU DF4Tm is a mixture of Curcuma longa, *Aloe* barbadensis and Allium sativum; and
e. MMSU DF4Ga is a mixture of Ocimum vulgare, *Curcuma longa* and *Aloe* barbadensis

***In vitro* evaluation of botanicals**

The agar- well diffusion method was followed to screen the efficacy of botanicals in the laboratory against *Alternaria solani*, *Alternaria porri* and *Cercospora duddiae.* Using distilled water, Iloco- vinegar and Iloco- wine as extractant at concentrations of 1:1, the presence and absence of antifungal activity were observed.

Evaluation of the products under screenhouse condition

Bio-pesticide products were evaluated under screenhouse condition for their efficiency and phytoxicity. For bio-insecticides, crops such as tomato, pepper and garlic were planted separately in pots. At 30 days after planting, initial population of insect pests were counted, followed by the spraying of the products.

For bio-fungicide products, tomato plants were inoculated with *A. solani* suspension, and were sprayed in the late afternoon two weeks after transplanting. This was done weekly, thereafter, for 4 sprayings. Plants were assessed with the appearance of symptoms and the intensity of the disease.

Field evaluation of the products

Bio-insecticides

The three bio-insecticides (MMSU Bio-In 3, MMSU Bio-In 6 and MMSU Bio-In 8) were tested against the target pests in tomato, pepper, eggplant and garlic under field condition.

Application of the products was done in four spraying schedules: at 30 days after transplanting and at 5-7 days interval. Percent disease index (PDI) of the sample plants were recorded at different intervals and at plant maturity. Disease rating scale for early blight disease of tomato and purple blotch of garlic were assessed.

Bio Fungicides

The best concentration of the formulated biofungicides were also tested for the management of *A. solani* causing early blight of tomato, *A. porri* causing purple blotch of garlic and *C. duddiae* causing cercospora leaf spot of garlic on station during early planting (October) and (November) late planting.

On Farm Evaluation

Bio-fungicide products were further evaluated in farmers' field in two sites (City of Batac and Paoay) following organic and farmers' practice, which is calendar spraying. Spraying of the formulated bio-fungicide products and chemical control was done at 30 DAP. Goat manure tea and Fish Amino Acids (FAA) were applied alternately with the bio-fungicides as food supplement.

Data on yield and yield characteristics were gathered such as bulb weight and size, and were statistically analyzed using IRRISTAT and RCROPSTAT. Monitoring of pests was done weekly through visual counts and actual counts in the field using the rating scale guide.

Formulated botanical insecticides MMSU Bio-In 3 obtained a lower damage rating scale against **tomato** fruitworm. For the **garlic** planted on-station and on-farm, plants treated

with MMSU Bio-In 6 had the lowest damage against thrips during bulb formation. Higher yield was noted on plants sprayed with MMSU Bio-In 8 with a yield increase of 19.40% over the control, when planted on station. The presence of garlic waste in MMSU Bio-In 8 formulation, combined with neem tree leaves enhanced the toxicity of the product. In addition, purple blotch infestation, as well as tangle top, was very low, also coupled with favorable weather conditions. Yield of **finger pepper** was higher in plants treated with MMSU Bio-In 6 where there was low damage observed caused by leaf curling. Highest yield was noted in plants treated with MMSU Bio-In 7 followed by MMSU Bio-In 6 with a percent yield increase of 24.85% and 12.25%, respectively. For **eggplant**, plants treated with MMSU Bio-In 6 obtained the highest yield due to the lesser attack of shoot/ fruitborer, compared to the control plants and those applied with chemical insecticide.

The different products can be useful for managing the target pest and a suitable alternative of chemical pesticide. They can be integrated with other pest management strategies and systems.

In plant disease management, time of planting is a part of the strategy to manage diseases particularly fungal diseases. Plants treated with bio-fungicide significantly had lower plant disease index ranging from 49.30% to 53.3% in October planting, which was comparable to the chemical fungicide. Similar result was obtained in November planting. This was due to the high relative humidity and some rains during the growing season, and in November planting, it had drier condition.

In terms of fruit infection, the bio-pesticide products significantly had lesser fruit infection range (1.68%-0.78%) comparable to plants sprayed with chemical fungicide; both in October and November planting.

For the control of purple blotch in garlic, lower PDI values were observed in garlic sprayed with bio-fungicide and was comparable with those sprayed with chemical fungicide at 75 DAP. In October planting, there was lower infection of purple blotch, compared to November planting due to the source of inoculum developed from infected plants in the October planting and which was also favored by the dry humid environment.

The infection of *Cercospora* leaf spot in garlic was lowest when sprayed with MMSU DF4Ga (2.22%), particularly in October planting, and also produced bigger bulbs. The use of MMSU DF4Ga gave higher yield of 3.13tha^{-1} in October planting, similar to the result obtained in November planting.

Results of on farm testing of the bio-fungicides showed that there is lower PDI of early blight infection in tomato at 75 DAT. This was observed in trials conducted in Paoay and City of Batac with 35.10% and 31.40%, respectively, while the farmers practice obtained higher PDI at 42.70% and 43.40%. Using the organic practice, there was a disease reduction of 17.70% in Paoay and 27.40% in City of Batac site.

Higher yield was obtained in Paoay using the organic products (26.90 t ha^{-1}) and City of Batac (20.50 t ha^{-1}), as compared to Farmers' practice. Yield increase of 17.20% (Paoay) and 9.70% (City of Batac) was realized using the organic technology. Lower infection of purple blotch in garlic was observed in organic practice (27.26-35.70%) in the trials conducted in Paoay and City of Batac at 75 DAP. There was a disease reduction of 7.90% (Paoay) and 9.60% (City of Batac), respectively, and eventually produced bigger bulbs.

Given such, the benefits of using bio-pesticides in garlic should be considered for proper management of purple blotch and *Cercospora* leaf spot.

CONCLUSIONS

- Many plants have potential pesticidal properties that are good and promising to be formulated as pest control methods in vegetable production.
- Success in the formulations of biopesticides points to a transition of developing essential products for solving the general concern of the society today such as the concern for environmental safety and human health.
- Effective use of the different alternatives like plant based pesticide requires that farmers should think in terms of long range control rather than the conveniences and short term profit only, thus, farmers should be fully convinced about the hazardous effect of pesticides not only to the farmers and the environment but also to the consumers.
- A concerted effort in research should be made in order to increase the competitiveness of alternatives to chemical pesticides. This effort is necessary for diversifying the pest management “toolbox” in an era of rapid economic and ecological change.
- Results mentioned proved that the different MMSU developed biopesticides products is essentials for vegetable production and can be a good alternatives to synthetic pesticides. These products help solve the general concern of the society especially on environmental safety and human health . Developed MMSU Biopesticide products have the potential to be included in Integrated Pest Management (IPM) program dissemination of the government in order to prevent or minimize the usual practice of calendar spraying/ mixing of synthetic pesticide by farmers and also prevent pest resurgence.
- The Philippine Department of Education should integrate the use of biopesticide on the gardening activities (Technical and Livelihood Education) of both elementary and high school in the province to have a better understanding of producing safe quality vegetable.
- Wider promotion and dissemination of the importance and benefits of using less toxic control measures such as biopesticides and how people can help in maintaining the environment.

- Since the government through the Department of Agriculture (DA) has a program in Integrated Pest Management (IPM) to the farmes, through Farmers Field School, there should be a continuous effort to extend the incorporation of biopesticides in their pest control programs.s

IMPLICATIONS/RECOMMENDATIONS

- Promotion and commercialization of the developed product in coordination with the University Extension Unit and Local Government Units (LGU's).
- LGU's through the DA should regularly conduct training to farmers so that they will be fully convinced about the hazardous effect of pesticides not only to the farmers and the environment but also to the consumers.

Approved through EdSeCom Resolution No. 16, s. 2018, enjoining concerned government institutions to consider the Policy Recommendations of the research entitled, "Plant-based Pesticides for the Management of Selected Pest for Organic Vegetable Production in Ilocos" presented during the 4th Quarter Meeting of the EdSeCom on November 21, 2018.

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