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Compatibility of Predators and Botanical Extracts against *Plutella xylostella* on round cabbage

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Abstract: *It is important to recognize the role of natural enemies (predators) and botanical pesticides in agriculture. Excessive use of synthetic insecticides has caused resistance in many agricultural pests. This has prompt researchers to focus more on botanical extracts due to its synergic compatibility with natural enemies such as predators and parasitoids. This study was done to determine the compatibility of Chili and Tobacco extracts against Diamondback moth (Plutella. xylostella L.). P. xylostella is a very destructive pest at the cabbage farm of Papua New Guinea University of Natural Resources & Environment (PNG UNRE). Due to its resistance with synthetic insecticide Karate®, it is impossible to control it with any other chemical pesticides. Therefore, the two locally abundant plant extracts, chili and tobacco were investigated for their impact on P. xylostella abundance. And also, the extracts were tested for their compatibility to predators, Red ant (Wasmania auropunctata) and 28-spotted ladybird beetle (Epilachna spp.). Chili extract (p=0.0001) has proven to be compatible with predators on round cabbage. Their synergic relationship contributed significantly to low number of P. xylostella larvae. Tobacco extract had a neutral effect and no significant impact (p=0.46) on abundance of P. xylostella. This study has proven that botanical pesticides are generally compatible with predators and other natural enemies.*

Keywords: *Plutella xylostella L., predators, chili extract, tobacco extract, compatibility*

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I. Introduction

A synergic relationship between control agents is something Integrated Pest Management (IPM) encourages. Diamondback moth (*Pluttela xylostella* L.) is a major and destructive pest at PNG University of Natural Resources & Environment (PNG UNRE) and throughout East New Britain Province of Papua New Guinea (PNG). Due to imprudent use of synthetic pesticides over the years, *P. xylostella* has developed resistance [18][19]. Recently there has been much interest in Botanical pesticides since they are environmentally friendly, locally available, offers novel modes of action and though to have minimal impact on natural enemies such as predators and parasitoids. The prospects of using chemical compounds in combination with effective natural enemies may be efficacious in an IPM program [5]. Application of non-host plant extracts is to develop a push-pull system in order to reduce oviposition of insect pest and concurrently enhancing parasitism by its parasitoids in crops [8]. Various semiochemicals are involved in push-pull strategies which act as repellent or attractant volatiles to orchestrate pests and natural enemy populations [16][11][15][1]. Pests can be 'pushed' out of the crop by repellents and deterrents, and natural enemies can be 'pulled' into the pervaded crop by foraging attractants 'volatiles' to suppress the pests [7]. This research was done to test if predators are compatible with Botanical extracts and thus *P. xylostella*. The application of Tobacco (*Nicotiana tabacum*) and Chili extracts (*Capsicum frutescens*) should be able to lower the pest population of *P. xylostella* with little or no adverse effect on number of predators. The study was done on K-K cross variety of round cabbage since it is the main leafy vegetable grown locally.

II. Material And Methods

2.1Description of the study area

The study was carried out in the Field Crops Section of PNG UNRE from October 2nd to 30th, 2019. UNRE is located in Vudal, East New Britain Province of Papua New Guinea. The climate here is classified as tropical with a great deal of rainfall experienced even in the driest month. PNG UNRE is located 4°21'01.90" S and 152°00'33.44" E with elevation of 51 meters above sea level. The field is surrounded by crops, shrubs, grasses with cattle paddock to the north-east. The soil type is sandy loam and is alkaline (high pH level, more calcareous). Predominant vegetables grown here are cabbages, tomatoes and capsicum growing all year round. It is an Agriculture and Environment University promoting sustainable farming practices and environmental studies.

2.2 Treatment Description and Experimental Design

There were three treatments used and replicated three times. Treatments used were: Treatment 1 (Tobacco extract), Treatment 2 (Chili extract) and Treatment 3 (control). Each extract was mixed in a ratio of 10mls to 1L water and sprayed using hand sprayers at 5 days interval for a duration of 4 weeks. Spraying covered both the top and underside of the round cabbage leaves. Round cabbages were planted 2 weeks prior to the experiment in a Randomized Complete Block Design (RCBD). A total of 9 plots with plot dimension of 1x4m and 20 cabbage plants per plot were used.

2.3Parameters and sampling

Since the study was specifically on predators, their abundance per sampling time was recorded. The abundance of predators was counted under each treatment and recorded in field data sheet. Consideration was not given to parasitoids since their abundance was so low. Three plants were randomly selected per plot for all treatments then the number of predators present on the leaf was counted and recorded. Leaves were carefully lifted to view any predators on the underside. Data was collected at 3 weeks after planting (WAP), 4 WAP, 5 WAP and 6 WAP.

2.3 Data analysis

All the data were entered into MS Excel according to the date of collection and then converted into CSV file. The CSV file was imported into R program for statistical analysis. Since it is a compatibility study between two factors (treatments and predator), General Linear Model (lm) was used to determine the two-way ANOVA and interaction effects. The response variable was the number of Diamondback moth (*P. xylostella*). The two-way ANOVA generated both significant and non-significant results.

III. Result

A total abundance of 1029 *P. xylostella* larvae and 223 predators were recorded during this study. The predators concerned in this study are Red ants (*Wasmania auropunctata*) and 28-spotted ladybird beetle (*Epilachna* spp.). They were abundant and therefore both were counted as predators. Table 1 shows the data of *P. xylostella* and number of predators on four sampling dates.

Table 1: Shows the number of DBM larvae and number of Predators (Pr) under three treatments (Chili extract, Control, Tobacco extract). The mean number of DBM on Chili is 81±42.68, Control 92.3±59.84 and Tobacco 84.0±52.14. The mean number of Predator (Pr) on Chili is 19.0±4.49, Control 16.5±5.12 and Tobacco 23.8±4.71.

Sampling date	**TREATMENTS**					
	Chili extract		**Control**		**Tobacco extract**	
	No. of DBM	No. of Pr	No. of DBM	No. of Pr	No. of DBM	No. of Pr
2/09/2019	63	13	23	2	38	17
12/09/2019	206	13	271	26	239	24
22/09/2019	37	32	48	20	46	17
30/09/2019	18	18	27	18	13	37
Mean ($\bar{x}$)	81.0	19.0	92.3	16.5	84.0	23.8

There is no significant difference (p=0.9) between the pest and treatments since their mean values are close to each other. There is also no significant difference between predator and pest (p=0.2). Moreover, there is no significant difference (p=0.3) between predator and treatments.

Since it is an interaction study between two factors, treatments and predators, two-way ANOVA (GLM) was used to test for significant differences. Considering the effect of botanical extracts on Predator abundance, there is very high significant difference in Chili extract treatment (p=0.0001) with significant difference in Control treatment (p=0.04). Tobacco extract treatment did not show any significant difference (p=0.46). Furthermore, there is interaction effect (p=0.001) between control treatment and number of predators. However, there is no evidence of interaction (p=0.24) between tobacco extract and predators. Concerning the pest (*P. xylostella*), there is very high significant difference in chili extract treatment (p=0.000) and significant difference in control treatment (p=0.03). Moreover, there is interaction between control treatment and number of *P. xylostella* (p=0.01), while there is no evidence of interaction between tobacco extract and number of *P. xylostella* (p=0.28). Following figures show the effect of chili and tobacco extracts on abundance of *P. xylostella* (fig.1) and Predators (fig.2).

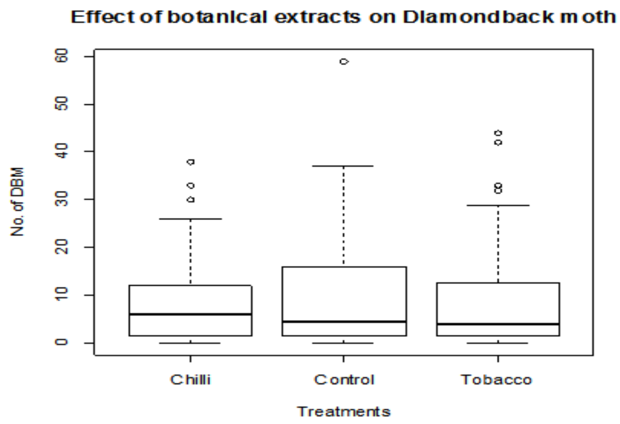

Figure 1. The control treatment has the highest number of *P. xylostella*. Chili and tobacco extracts have similar number of *P. xylostella* but relatively lower than control treatment. However, the mean values for control and tobacco extract are quite similar.

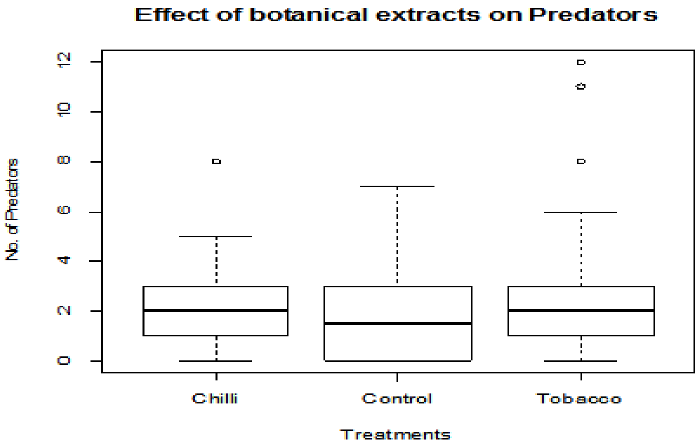

Figure 2. All treatments do not differ in number of Predators. However, the mean values for control is slightly less than that of chili and tobacco extracts. Predators seem to be showing preference to tobacco extract as shown by furthers outliers.

Figure 3 shows the effect of treatments on the abundance of *P. xylostella* and Predators. There is positive relationship between number of *P. xylostella* and predator abundance under control treatment. However, a negative relationship occurred between *P. xylostella* and predator abundance. The relationship is neutral (horizontal line) in tobacco extract with no effect on number of *P. xylostella*.

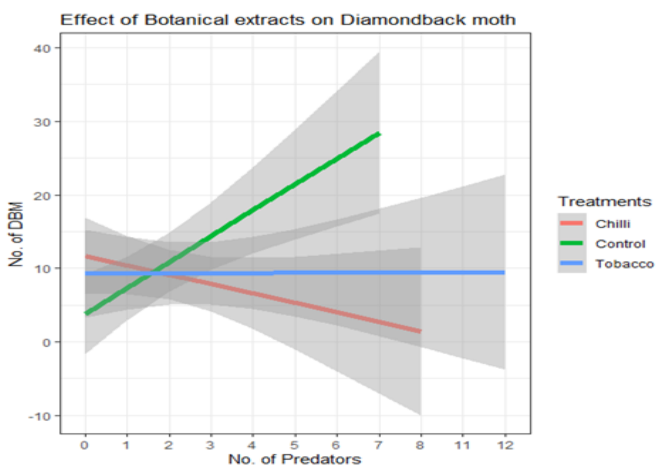

Figure 3. There is a relationship between the treatments and abundance of *P. xylostella* and Predators.

IV. Discussion

There were no significant differences in the means of pest (*P. xylostella*) and predators (*Wasmania auropunctata* & *Epilachna* spp.) under chili, tobacco and control treatments. Probably due to interluding rains during the time of spraying may have disrupted the repellent and deterrent effect of phytochemicals on the foliar. On average, chili extract had low number of *P. xylostella* ($\bar{x}$=81) when compared totobacco extract ($\bar{x}$=84) and control($\bar{x}$=92.3). However, the high significant difference (p=0001) in interaction analysis of chili extract proves that it is an effective control of *P. xylostella*.

According to [4], cabbages treated with chili, and other botanical extracts produced comparable yield. *Capsicum frutescens* contains active phytochemical family of Capsaicinoids which are associated with caustic or spicy characteristics [17]. *C. frutescens* also contains diterpenoids, flavonoids, saponins, and phenolic compounds which possess lethal effects, antifeedant effects, and parasite repellency [6][9]. Tobacco extract was not effective as chili extract (p=0.46) in controlling *P. xylostella* due to its phytochemical contents at different physiological growth stage. Tobacco was ineffective against the flower thrips and only proves beneficial when applied following cypermethrin at the podding stage of cowpea [13]. The highest nicotine content was found at 40 days after transplanting (DAT) and lowest at 60 DAT with similar scenario in rutin content [22]. Probably due to usage of matured tobacco leaves (>60 DAT) for extraction might have resulted in it being less effective than chili extract. According to [14], root and stem extract of tobacco produced LC_{50} at concentration of 5.175% and 5.870% while feeding activity of larva decreased at 5.98% and 6.53% respectively. Therefore, it can be recommended to test the root and stem extract in order to compare with results of leaf extract. Yet in other studies, tobacco extract was found to be very active against larval instar of *P. xylostella* (Mari, 1999; Waiganjom et al. 2008).

There is a negative relationship between number of DBM and number of predators (fig.3) under chili treatment. This shows that both the chili extract and predators are controlling *P. xylostella*. Chili extract and predators are compatible with each other with no evidence of antagonism. As a result of this synergic relationship, there is a decrease in the number of pest (*P. xylostella*) [5]. This supports the idea of using chemical compounds in combination with effective natural enemies in order to achieve an efficacious IPM program [5]. All botanical extracts had significantly higher coccinellid numbers (third trophic level predators) than synthetic insecticide (Attack®) treatment [2].

There is interaction effect (p=0.04) between DBM and predators under control treatment with a positive relationship. Absence of botanical extracts as repellent and deterrent agents led to the buildup of *P. xylostella* abundance.[3] demonstrated that control treatment (unsprayed) had the highest number of DBM pupae per plant than botanicals and chemical in 24 h applications. Results by [12] shows that fruit infestation was higher in control treatment (untreated) than neem extract and other insecticides.

The number of predators seem to be increasing under control treatment (p=0.001). Absence of botanical extracts as repellent and deterrent agents intend attracted both *P. xylostella* and predators. Both predators, *W. auropunctata* and *Epilachna* spp consumes their entire prey therefore they are most succumb to the toxicity of pesticides unlike parasitoids [20]. There is no interaction effect (p=0.24) which can imply that there is no synergic relationship between tobacco extract and predators. As a result of this incompatibility, there is no decrease in the number of pest (*P. xylostella*). Presence of botanical extracts as antifeedant would have higher number of parasitism (predation) [5].

V. Conclusion

It is important to recognize the role these biocontrol agents play in a crop ecosystem. As emphasized by IPM, natural enemies (NE) such as predators and parasitoids should be conserved. Most synthetic chemicals are toxic to NE and when used unwisely can lead to decline in their numbers. This study has shown that Chili extract is compatible with predators. Tobacco extract on the other hand had a neutral effect on *P. xylostella* abundance and proven to be incompatible with predators. Chili extract was found out to be an effective control of *P. xylostella* with a synergic relationship. The number of *P. xylostella* decreased and number of predators increased under chili treatment. This finding supports other studies that has proven that parasitism and predation increases with botanical pesticide and vice versa under synthetic insecticides. Chili extract has proven to be a compatible botanical pesticide and therefore should be utilized in an IPM program to counteract *P. xylostella*.

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