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LABORATORY EVALUATION OF *Tinosphora rumphii* AS GRAIN PROTECTANT AGAINST RICE WEEVIL, *Sitophilus oryza* L.

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ABSTRACT

Rice is the most important widely grown cereal in the Philippines. During storage, rice severely attacked by storage pests, mainly rice weevil, *Sitophilus oryza*. This study aims to determine the grain protectant efficacy of Tinospora *rumphii* against *S. oryza*. Plant stem was pulverized and extracted in concentrated ethanol. Phytochemical analysis of the extract was carried out to determine the secondary metabolites that posses toxic and insecticidal activities. The extract was applied at three various concentrations, 6%, 12% and 18% concentrations. Adult rice weevils were exposed to treated rice grains and mortality was determined after 24, 48, 72, 96 and 120 hours of exposure. The study was laid out in complete randomized design with four (4) replicates in every treatment concentrations and the control groups (negative and positive control). The efficacy of the extract was assessed based on rice weevil's mortality, number of holes and weight loss. Results showed that *T. rumphii* extract contain flavonoids, alkaloids, steroids and tannins. In addition, the various concentrations of *T. rumphii* extract caused 35% to 85% weevil's mortality after 120 hours of exposure which is extremely high compared to the negative control (5%). The plant extract showed significant increase on rice weevil' mortality compared to the control group at 0.05 level of significance. On the other hand , the mortality of rice weevils treated with the plant products does not show concentration-dependent effect since the percentage of weevil's mortality does not significantly increase in relation to the increase of concentration. This suggests that the lowest concentration (6%) of the extract already exhibited an optimum effect on mortality of rice weevils. The rice grains treated with *T. rumphii* extract showed a significant decrease of the number of holes compared to the negative control which indicates its protective effect against weevil from damaging the rice grains. Moreover, the extract also showed a significant decrease of the percentage weight loss of grains infected with the weevils. The significant decrease of weight loss in treatment/experimental groups as compared to the negative control could be a result of higher rice weevil's mortality. *T. rumphii* stem extract demonstrated rice grain protectant against *S. oryza.* The plant's high insecticidal activity against rice weevil is supported by the presence of phytochemicals flavonoids, alkaloids, steroids and tannins that have strong insecticidal activity.

Keywords: mortality, grain protectant, phytochemicals, *Tnospora rumphii, Sitophilus oryza*.

INTRODUCTION

Pesticides are commonly use as the most effective control technology against insect pests. However, the huge extent and continuous application of synthetic pesticidesresulted to many problems. Among them are pollution of the biosphere, pest resistance and increasing costs of which farmers in various agricultural countries like Philippines do not have enough money to buy pesticides. On the other hand, due to continouos damage of crops caused by pest, control is indeed very essential to obtain reasonable yields (Rejesus*et al*., 1987). Pests are not only the source of problem in crop production but also in storing agricultural products especially rice and corn grain.

The abundance of plants in the Philippines and the huge potential to produce extracts using simple and affordable means is a very significant basis forconducting researches of the effects of natural products fromplants against pests (Rejesus*et al*., 1987).

Tinospora rumphii is a promising bio-pesticide against green leafhopper and brown planthoppers (Leonardo, 1983). Salazar *et al.* (1988) on the study of the effectivityof lotion frommacerated stem of *T. rumphii* in the treatment of scabies established theacaricidalproperty of the said plant. It provides analternative tocostly drugs andpotentially toxicchemical pesticides.

Rice botanically belongs to *Oryza sativa* L. of Gramineae family. It is the most important and extensively grown food crop in the World. It is the staple food of more than 60 percent of the world population. Rice is mainly produced and consumed in the Asian region. It is primarily a high energy calorie food. The major part of rice consists of carbohydrate in the form of starch, which is about 72-75 percent of the total grain composition. The protein content of rice is around 7 percent (Farm Machinery Research Digest, 1997).

Stored agricultural products such as corn and rice areattacked by various kinds of insects which cause quantitativeand qualitative losses (Sarker*et al.,* 2006; Rajendran and Sriranjini, 2008). This damage may loss about 5 to 10% in temperate zone and 20-30% in tropical zone (Haque*et al*., 2000). One of the major pests of stored commodities intropics is "rice weevil" *Sitophilus oryzae*L. (Col: Curculionidae) (Lucas and Riudavets, 2002). Adult weevils feed on rice and lay their eggs inside rice kernels, where the larva can develops to the adult stage (Lee *et al.,* 2001; Lucas and Riudavets, 2002).

The use of botanical pesticides to protect plants from pests is very promising because of several distinct advantages. Pesticidal plants are generally much safer than conventionally used synthetic pesticides. Pesticidal plants have been in nature as its component for millions of years without any ill or adverse effect on the ecosystem. In addition, plant-based pesticides are renewable in nature and cheaper. Also, some plants have more than one chemical as an active principle responsible for their biological properties. These may be either for one particular biological effect or may have diverse ecological effects. The chances of developing quick resistance to different chemicals are highly unlikely (Saxena*et al*., 1989; Parugrug and Roxas, 2008).

Phytochemicals constitute one of the most numerous and widely distributed groups of substances in the plant kingdom (Close and McArthur, 2002). Phytochemicals can be extracted from either the whole plant or from specific parts of the plant known to contain a concentration of the desired active chemical (Shaalan*et al.*, 2005). Concentrations can occur when bioactive chemicals accumulate in the various parts of the plant, such as leaves, stems, bark, flowers, fruits, seeds, and roots (Shaalan*et al.*, 2005).

Alkaloids, saponins, flavonoids and tannins are known to possess medicinal and pesticidal properties (Azmathullah, 2011; Nweze*et al*., 2004).

The alkaloids are one of the most diverse groups of secondary metabolites found in living organisms and have an array of structure types, biosynthetic pathways, and pharmacological activities (Roberts and Wink, 1998). Saponins are a class of secondary plant metabolites with diverse biological properties which possess clear insecticidal activities characterized by increased mortality levels, lowered food intake, weight reduction, retardation in development, disturbances in development and decreased reproduction in pest insects (Geyter*et al.,* 2007).

Flavonoids exhibit a wide range of biological properties including antimicrobial, insecticidal and oestrogenic activities. Important phenolics in terms of insecticidal, repellent and feeding deterrent functions are flavonoids which are characteristics of higher plants (Dakora, 1995; El-Fadaly and El-Badrawy, 2001; Stephen *et al*., 2003; Upasani*et al*., 2003; Jung *et al*., 2005; Marcio, 2007; Georges *et al*., 2008).

METHODOLOGY

Data gathering procedures

A. Insect culture

Adults of rice weevil were collected from the National Food Authority warehouse of Cebu City, Philippines. The weevils were reared on rice grains in jars. The containers werecovered with muslin cloth for gas exchange and held in place with the aid of rubber band. The jars were kept aside atambient temperature 27^0C.

B. Collection and preparation of plant products

Tinospora rumphii stem was collected from Carcar, Cebu. This was washed with tap water and then rinsed with distilled water. The plant samples were air dried for 96 hours at room temperature. Dried stem of the plant was chopped using a kitchen knife and pulverized using an electric blender.

C. Extraction of plants

Pulverized plant samples were placed in a glass container. The samples extracted by soaking with concentrated (100%) ethanol andwas left tostand for48 hours and then filtered.

D. Rotary evaporation and phytochemical analysis

The filteredethanolic plant extracts was then concentrated using rotaryevaporator until it was semi-solid in form. The phytochemical screening was done following the standard procedure as described by Harborne (1998) evaluating the qualitative determination of major phytochemical constituents such as alkaloids, flavonoids, tannins, saponins, steroids, anthraquinone, and cyanogenic glycosides.

E. Bioassay of plant extract

The efficacy of *T. rumphii* extract as rice grain protectant against adultrice weevil was carried out using 200ml plastic containers containing 10g of rice with three (3) different concentrations (6%, 12% and 18%) of the plant extract. Four replicates were made for each treatment concentration of the extract and the control groups. Malathion was used as the positive control. To determine each concentration, preliminary test or range finding was conducted prior to the actual/definitive test. The containers were shaken for 5-10 min to ensure uniform mixing and coating. The containers were left open for 30 min so as to allow traces of solvent to evaporate off. Twenty (20) adult insects of rice weevil were introduced into the treated and control. Weevil mortality was assessed every 24 hours for five days. The insects were confirmed dead when there was no response to probing with sharp pin at the abdomen (Adedire*et al*., 2011).

F. Grain damage determination

On day 45, samples of the grains were taken for the determination of grain damage holes and weight loss. For grain damage determination, 10 seeds were taken randomly from each replication and examined for exit holes and occurrence of larvae within the seeds, if any. Weight loss was obtained using the formula described by Ileke and Oni (2011) which is given by:

G. Statistical analysis

The statistical tools that were used in this study are the following: the Arithmetic Mean to get the average number of dead rice weevils, Analysis of Variance (ANOVA), to determine the significant difference on the mortality of weevils between the control and the experimental groups, Post –Hoc Analysis using the Tukey Test to determine the degree of variability between the control and differentconcentrations of the plant extracts.

RESULTS AND DISCUSSIONS

A. Phytochemical screening

Table-1 shows that *Tinospora rumphii* stem extract contain the following phytochemicals: alkaloids, flavonoids, steroids and tannins. The plant's

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phytochemicals/secondary metabolites serve as enormous compartment that have strongbiological activity. Rupp (2005) stated that phytochemicals provide various biological effects such as medicine, insecticide, anti-microbial, repellent, larvae insecticide and many others. In addition, phytochemicals also represent significant functions such as anti-herbivore and plant defense responses; the plant that produces them, performing as insecticide substances, comparable to synthetic insecticides (Stangarlin*et al*., 1999).

Alkaloids and tannins demonstrate pesticidal activity which revealed as a very potential compounds use to kill mosquito larvae (Khanna and Kannabiran, 2007). Lee (2000) also stated that tannins can be used as insecticide against *Culex quinquefasciatus* larvae. Flavonoids exhibit a wide range of biological properties including antimicrobial, insecticidal and estrogenic activities. Alkaloids and tannins are also known to possess medicinal and pesticidal properties (Azmathullah, 2011). Hopkins (2009) stated that steroids play a protective function by disrupting the insect's molting cycle when ingested by insect herbivores.

B. Percentage mortality of rice weevil, *Sitophilus oryza*L.

Table-2 shows the mean percentage mortality of rice weevil, *Sitophilus oryza* L. treated with the various concentrations of *Tinospora rumphii* extract and the control groups. Variations of the death percentage of rice weevil were noted. The least percentage mortality was observed in the negative control (5%) after 120 hours of exposure which is very low than those in the experimental groups. The highest concentration of the plant extract revealsthe highest percentage of mortality of rice weevil. In addition, it is also noted that the plant extractexhibited a concentration-dependent effect against the rice weevil since thepercentage mortality were observed to increase with increasingconcentrations of the extract. The Two-Way ANOVA results (Table-3) showed a significant differences of percentagemortality of rice weevil among treatments of various concentrations of the plant extract and the control groups, p = 0.000. This implies that the various concentrations significantly affect on the increase of the percentage mortality of rice weevil.

Table 1. Phytochemicals present in *Tinospora rumphii* stem extract.

Plant Sample	Alkaloids	Cyanogenic glycosides	Flavonoids	Saponins	Steroids	Tannins
Tinospora rumphii	+++	-	+++	-	+++	+++

Legend: (-) absence; (+) - less abundant; (++) - average; (+++) - very abundant

Table-2. Mean percentage mortality of Rice Weevil, *Sitophilus oryza* L.treated with various concentrations of *Tinospora rumphii*extract and the control groups.

Treatments	Mean percentage (%) mortality									
	24 Hours	**SD**	**48 Hours**	**SD**	**72 Hours**	**SD**	**96 Hours**	**SD**	**120 Hours**	**SD**
Negative Control	1.25	2.50	2.50	2.89	2.50	2.89	5.00	4.08	5.00	4.08
Positive Control (Malathion)	6.25	4.79	17.50	8.66	41.25	8.54	55.00	9.13	68.75	10.31
6%	7.50	2.89	16.25	4.79	23.75	4.79	31.25	2.50	35.00	4.08
12%	10.00	4.08	26.25	7.50	38.75	8.54	48.75	7.50	53.75	7.50
18%	17.50	6.45	37.50	6.45	38.75	8.54	73.75	11.09	85.00	10.80

Table-3. Two -way ANOVA with replications results for the differences on the percentage mortality of Rice Weevil, *Sitophilus oryza* L. amomg treatments with various concentrations of *Tinospora rumphii*extract andthe control groups across different time of observations.

Sources of variation	Degrees of freedom	Sum of squares	Mean squares	*F*- Value	*P* -Value
Treatments	4	25,573.50	6,393.25	139.23^{*}	0.000
Time of Observation	4	22,121.00	5,530.25	120.43^{*}	0.000
Error	75	3,443.80	45.92		
Total	99	59,274.80			

Table-4 presents the Tukey test results showing the differences on the percentage mortality of S. oryza among treatments of various concentrations of T. rumphii extract and the control groups. Results reveal that the positive control, 6%, 12% and 18% concentrations of T. rumphiiextract are significantly higher than the negative control group in terms of killing rice weevil as evidenced on the growing percentage mortality. However, the three various concentrations (6%, 12% and 18%) of the extract showed a comparable effect to the positive control group on weevil's mortality. In addition, 6% vs. 12% and 12% vs. 18% of the extract show comparable results in killing the rice weevil while 6% vs. 18% shows a significant difference.

Table-4. Summary of all pairwise comparison results showing the differences on the percentage mortality of Rice Weevil, *Sitophilus oryza*L. among treatments of various concentrations of *Tinospora rumphii* extract and the control groups using the Tukey Test.

Pairwise comparisons (Treatments)	**Difference of means**	***T* – Value**	***P* – Value**	**Interpretation**
Positive Versus Negative	34.50^{*}	5.792	0.000	Significant Difference
6% Versus Negative	19.50^{*}	3.274	0.013	Significant Difference
12% Versus Negative	32.25^{*}	5.415	0.000	Significant Difference
18% Versus Negative	47.25^{*}	7.933	0.000	Significant Difference
6% Versus Positive	-15.00^{ns}	-2.518	0.095	No significant Difference
12% Versus Positive	-2.25^{ns}	-0.378	0.996	No significant Difference
18% Versus Positive	12.75^{ns}	2.141	0.212	No significant Difference
12% Versus 6%	12.75^{ns}	2.141	0.212	No significant Difference
18% Versus 6%	27.75^{*}	4.659	0.000	Significant Difference
18% Versus 12%	15.00^{ns}	2.518	0.095	No significant Difference

C. Number of holes

Table-5 shows the average number of holes of ten (10) seeds randomly selected from infected rice grains treated with various concentrations of *Tinosphora rhumpii* extract and the control groups. Result reveals a statistically significant difference, p = 0.000 (Table 6) on the variations of the number of holes that were observed among the control groups and those treated with the three concentrations of the plant extract. On the other hand, the highest number of exit holes was observed in the negative control (3.25 out of 10 grains). The 18% concentration (highest concentration) of the plant extract does not show signs of exit holes, which indicates that the plant extract has a preventive activity against rice weevil.

Table-7 presents the Tukey test results on the Number of holes of ten (10) grains randomly selected from infected rice among treatments of various concentrations of *T. rumphii* extract and the control groups. Results reveal that the positivecontrol, 6%, 12% and 18% concentrations of T. rumphiiextract are significantly lower thanthe negative control group in terms of the average number of rice weevil's holes. However, the three various concentrations (6%, 12% and 18%) of the extract showed a comparable effect to the positive control group. In

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addition, the 6%, 12% and 18% concentrations are found to have the same effect of the number of rice weevil'sholes.

Table-5. Average number of holes of ten (10) seeds randomly selected from infected rice grains treated with various concentrations of *Tinospora rumphii*extract and the control groups.

Treatments	Average number of exit holes per 10 grains	Standard deviations
Negative Control	3.25	0.50
Positive Control (Malathion)	0.50	0.58
6%	0.50	0.58
12%	0.25	0.50
18%	0.00	0.00

Table-6. One - Way ANOVA result for the differences of the number of holes of ten (10) seeds randomly selected from infected rice grains among treatments of various concentrations of *Tinospora rumphii* extract and the control groups.

Source of variation	Degreesof freedom	Squares	Sum of squares	Mean	*F*- Value	*P* -Value
Treatments	4	28.300	7.075	30.36^{*}		0.000
Error	15	3.500	0.233			
Total	19	31.800				

Legend

P - Value $< \alpha = 0.05$ - Significant at $\alpha = 0.05$ (*)

$P -$ Value $> \alpha = 0.05$ - Not Significant at $\alpha = 0.05$ (*ns*)

Table-7. Summary of all pairwise comparison results for the differences on the number of holes of ten (10) seeds randomly selected from infected rice grains among treatments of various concentrations of *Tinospora rumphii*extract and the control groups using theTukey Test.

Pairwise comparisons (Treatments)	Difference of means	*T* – Value	*P* – Value	Interpretation
Positive (Malathion) Versus Negative	-2.75^{*}	-8.051	0.000	Significant Difference
6% Versus Negative	-2.75^{*}	-8.051	0.000	Significant Difference
12% Versus Negative	-3.00^{*}	-8.783	0.000	Significant Difference
18% Versus Negative	-3.25^{*}	-9.515	0.000	Significant Difference
6% Versus Positive	0.00^{ns}	0.000	1.000	No Significant Difference
12% Versus Positive	-0.25^{ns}	-0.732	0.946	No Significant Difference
18% Versus Positive	-0.50^{ns}	-1.464	0.599	No Significant Difference
12% Versus 6%	-0.25^{ns}	-0.732	0.946	No Significant Difference
18% Versus 6%	-0.50^{ns}	-1.464	0.599	No Significant Difference
18% Versus 12%	-0.25^{ns}	-0.732	0.946	No Significant Difference

Legend

P - Value $< \alpha = 0.05$ - Significant at $\alpha = 0.05$ (*)

$P -$ Value $> \alpha = 0.05$ - Not Significant at $\alpha = 0.05$ (*ns*)

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D. Percentage weight loss of rice grains

The average percentage (%) of weight loss of rice grains treated with various concentrations of *Tinospora rumphii* extract and the control groups is presented in Table-8. Result demonstrates a statistically significant difference, *p* = 0.000 (Table 9) on the variations of the average percentage weight loss that were observed among the control groups and those treated with the various concentrations of the plant extract. Negative control shows thehighest percentage of weight loss (1.73%) while the highest treatment concentration (18%) of the extract and the control group do not exhibit weight loss. In addition, the *T. rumphii*extract showed a concentration-dependent in terms of the percentage weight loss. The significant decrease of weight loss in treatment/experimental groups as compared to the negative control could be aresult of higher rice weevil's mortality. The Post–Hoc Analysis results using the Tukey Test (Table-10) revealed that the positive control, 6%, 12% and 18% concentrations of the plant extract are lower than the negative control group in terms of average percentage weight loss of rice grains. However, the 6%, 12% and 18% concentrations showed a comparable effect to the positive control group on the weightloss.

Table-8. Average percentage (%) of weight loss of rice grains treated with various concentrations of *Tinospora rumphii*extract and the control groups.

Treatments	Average percentage (%) of weight loss	Standard deviations
Negative Control	1.73	0.68
Positive Control (Malathion)	0.00	0.00
6%	0.30	0.35
12%	0.025	0.05
18%	0.00	0.00

Table-9. One -way ANOVA result on the differences of the percentage (%) weight loss of rice grains among treatments of various concentrations of *Tinospora rumphii*extract and the control groups.

Source of variation	Degrees of freedom	Sum of squares	Mean squares	*F*- Value	*P* -Value
Treatments	4	8.903	2.226	19.03*	0.000
Error	15	1.755	0.117		
Total	19	10.658			

Legend

P - Value $< \alpha = 0.05$ - Significant at $\alpha = 0.05$ (*)

$P -$ Value $> \alpha = 0.05$ - Not Significant at $\alpha = 0.05$ (*ns*)

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Table-10. Summary of all pairwise comparison results for the differences of the percentage (%) weight loss of rice grains among treatments of various concentrations of*Tinospora rumphii* extract and the control groups with theTukey Test.

Pairwise comparisons (Treatments)	**Difference of means**	***T* – Value**	***P* – Value**	**Interpretation**
Positive (Malathion) Versus Negative	-1.725^{*}	-7.132	0.000	Significant Difference
6% Versus Negative	-1.425^{*}	-5.892	0.000	Significant Difference
12% Versus Negative	-1.700^{*}	-7.029	0.000	Significant Difference
18% Versus Negative	-1.725^{*}	-7.132	0.000	Significant Difference
6% Versus Positive	0.300^{ns}	1.240	0.729	No Significant Difference
12% Versus Positive	0.025^{ns}	0.103	1.000	No Significant Difference
18% Versus Positive	0.000^{ns}	0.000	1.000	No Significant Difference
12% Versus 6%	-0.275^{ns}	-1.137	0.785	No Significant Difference
18% Versus 6%	-0.300^{ns}	1.240	0.729	No Significant Difference
18% Versus 12%	-0.025^{ns}	-0.103	1.000	No Significant Difference

Legend

P - Value $< \alpha = 0.05$ - Significant at $\alpha = 0.05$ (*)

$P -$ Value$> \alpha = 0.05$ - Not Significant at $\alpha = 0.05$ (*ns*)

Based on the results, ethanolic stem extract of *T. ruumphii* is an effective rice grain protectant against rice weevil, *S. oryza* L.The presence of secondary metabolites such alkaloids, flavonoids, steroids and tanniscan be the strong contributing factors of the plant extract as killing chemical agent against rice weevils.

A study conducted by Adeniyi*et al* (2010) showed that *Bryophyllum pinnatum* and *Eucalyptus globules* leaf extracts showed insecticidal effect against rice weevil, *Sitophilus oryzae*. Results on phytochemical screening of these plants reveals the presence of flavonoids, saponins, alkaloids, steroids, tannins and terpenoids.Umadevi and Sujatha (2013) showed that different extracts of *Curcuma longa, Gymnemasylvestre, Azadirachtaindica, Chrysanthemum trifurcatum* are effective as insecticide against red flour beetle (*Triboliumcastaneum*). Phytochemical analysis showed that these plants contain alkaloids, amino acids, terpenoids, flavonoids, saponins, steroids, and tannins. In addition, the petroleum ether extract of *Aristolochiaringens* showed grain protectant efficacy against maize weevil from infestation and damage (Arannilewa*et al*., 2006). Progrog and Roxas (2008) conducted a study to evaluate the insecticidal action of five plant species, namely: *A. indica*, *C. citratus*, *L. camara*, *O. basilicum*and *T. erecta*against maize weevil, *Sitophiluszeamais*Motsch. Results revealed that all test materials exhibited repellency action against maize weevil.

Several studies suggest that *T. rumphii* is effective in controlling some insects and pests. Re jesus*et al.* (1987) reveal that the use of makabuhai/panyawan aqueous extract for seedling root soaking and broadcasting of chopped or immersion of coiled vines are effective in controlling the brown planthopper, green leaf11opper and rice stem borers of rice. In addition, Gutierrez *et al.* (2014) conducted study on larvicidal activity of selected plant extracts against the dengue vector *Aedes aegypti* mosquito showed that *Tinospora rumphii*t ogetherwith other plant extracts are potent larvicides on*Aedesaegypti*mosquito larvae. Moreover, *T. rumphii*has been used as pesticide against rice black bugs, rice green leafhoppers, and rice stem borers. The lotion derived from macerated stem of the said plant is also effective in treating scabies (Salazar, 1988). Furthermore, a study reported that *T. rumphii*is an effective dewormer for goats. Findings of his study showed that the crude extract of *T. rumphii*vine at 40 mL/kg body weight significantly reduced the eggs per gram by 85.6 percent in naturally infected goats (Fernandez, 1996).

Natural products/phytochemicals of plants are recognized for their insecticidal/pesticidal activity. In recent years, several researches provide evidences that phytochemicalsperformconsiderable environmental/ecological functions, such as protection against insect or microbial attack (Hopkins and Huner, 2009). Gutierrez *et al.* (2014) revealed that the presence of phytochemicals such flavonoids, alkaloids, saponins, steroids, and tannins are the strong potential for the plants' insecticidal activity against mosquito larvae.

Flavonoids exhibit a wide range of biological properties including antimicrobial, insecticidal and estrogenic activities. Alkaloids and tannins are also known to possess medicinal and pesticidal properties (Azmathullah, 2011).

Alkaloids and tannins demonstrate pesticidal activity and medicinal value. Alkaloids isolated from *Piper longum*plant revealed as a very potential compounds use to kill mosquito larvae (Khanna and Kannabiran, 2007). In addition, Nenaah (2011) revealed the toxic effect of a certain kind of alkaloid known as glycoalkaloidsfrom *Solanum tuberosum*and*lycopersiconesculentum*against *Triboliumcastaneum* beetles and rice weevils, *S. oryzae*. Lee (2000) also stated that tannins can be used as insecticide against Culex*quinquefasciatus*larvae. Hopkins (2009) stated that steroids play a protective function by disrupting the insect's molting cycle when ingested by insect herbivores

SUMMARY AND CONCLUSIONS

The grain protectant efficacy of *Tinospora rumphii* products against rice weevil, *Sitophilus oryza* L. showed that the plant stem contains alkaloids, flavonoids, steroids and tannins. These phytochemicals exhibit insecticidal and pesticidal activities to insects and pests.

T. rumphii products ethanolic extract showed insecticidal activity to rice weevils which is manifested by high percentage of mortality as compared to the non treated/negative control group. The mortality of the rice weevils treated with the three various concentrations of the plant extract are significantly different,p =0.000 as compared to the control groups. The highest concentration (18%) of *T. rumphii* stem extract reveals the highest percentage of rice weevil's mortality after 120 hours of exposure. In addition, the rice grains treated with the plant extract shows the least number of holes compared to the negative control. This indicates that the plant extract has a preventive effect against weevil from damaging the rice seeds. The presence of phytochemicals of *T. rhumpii* such as alkaloids, flavonoids, steroids and tannins can be attributed to the plant's grain protectant efficacy as killing agent against maize and rice weevil.

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