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Balakat (*Ziziphus talanai)* Leaf Powder as an Alternative Molluscicide against Golden Apple Snail (*Pomacea canaliculata* Lamarck) In Direct Seeded Rice Areas of Pampanga, Philippines

Jacqueline V Bagunu[1*], Virgilio dM Gonzales [2], Evelyn V Totaan[3], Myer G Mula[4], Noel C Surban[5], Manuelito Mallari[5], Stephen V Miclat[6]

[1]Professor and Project Leader, College of Arts and Sciences, Pampanga State Agricultural University, Magalang, Pampanga
[2]Professor and Study Leader, College of Agriculture Systems and Technology, Pampanga State Agricultural University, Magalang, Pampanga
[3]Professor and Study Leader, College of Arts and Sciences, Pampanga State Agricultural University, Magalang, Pampanga
[4]Assoc Professor and Study Leader, College of Agriculture Systems and Technology, Pampanga State Agricultural University, Magalang, Pampanga
[5]Research Assistants, Pampanga State Agricultural University, Magalang, Pampanga
[6]Thesis Student, College of Agricuture Systems and Technology, Pampanga State Agricultural University, Magalang, Pampanga

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[*]**Corresponding author:** Jacqueline V Bagunu, College of Arts and Sciences, Pampanga State Agricultural University, Magalang, Pampanga, Philippines. Email: jackbagunu@gmail.com

Abstract

The Golden Apple Snail (GAS), *Pomacea canaliculata* Lamarck, was once introduced to increase the protein source of Filipino diets. But has now become invasive and a major pest in direct-seeded rice, devouring rice seedlings during the first 30 days of its life cycle. Farmers usually resort to use of chemical molluscicide to combat GAS; however, this has imposed hazards to farm workers, draft animals and non-target organisms. The use of biological controls, such as *Ziziphus talanai* (balakat) tree in this study, therefore, is a welcome development. The application of dried balakat leaf powder at 7 kg/ha is a feasible and farmer-accepted alternative to chemical molluscicide to control GAS in direct- seeded rice areas of Pampanga, Philippines. It is an alternative to conventional chemicals due to perceived low cost, reduced detriment to the soil environment, and safety and convenience to farm workers.

Keywords: golden apple snails; golden kuhol; molluscicide; *Pomacea canaliculata*

Introduction

Pomacea canaliculata also known as “golden kuhol” or golden apple snail (GAS) was introduced in the Philippines during the 1980s. From its native habitat, GAS has been introduced in several countries as human food and as a means to control aquatic weeds. Despite its potential benefits and many uses (Ranmukhaarachchi and Wickramasinghe, 2006), the snail is a problem pest in lowland rice in areas near waterways, canals, and river systems.

The most common control strategies adopted by farmers were the application of synthetic molluscicides, tea seed powder application in Malaysia, handpicking, duck herding, use of older rice seedlings, and water management (Teo, undated). Biological control of GAS using a soft-shelled turtle, *Pelodiscus sinensis* was recommended in China (Dong et. al, 2012). However, such turtle have become a problem pest as predators of fish in commercial fishponds.

In transplanted rice, the cost of GAS control using synthetic molluscicides may reach PhP1400 or US$27 per hectare in Pampanga, Philippines. In Sabah, Malaysia, the cost of tea seeds to control GAS was US$ 27 per hectare excluding the labor cost in field applications (Teo, 2005).

Chemical molluscicides utilized to control GAS are known to persist and create health hazards such as skin problems, loss of nails, blurred vision or blindness (Ranmukhaarachchi and Wickramasinghe, 2006). Chemical pesticides for GAS control are known to inflict hazards to farm workers, draft animals, and non-target organisms, such as fish, frogs, and beneficial arthropods (De la Cruz et al, 2003).

The use of single or combined plant extracts from several plant species as potential molluscicide has been examined in the literature (Demetillo *et al.*, 2015; Kashyap, 2019; Musman, 2010; Taguiling, 2015). The main intention of plant-based molluscicides was to reduce the GAS population below the economic threshold level without detrimental effects on non-target organisms and their environment (Picardal *et. al.*, 2018). Based on standard of the World Health Organization (WHO), an aqueous extract to become a molluscicide, it must exhibit mortality at a dose lower than 20 ppm. Among the studies reviewed, however only the bulb extract of garlic has met the WHO requirement as molluscicide, i.e. LD_{90} =10 ppm (Picardal et. al., 2018). The LC_{90} or LD_{90} is defined as the lethal concentration or dose (LD) to kill 90% of snail samples. LC_{90} recorded from other plant extracts ranged from 177 to 804 ppm (eg. Quijano-Avile et al., 2016; Phrabhakaran *et al.*, 2017). It appears that the use of dried powder form of plant parts was more acceptable to farmers. For example, tea seed powder is a common plant molluscicide applied by farmers in Sabah, Malaysia (Teo, 2005). Dry leaf powder of yellow furcraea (*Furcraeaselloavar.Marginata*) was recommended at a lower amount to control GAS.

Meanwhile, a study indicated that among the plant species evaluated (m*akabuhay*, *balakat*, neem, and pepper), the application of dried *balakat* (*Ziziphus talanai*) leaf powder was most effective against GAS in rice pan experiments. Balakat leaves are known to contain flavonoids, saponins, and tannins as active constituents (Mula, 2019). The present study therefore was conducted to verify the effects of Balakat powder in field-grown rice. Other plant-derived molluscicides have been identified as alternatives in GAS management. However, the adoption of such technology may be hindered by uncertain factors. The second component of the study, therefore, is intended to determine the farmers acceptance and limitations of balakat as molluscicide in actual farming situations. The ultimate objective of this study is to determine whether balakat powder could be an alternative to conventional chemicals in the control of GAS in rice fields.

Methodology

Collection of Fresh Leaves

Atleast 28 kg fresh leaves (equivalent to 7 kg of dried leaves) were collected from *balakat* trees using a sharp bolo. The collected fresh leaves were secured in net bags or sacks. One kilogram of dried balakat leaves is equivalent to four kg fresh leaves. Approximately 2-3 balakat trees with a planting distance of 5 m with a canopy diameter of 4 meters and 6-7 m in height may yield at least 28 kg of fresh leaves. Balakat trees are expected to produce leaf flush approximately one month after defoliation. Topping or top pruning is recommended to yield short-statured trees with wide canopies for easier leaf collection.

Sun Drying

Fresh leaves were dried in concrete pavements until crispy for 5-10 days depending on the prevailing weather conditions, 5 days during hot dry months and up to 10 days in case of occasional cloudy weather.

Powdering

Crispy-dried leaves were pulverized to produce the following:

- 7 kg powder in 1 h using powdering machine
- 7 kg powder in 3.5 h using Home blender

The other option used for producing powder was by placing the dried crispy leaves in sacks and applied with repeated hits until they turn 1cm leaf fragments.

Field Application of Powdered or Crushed Leaves

A water depth of 1-2 inches before applying the leaf powder was maintained by closing the outlet for each paddy. Broadcasting is ideal during non-windy weather conditions. In case of windy conditions, the leaf powder is mixed with moist fine sand, and the water depth is reduced to one inch or less. The maximum control of FAS will be noticed during the first two days after application.

Evaluation of Balakat Leaf Powder on GAS Control and Field Establishment in Wet- Seeded Rice

The field experiment was established in December 2018 in a rice growing area of 360 m^2 at Pampanga State Agricultural University, PAC, Magalang, Pampanga. The area was previously grown with lowland wet-seeded rice. The area was plowed and harrowed two times before sowing.

Rice cv NSIC RC 222 (Tubigan 18), a common inbred farmers' variety for irrigated lowland, was used as the experimental crop. Seeds were soaked in water for 24 h and incubated for another 24 h. The field was puddled, levelled and drained before sowing. *Pre-germinated rice* seeds were broadcasted at a rate of 120 kg/ha. Ot the day of sowing, 50 snails with 10-25 mm shell diameter were introduced per plot, or 4.2 snails/m^2. The area has been infested with GAS due to the adjacent canal with water continuously flowing throughout the year round.

Treatments were arranged following the procedures in a randomized complete block design (RCBD) with four replications. Each block was further subdivided into five plots to accommodate the treatments. The plot dimension was 3m x 4m, or a plot area of 12 m^2. The treatments were as follows: a negative control, metaldehyde at the recommended rate of 7 kg/ha (farmers' check or positive control), and balakat powder applied at 3.5, 7.0, and 10.5 kg/ha. Treatments were applied five days after sowing (DAS), the same day when flood irrigation commenced. Water was maintained at 3-5cm depth until 30 DAS.

Plots were maintained free of significant weeds through hand weeding. There were no apparent insect pests and disease infestation.

Data were analyzed using analysis of variance. Treatment means were compared using least significant differences (LSD). There were four sampling quadrants per plot with a size of 1.0m x 1.5m per plot, as basis for collecting data on GAS mortality.

Farmers' Assessment of Balakat Powder as Molluscicide

Farmers' field day was conducted in a rice growing community in Capalangan, Apalit, Pampanga, Philippines. One to seven days before the field day, Balakat powder was applied to rice farms at the rate of 7.0 kg/ha, three farms in Apalit, and two farms in Magalang, Pampanga. During the farmers' field day, there were 34 participants composed of rice farmers and agricultural extension workers (AEWs). Farmers and AEWs in target communities conducted ocular observations to compare Balakat powder with synthetic molluscicide in the pilot farms before and during the early part of the field day proper.

After the field observation, experimental data generated from the field experiment, including video testimonials of farmer cooperators were presented during the field day. An evaluation form or pre-tested questionnaire in the Filipino dialect was distributed to, and filled-up by participating farmers and AEWs. The aim was to determine perceptions and to identify advantages and problems associated with the use of Balakat powder as component in the management of GAS based on farmers' perspective. Responses of Participants were tabulated and analyzed using descriptive analysis.

Results and Discussion

Results

Balakat leaf Powder on GAS control and early crop establishment of wet-seeded rice

Needless to mention, no GAS mortality was counted in the negative control plots **(Table 1)**. Balakat powder applied at 7 kg/ha recorded snail mortality similar to that of commercial metaldehyde. Increasing the amount of balakat powder to 10.5 kg/ha did not present additional benefits in GAS control. Balakat powder at a lower level of 3.5 kg/ha resulted to lower snail mortality, or 49% of that of chemical metaldehyde. Live snail count was highest in the control plots. The number of surviving snails after Day 5 was lowest in rice plots applied with 3.5 kg/ha to 7 kg/ha of Balakat powder, which was fairly similar to that recorded in plots supplied with the same 7 kg/ha of metaldehyde. The powder was observed to be effective for a maximum of two days and the efficacy period was 10 days. Balakat leaves have been found to contain bioactive components such saponins (Reyes, *et al*., 2018). Saponins are a group of steroidal or triterpenoid secondary metabolites which are responsible for plant defense against antagonists such as mollusks like Golden Apple Snail. They influence various biotic stimuli that attack pests and pathogenic infections. Its biological activity is attributed to the amphiphatic properties of the constituting molecules, which consist of a hydrophobic triterpene or sterol backbone and a hydrophilic carbohydrate chain. The combination of hydrophilic sugars and hydrophobic sapogenin incorporated into biological membranes might be related to their soap-like properties (Hussain *et al.*,2019).

TREATMENT	Mortality (no/m^2)$^+$	Survival (no/m^2)$^+$
Control	0.00c	9.81c
Metaldehyde at 7 kg/ha	7.75a	2.56a
Balakat powder at 3.5 kg/ha	3.81b	5.19b
Balakat powder at 7 kg/ha	7.63a	2.38a
Balakat powder at 10.5 kg/ha	6.19a	3.00ab
+Means within the same column with a common letter are not significantly different at 5% LSD.		

Table 1: Mortality and survival of snails within five days after treatment imposition in rice cv NSIC Rc 222 applied with metaldehyde and varying levels of balakat powder.

The plant height of rice was not affected by the application of metaldehyde or by the application of balakat powder **(Table 2)**. However, plots that did not receive chemical or balakat powder exhibited the highest number of damaged plants due to

GAS **(Table 3)**. The number of tillers counted per unit area in the control treatment was about 86% of the plots that were applied with either metaldehyde or balakat powder. The tiller number of rice plants applied with balakat powder was similar to that recorded in plants applied with commercial metaldehyde.

TREATMENTS	Days after sowing		
	7	14	21
	Plant height (cm)		
T1 - Control	12.43	22.78	32.63
T2 - Metaldehyde at 7 kg/ha	13.05	23.7	33.45
T3 -Balakat Powder at 3.5 kg/ha	13.33	23.28	33.63
T4 - Balakat Powder at 7 kg/ha	13.18	23.5	33.58
T5 - Balakat Powder at 10.5 kg/ha	13.53	23.33	33.48

Table 2: Plant height of wet seeded rice cv NSIC Rc 222 applied with metaldehyde and varying levels of balakat powder.

TREATMENT	Snail damaged plants (no/m^2)$^+$	Tiller number (no/m^2)$^+$
Control	22.13^b	87.63^b
Metaldehyde at 7 kg/ha	19.50^a	101.06^a
Balakat Powder at 3.5 kg/ha	19.06^a	99.19^a
Balakat Powder at 7 kg/ha	18.69^a	101.69^a
Balakat Powder at 10.5 kg/ha	18.63^a	98.63^a
+Means within the same column with a common letter are not significantly different at 5% LSD.		

Table 3: Number of damaged plants at 15 DAS, and tiller number at 30 DAS in rice cv NSIC Rc 222 applied with metaldehyde and varying levels of balakat powder.

Farmers' Perceptions: Benefits and Limitations of Balakat as Alternative Molluscicide

Based on the evaluation of farmers and AEWs, all respondents perceived the benefits of using balakat as alternative molluscicide **(Table 4)**. All respondents realized the need to plant such trees in rice farms. Balakat is cheaper, biodegradable, and more eco-friendly than conventional commercial molluscicides were the most common benefits cited by 33 out of 34 respondents **(Table 5)**. There were 32 respondents who sensed the safety or low risk of using such plant-based powder to farm workers.

Perceptions		Number of respondents with particular response	
Yes		Yes	No
1.	There exist any benefit that could be obtained by farmers should they use balakat powder or crushed dry leaves in controlling golden apple snails.	34	0
2.	The farmer is willing to try planting few balakat trees in his or her rice farm.	34	0

Table 4. Perceptions of 34 field day participants on balakat powder as an alternative strategy for the control of golden apple snail.

Benefits		Number of respondents citing a particular benefit
1.	Balakat is cheaper than the use of commercial molluscicides.	33
2.	Balakat is more environment-friendly than chemical molluscicides, biodegradable and does not persist in the soil.	33
3.	Health safety or low risk to farm workers	32
4.	No perceived benefits	0
5.	No response	1

Table 5. Benefits cited by respondents that could be derived from using powderized or crushed balakat leaves in GAS management.

There were apparently potential problems or limitations expected to limit the use of balakat for GAS control in farmers' fields **(Table 6)**. Fifty percent (50%) of the respondents indicated that it will take a number of years for newly planted trees to supply enough volume of leaves. Powdering equipment and needed materials are not available in the household was one of the constraints raised by 16 out of 34 respondents. Seven respondents (29%) perceived that leaf collection, including powdering or crushing, is more laborious, and may be an added cost to the farmer.

Other comments and recommendations mentioned by the respondents in the questionnaire were as follows: a) the use balakat should be disseminated to many farmers; b) cost saving; c) farmers should be provided with free balakat seedlings; and d) dried balakat leaves should be applied in pellet form to ensure even distribution when applied in the field during windy conditions. During the open forum, two major concerns were raised by farmers. First, strong winds tend to move the floating powder along dikes resulting in uneven distribution in rice paddy. Second, new transplants of such plant species will not survive in flood-prone farms during the monsoon season.

	Problems/Limitations	Number of respondents citing a particular problem/limitation
1	Should planting of balakat be done, it will take number of years for the newly planted tree to produce enough supply of leaves for snail control.	17
2	No equipment nor material is available to powderize or crushed dried balakat leaves	16
3	It is more expensive with more labor effort/cost in collecting leaves including the powdering or crushing process.	7
4	No perceived problems or limitations	10
5	No response	1

Table 6. Problems or limitations cited by respondents in using powderized or crushed balakat leaves in GAS management.

Discussion

Rice plots in the negative control exhibited the highest number of damaged plants, recording with the lowest tiller number per unit area **(Table 3)** due to high GAS population density **(Table 1)**. The effectiveness of such powder in snail control in the field conforms to the results of rice pan trials (Mula, 2019). Balakat powder at 7 kg/ha had similar lethal effects as those of same amount of commercial metaldehyde in terms of snail mortality and survival **(Table 1)**, which reflected the same tiller count at 30 DAS.

Tea seed powder is a common plant molluscicide applied by farmers in Sabah, Malaysia at a rate of 51 kg/ha (Teo, 2005). Dry leaf powder of yellow furcraea (*Furcraeaselloavar marginata*) at a lower rate of 45 kg/ha was recommended to control GAS. In the present trial, a much lower amount of 7 kg of powder was required per hectare to achieve the same effect as that of chemical molluscicide.

Balakat leaves are known to contain flavonoids, saponins, and tannins as active constituents (Mula, 2019). Saponin was established to cause hemolysis (rupture or destruction of red blood cells) in animals (Teo, 2005 after Minsala and Chiu, 1988). The presence of both saponins and flavonoids in the kernel extract of *Barringtonia racemosa* (L.) was more effective than extracts containing sole flavonoids in inflicting GAS mortality (Musman, 2010). Saponin in kernel extract was attributed to its effect on the cell membrane and by its ability to lower the surface tension of water. Saponin is known to cause the production of mucus as a GAS reaction to reduce further contact of body surfaces with molluscicide. Mucus secretion is reported to block the breathing process of snails (Musman, 2010).

Farmers and AEWs responded in favor of the use of balakat powder as an alternative to conventional chemicals **(Table 4)** due to perceived low cost, reduced detriment to the soil environment, and safety to and convenience of farm workers **(Table 5)**. For chemical molluscicides, it has been a common practice by farm workers to apply diesel on their feet and arms as body protection from the pesticides during field application.

Farmers' evaluation, however, suggests that flood-prone areas may not be suitable for planting balakat trees in rice farms. One alternative is the establishment of community-based plantation in elevated areas such as river banks, dikes, and public reforestation areas. Balakat has been preferred by the Philippine Department of Natural Resources and Environment (DENR) as one of the indigenous reforestation species through the National Greening Program. If the planting of few balakat trees in rice farms is adopted by farmers, it is expected that the impact may be realized after at least three years **(Table 6)**. About 28 kg of fresh balakat leaves is needed to prepare 7 kg of balakat powder per hectare. Establishment of balakat plantations should complement the commercialization of balakat as molluscicide.

Farmers expressed concerns on the uneven distribution of powder during windy conditions. Tea seed powder is a conventional molluscicide in Sabah, Malaysia (Teo, 2005), and it has been commonly used to get rid unwanted fish species in commercial fishponds in Pampanga, Philippines. It appears that the powder form of tea seeds may likewise be a farmers' problem in such plant-based molluscicide. It is possible that balakat leaf powder may be lighter in weight or less dense than tea seed powder, which makes the former more vulnerable to strong winds during field application. Farmer cooperators in the present research recommended the lowering of water depth during windy conditions with predominant standing water in the paddy with closed water outlets. AEWs suggested the field application of dried balakat leaves in pellet form to address application problems during windy days. One possible solution is the mixture of moist fine sand and dried balakat powder before field application. However, no research data are available to support whether mixture with moist fine sand does not alter the lethal effects of balakat in reducing GAS population.

Production of balakat powder was mentioned to be highly laborious according to seven out of 34 respondents **(Table 6)**. However, the cost to produce one kilogram of balakat powder was PhP 136 (US$2.62), which was 54% lower than that of the retail price of commercial metaldehyde of PhP 300 (US$5.79) based on cost analysis of Mula (2019).

Conclusion and Recommendation

The field trial established that balakat powder is a potential substitute for the same amount of commercial molluscicide due to their recorded similar GAS mortality, associated with similar tiller number per unit area. The use of balakat leaf powder as molluscicide was perceived by farmers and agricultural extension workers to be cheaper, and environment-friendly alternative to conventional chemicals. However, there is a need to identify the optimum ratio of moist fine sand:balakat powder to address application problems during windy conditions. Likewise, it is expedient to conduct a study comparing the lethal effects of pellet versus powder form of dried leaves. Similarly, toxicity and ecotoxicty of the balakat powder be conducted during wet and dry seasons. Lastly, a deeper quantitative analysis of the bioactive components, such as saponins, may be conducted in support of the established bioactivity of the balakat powder as molluscicide.

Plate 1: The farmers' field day was conducted on April 15, 2019 to demonstrate the research- based alternative approach against Golden Apple Snail. The activity was undertaken in cooperation with the MS Biology, BS Biology and Agriculture Programs of the University. The research project is a multi-disciplinary research composed of a team of biologists and agriculturists with the Project Leader, Dr. Jacqueiine V. Bagunu of CAS, Dr. Evelyn V. Totaan (Study Leader, CAS), Dr. Virgilio DM Gonzales (Study Leader, CASTech) and Dr. Myer G. Mula (Study Leader, CASTech).

References

1. Dela Cruz MS, Joshi RC, and Martin AR (2003) Basal application of organic fertilizer reduces golden apple snail population. Crop Protection Division, Philippine Rice Research Institute, Maligaya, Muñoz, Nueva Ecija.
2. Demetillo MT, Baguio ML, Limitares DE, Madjos GG, Abrenica - Adamat LR (2015) Effect of *Cymbopogoncitratus* (lemon grass) crude leaf extracts on the developmental stages of *Pomacea canaliculata* (golden apple snail). Advances in Environmental Sciences - International Journal of Bioflux Society 7:460-467.
3. Hussain M, Debnath B, Qasim M, Bamisile BS, Islam W et al. (2019) Role of Saponins in Plant Defense Against Specialist Herbivores. Molecules. 24:2067.
4. Kashyap S, Khagta S, Guleria K, Arya V (2019) Plants pesticide: A recent update. International Journal of Botany Studies 4:50-56.
5. Mula M (2019) Development of Innovative Management Approaches Against Golden Apple Snail in Direct-Seeded Rice Areas of Pampanga. Study 2.Identification and development of innovative methods of golden apple snail management through discovery-based research. Terminal Report. PSAU-DARFO III R&D Project. Pampanga State Agricultural University, PAC, Magalang, Pampanga.
6. Musman M (2010) Toxicity of *Barringtoniaracemosa* (L.) kernel extract on *Pomacea canaliculata* (*Ampullariidae*). Tropical Life Sciences Research. 21:41-50.
7. Picardal MT, Panlaan KT, Castaño PM, Peña LG, Abella KT et al. (2018) Molluscicidal activity of aqueous extract of garlic (*Allium sativum* L.) bulb against golden Apple snail (*Pomacea cannulate* L.). International Journal of Biosciences 13:75-87.
8. Phrabhakaran G, Bhore SJ, Ravichnadran M (2017) Development and evaluation of poly herbal molluscicidal extracts for control of golden apple snail (Pomaceamaculata). Agriculture 7:1-11
9. Quijano-Avile MF, Lara G, Riera-Ruiz C, Barragán-Lucas AD, Miranda M et al (2016) Field evaluation of plants molluscicide against *Pomacea canaliculata*. Emirates Journal of Food and Agriculture 28:224-226.
10. Ranmukhaarachchi SL, Wickramasinghe S (2006) Golden apple snails in the world: introduction, impact, and control measures. Global advances in ecology and management of golden apple snails 133-152.
11. Taguiling NK (2015) Effect of combined plant extracts on golden apple snail (*Pomacea canaliculata*(Lam.) and giant earthworm (*Pheretima*sp). International Journal of Agriculture and Crop Sciences 8:55-60.
12. Teo SS (2003) Golden apple snail, (*Pomacea canaliculata* Lamarck 1819) in Sabah, Malaysia - Current Situation and Management Strategy. Agriculture Research Centre, P.O. Box 3, 89207 Tuaran, Sabah, Malaysia.

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