The production of bio-pellet fertilizer from discarded shrimp shells coated with a jellose substance derived from tamarind seeds has implications for the growth and yield of rice variety RD79.

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Abstract

Plants often lack essential nutrients, necessitating the development of fertilizers that provide adequate nourishment while allowing for nutrient adjustments suitable for both soil and crops. This study investigated the optimal ratio of shrimp shell waste to tamarind seed gelose at 1:1, 2:1, and 3:1, confirming that all ratios could form solid granules. The researchers selected the 3:1 ratio for experimentation. Using a Scanning Electron Microscope (SEM) to analyze the fertilizer's composition, key plant macronutrients were identified: nitrogen (N) at 9.70±2.41%, phosphorus (P) at 2.44±0.29%, and potassium (K) at 0.92±0.08%. The micronutrients detected included magnesium (Mg) at 0.60±0.07%, calcium (Ca) at 8.86±1.69%, and silicon (Si) at 0.48±0.13%.

In a controlled study, RD79 rice (Oryza sativa L.) was grown with varying fertilizer application rates. The rice plants that received 8 grams of the bio-granular shrimp shell fertilizer exhibited the best growth at 50 days, reaching an average height of 70.36±0.80 cm, with a dry weight of 2.31±0.06 g and an average of 11.36±1.12 leaves per plant. Soil fertility was assessed using an N-scale with three levels: Too Little (N), Ideal (P), and Too Much (M). The soil treated with 8 grams of the shrimp shell fertilizer coated with tamarind seed gelose showed the most favorable chemical properties for plant growth.

When RD79 rice was cultivated in real farming conditions, plant growth varied. By the third growth stage, rice plants treated with the bio-fertilizer reached a greater height of 131.70±0.96 cm, with a dry weight of 8.09±0.07 g and an average of 25.00±1.24 leaves per plant. Additionally, yield analysis revealed differences among treatments. The RD79 rice treated with the bio-fertilizer at the third growth stage produced grains with an average 100-grain weight of 3.11±0.13 g, an average of 131.00±2.00 grains per panicle (based on 10 panicles), and an average 100-grain length of 1.06±0.05 cm.

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The Research Team

Contents

Chapter 1

Introduction

1.1 **Background and Significance**

Thailand's economy heavily relies on agricultural products, with rice being the most widely cultivated economic crop. According to customs statistics and rice export licenses from the Department of Foreign Trade, from January 1 to July 21, 2022, Thailand exported 3.99 million tons of rice, marking a 58.28% increase in export volume and a 34.16% increase in export value compared to the previous year. Additionally, the Ministry of Commerce and the Ministry of Agriculture and Cooperatives have jointly driven the Thai Rice Strategy for 2020-2024, predicting that rice farming in Thailand will continue to be a major economic and trade attraction, leading to increased investment in the sector (https://bit.ly/3ClXywC).

However, rice cultivation in Thailand faces various challenges, including rice diseases that require continuous monitoring and management. One significant issue is rice yellowing disease, which results from nitrogen deficiency during crucial growth stages, leading to stunted growth and yellowing of rice leaves due to a lack of chlorophyll (https://bit.ly/3GD3jbW).

Additionally, Kalasin Province has a widespread shrimp farming industry (https://bit.ly/3Gf3Uzk) and numerous grilled shrimp restaurants, resulting in an abundance of discarded shrimp shells. Further research has revealed that shrimp shells contain essential nutrients that support rice growth at different stages. The chemical composition of shrimp shells includes polysaccharides, particularly chitin, which is a bio-polymer and a major component. Chitin is a long-chain carbohydrate polysaccharide with a structure similar to cellulose. It functions similarly to keratin protein and is widely used in medical, biotechnology, and industrial applications as a stabilizing and thickening agent (https://bit.ly/3jNc4q).

Given these factors, the research team aims to explore the potential use of shrimp shells as a nutrient source for rice seedlings. This study focuses on dry-season rice (off-season rice), which is grown outside the traditional planting season. The selected rice variety, RD79, is a photoperiod-insensitive rice type, meaning it flowers and matures based on age rather than light exposure.

1.2 **Research Objectives**

- To study the production of bio-organic fertilizer granules made from discarded shrimp shells coated with tamarind seed gum extract and their effects on the growth and yield of RD79 rice.

1.3 **Research Question**

- How does the production of bio-organic fertilizer granules from discarded shrimp shells coated with tamarind seed gum extract affect the growth and yield of RD79 rice?

1.4 **Research Hypothesis**

- The production of bio-organic fertilizer granules from discarded shrimp shells coated with tamarind seed gum extract positively affects the growth and yield of RD79 rice.

Chapter 2

Literature Review and Related Research

In the study on the production of bio-organic fertilizer granules from discarded shrimp shells coated with tamarind seed gel, which affects the growth and yield of RD79 rice, the following documents and related research were reviewed:

2.1 RD79 Rice Variety

2.2 Essential Nutrients for Plant Growth

2.3 Chemical Structure of Tamarind Seeds

2.4 Chemical Composition of Shrimp Shells

2.1 RD79 Rice Variety

The RD79 rice variety was officially recognized on February 21, 2019, and is currently undergoing seed multiplication to support a cultivation area of 500,000 rai by 2020. The Rice Department adjusted its plan to introduce a portion of the RD79 seeds into a pilot project for comprehensive soft rice production and marketing in irrigated areas, covering approximately 10,000 rai. This initiative aimed to accelerate the cultivation of RD79 rice and test the market response to its yield while simultaneously expanding seed production for sale to farmers as scheduled in 2020.

Figure 1: RD79 Rice Grains

- It is a non-photoperiod-sensitive rice variety with a harvesting period of 112–118 days when grown by transplanting.
- The plant height is approximately 102 cm.

- It has an erect growth habit, strong stems, green leaves, and an upright flag leaf with slightly exposed panicles.
- It has excellent milling quality, producing 100% premium-grade rice. The cooked rice is soft.
- It has a high average yield of 809 kg per rai, with a potential maximum yield of 1,182 kg per rai, which is higher than other soft rice varieties.
- It is resistant to brown planthoppers and rice blast disease.
- The size of the brown rice grain is 7.74 x 2.16 x 1.80 mm.
- It has a dormancy period of 6 weeks.

1.1.2 Key Characteristics

- Amylose content: 16.82%
- The cooked rice is soft but not fragrant.

The ideal soil for rice cultivation is semi-clay to clay loam, in lowland areas with good water retention. The topsoil should be at least 15 cm deep, with a pH range of 5.0–6.5. Essential nutrients include nitrogen, phosphorus, and potassium, with average concentrations of 3.55%, 0.22%, and 1.8%, respectively (Rice Department, 2019).

1.2 Essential Nutrients for Plant Growth

1.2.1 Macronutrients

These are nutrients required in large quantities, including:

1. **Nitrogen (N)** – A key component of amino acids, nucleic acids, nucleotides, and chlorophyll. Nitrogen promotes plant growth, increases leaf size, enhances seed count per panicle, improves grain quality, and raises protein content in rice grains It is crucial at all growth stages, particularly in early development. Adequate nitrogen enhances tillering and yield, while deficiency results in yellowing leaves ().
2. **Phosphorus (P)** – Strengthens the root system, stimulates early stem development, enhances tillering, and plays a critical role in yield formation. Although central plains soils contain high phosphorus levels, fertilizer application remains necessary for rice cultivation ().

3. **Potassium (K)** – Sufficient potassium improves nitrogen and phosphorus utilization efficiency, promotes tillering, strengthens stems and roots, increases panicle formation and seed setting, enhances stress tolerance, and improves both yield and quality

1.2.2 Secondary Nutrients

These are required in moderate amounts

1. **Calcium (Ca)** – Supports cell division, pollination, seed germination, and plant structure while aiding nutrient transport and pH balance.
2. **Magnesium (Mg)** – A component of chlorophyll that assists in amino acid, vitamin, fat, and sugar synthesis, essential for photosynthesis and enzyme activation.
3. **Sulfur (S)** – An essential element of amino acids, vitamins, and proteins. It helps form chlorophyll, promotes root and seed growth, and strengthens plants against cold stress.

1.2.3 Micronutrients

These are needed in trace amounts

1. **Boron (B)** – Regulates nutrients essential for seed development, flowering, pollination, fruit formation, and sugar translocation.
2. **Copper (Cu)** – Supports reproductive development, root metabolism, protein utilization, chlorophyll synthesis, and enzyme activity.
3. **Chlorine (Cl)** – Found in soil, aids plant metabolism and hormonal regulation.
4. **Iron (Fe)** – Essential for chlorophyll formation and photosynthesis.
5. **Manganese (Mn)** – A key enzyme activator, essential for carbon dioxide fixation and nitrogen metabolism.
6. **Molybdenum (Mo)** – Facilitates nitrogen assimilation and protein synthesis, commonly found in soil.
7. **Zinc (Zn)** – Supports auxin hormone production, chlorophyll synthesis, carbohydrate metabolism, and enzyme activation for plant growth.
8. **Nickel (Ni)** – Plays a vital role in enzyme function, nitrogen metabolism, and seed germination.

1.3 Chemical Structure of Tamarind Seeds

Tamarind seeds are initially soft and white but harden into a shiny dark brown color as the pod matures. The seed consists of approximately **30% seed coat** and **70% endosperm**, with the endosperm primarily composed of **tamarind gum**, a polysaccharide accounting for 65% of its composition. The remaining contents include **15-21% protein** and **3-8% fat**.

The **chemical structure of tamarind gum** consists of three monosaccharides: **glucose, xylose, and galactose**, forming a long-chain polymer with an average molecular weight of 720,000–880,000 Daltons. Its backbone structure is made up of **(1-4)-β-D-glucan**, with branches of **xylose (1-2)-D-Xylose** or **galactose (1-2)-D-Galactoxylose**.

Tamarind seeds also contain **non-volatile seed oil**, which consists of fatty acids such as:

- Palmitic acid
- Stearic acid
- Oleic acid
- Linoleic acid
- Arachidonic acid
- Behenic acid
- Lignoceric acid

Tamarind gum has **excellent water solubility**, **acid-base stability**, and **gel-forming properties**, particularly in sugar-containing systems ([Shankaracharya, 1998; Goyal et al., 2007]; **Sirikan Noosing & Warangkana Sompong, 2016**; **Paksiri Sinchaikit & Maitree Suttajit, 2011**).

Tamarind seed gum, known as **Jellose**, is named for its ability to form a highly viscous solution when dissolved in water.

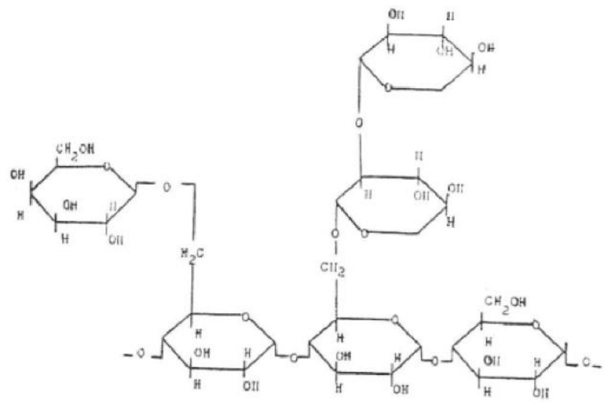

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Figure 2: Structure Formula of jellose
Source: (Thong Phakrachapan, 1991)

1.4 Chemical Composition of Shrimp Shells

The chemical composition of shrimp shells contains polysaccharides, which are biopolymers known as **chitin**. Chitin is the main component, and it is a carbohydrate polymer of **N-acetyl-D-glucosamine**, a glucose derivative. The chain is connected by **β-1,4 glycosidic bonds**, with the hydroxyl group (-OH) at position C2 replaced by an acetylamino group (-NHCOCH3). Chitin forms the primary structure of fungal cell walls and is found in the exoskeletons of arthropods, such as shrimp, crabs, and insects, as well as in the beaks of mollusks and squid, fish scales, and the exoskeletons of lissamphibians. The structure of chitin is similar to cellulose.

Chitin serves a function similar to the protein **keratin** and is used in various applications, including medicine, biotechnology, and industry. In industry, it is used as a stabilizing agent and a substance that imparts viscosity.

(https://th.m.wikipedia.org/wiki/%E0%B9%84%E0%B8%84%E0%B8%97%E0%B8%B4%E0%B8%99)

Chapter 3

Research Methodology

The project titled *Production of Biofertilizer Pellets from Leftover Shrimp Shells Coated with Gelose from Tamarind Seeds and Their Effect on Growth and Yield of RD79 Rice Variety* has designed the following experimental methods:

Part 1: Study on Fertilizer from Shrimp Shells Coated with Gelose from Tamarind Seeds

1.1 Extraction of Gel (jellose) from Tamarind Seeds

Materials and Equipment

1. Microwave (Samsung, ME711K/XST, Thailand)
2. Equipment for grinding seeds
3. Microwave-safe cups
4. Sieve for size separation
5. Plastic bags
6. Soil mineral testing equipment
7. Equipment for grinding shrimp shells
8. Sealed containers

Procedure

1. **Preparing Tamarind Seeds:** Wash the tamarind seeds with water to remove dirt, then microwave at 500 watts (Samsung, ME711K/XST, Thailand) for 3 minutes. Store the seeds in vacuum-sealed bags until needed.
2. **Preparing Tamarind Seed Flour for Gel Extraction:** Boil the tamarind seeds in water at 80°C in a 1:10 seed-to-water ratio by weight. After boiling, wash off the pulp and microwave the seeds at 500 watts for 3 minutes to crack the seed shell. Peel the tamarind seeds to separate the inner flesh, then grind and sift the tamarind flesh using a sieve to obtain tamarind seed powder.
3. **Extraction of Gel (Gelose) from Tamarind Seeds:** Mix the tamarind seed powder with water in a 1:10 weight ratio, stir, and heat in the

microwave at 640 watts for 4 minutes. Let the mixture sit at room temperature for 24 hours. Then, precipitate the clear liquid by adding 95% ethanol in a 1:2 ratio, let it sit for 20 minutes, and filter using a fiber filter with a vacuum filtration system. Dry the gel (jellose) in a microwave at 480 watts for 8 minutes. Finally, grind and weigh the dried gel before storing it in vacuum-sealed plastic bags.

Source: (Worangkanha Somphong et al., 2016)

1.2 Producing Fertilizer from Shrimp Shells

Take the shrimp shells obtained after consumption, dry them in a temperature-controlled oven at 80°C for 24 hours to make them dry and brittle, which makes them easier to grind. Then, grind the dried shrimp shells with a 750-watt grinder for 3 minutes and store the powder in sealed containers.

1.3 Coating the Fertilizer

Mix the gel (jellose) extracted from tamarind seeds with water in a 1 gram: 15 milliliters ratio, then add it to the shrimp shell fertilizer and mix well using a simple fertilizer mixer. Test the following ratios of shrimp shell powder to jellose: 1:1, 2:1, 3:1, and 4:1. Choose the ratio that forms easily and is most appropriate. Dry the coated fertilizer before analyzing the data.

1.4 Nutrient Analysis of Fertilizer

Take a sample of the completely dried fertilizer and send it for analysis at the Faculty of Science, Khon Kaen University. Nutrient analysis will be performed using a **Thermo Scientific Quattro S SEM** (Scanning Electron Microscope/SEM), which captures images by scanning the sample's surface with high-energy electrons released from an electron gun. These electrons interact with the atoms on the surface of the sample, releasing signals that are processed to provide detailed information about the surface’s composition and properties.

1.5 Testing the Nutrient Release of Shrimp Shell Fertilizer Pellets

1. **Test Fertilizer with RD79 Rice Cultivation:**
   Test the fertilizer with RD79 rice by applying the following amounts:

Pot 1: 1 kg soil : 2 grams fertilizer

Pot 2: 1 kg soil : 4 grams fertilizer

Pot 3: 1 kg soil : 6 grams fertilizer

Pot 4: 1 kg soil : 8 grams fertilizer

Pot 5: 1 kg soil : 10 grams fertilizer

Monitor the vegetative growth (stem and leaf development) of the rice from germination until the rice reaches 50 days old.

Part 2: Testing Fertilizer in Rice Fields with RD79 Rice

Materials and Equipment

1. Shrimp shell fertilizer
2. Soil property testing equipment
3. Experimental plot boundary markers (string, flag poles)

Procedure
Randomly select 3 areas with yellowing rice and apply the fertilizer at a rate of 5 kilograms per rai, calculated from: [https://natres.psu.ac.th/fercal/]. After 2 weeks, collect data on the height and number of leaves of RD79 rice in the experimental areas.

Experimental Parameter Measurements

1. Measure growth by recording rice height, leaf count, and dry weight, divided into 3 growth stages:
   - **Stage 1:** Vegetative growth (from germination to 50 days old).
   - **Stage 2:** Reproductive growth (30 days after vegetative growth).

- **Stage 3:** Grain development (20 days after reproductive growth).

2. Drain the experimental field and leave it for 10 days before harvesting the rice for yield and quality analysis.

Yield Analysis

Dry the harvested rice under the sun from 8:30 AM to 4:00 PM for 2 days. Then, measure the length of 100 grains, the number of grains per panicle, and the total weight of 100 grains. Compare the rice yield with the yield from local farmers randomly selected from Buengwichai sub-district, Mueang district, Kalasin province.

Chapter 4
Results

The project titled *Production of Biofertilizer Pellets from Leftover Shrimp Shells Coated with jellose from Tamarind Seeds and Their Effect on Growth and Yield of RD79 Rice* produced the following experimental results:

Part 1: Study on Fertilizer from Shrimp Shells Coated with Gelose from Tamarind Seeds

1.1 Study on Fertilizer Coating

The gel (gelose) extracted from tamarind seeds was mixed with water in a ratio of 1 gram of gelose to 15 milliliters of water. The mixture was then added to the shrimp shell fertilizer and thoroughly mixed using a simple fertilizer mixer at the appropriate ratio. The experimental results are as follows:

Table 1: Study on the Ratio of Shrimp Shells to Tamarind Seed Gel (jellose)

The time	Shrimp shell: rubber (jellose), tamarind seeds			
	1:1	2:1	3:1	4:1
1 2 3				

From the table, it was found that the study on the ratio of shrimp shells to tamarind seed gel (jellose) in the ratios of 1:1, 2:1, and 3:1 resulted in pellets. Therefore, the ratio of shrimp shells to tamarind seed gel (jellose) 3:1 was chosen for further experiments.

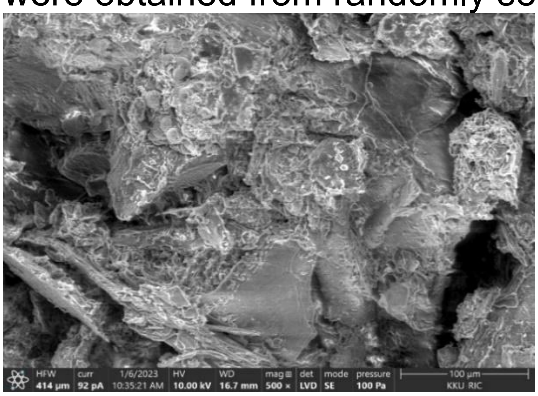
1.2 Analysis of Nutrient Content in the Fertilizer

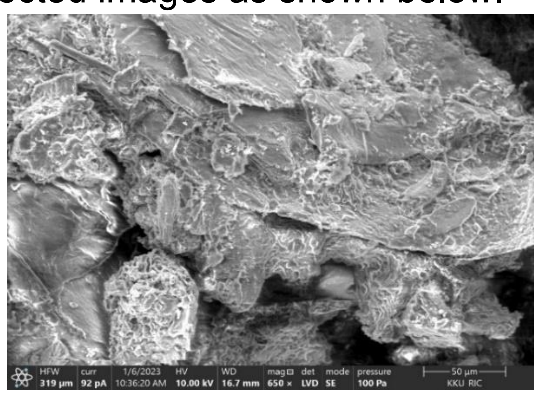
Samples of the fully dried fertilizer were analyzed for their nutrient content using the Thermo Scientific Quattro SEM (Scanning Electron Microscope / SEM). When electrons interact with the surface of the fertilizer, which consists of various atoms, they emit signals that can be processed to provide surface images of the object and its composition. The experimental results are as follows:

Table 2: Percentage of Elements Found in Shrimp Shell Fertilizer Coated with Tamarind Seed Gel (jellose)

Minerals found	**C**	**O**	**N**	**P**	**K**	**Mg**	**Si**	**Ca**
amount (w%)	32.58±2.38	41.78±3.04	9.70±2.41	2.44±0.29	0.92±0.08	0.60±0.07	0.48±0.13	8.86±1.69

From the table, it was found that when the Scanning Electron Microscope (SEM) captured images of electrons interacting with the surface of the fertilizer, which consists of various atoms, the following elements were identified as essential plant nutrients: Nitrogen (N) 9.70±2.41%, Phosphorus (P) 2.44±0.29%, and Potassium (K) 0.92±0.08%. As for secondary nutrients, Magnesium (Mg) was found to be 0.60±0.07%, Calcium (Ca) 8.86±1.69%, and Silicon (Si) 0.48±0.13%. These findings were obtained from randomly selected images as shown below.





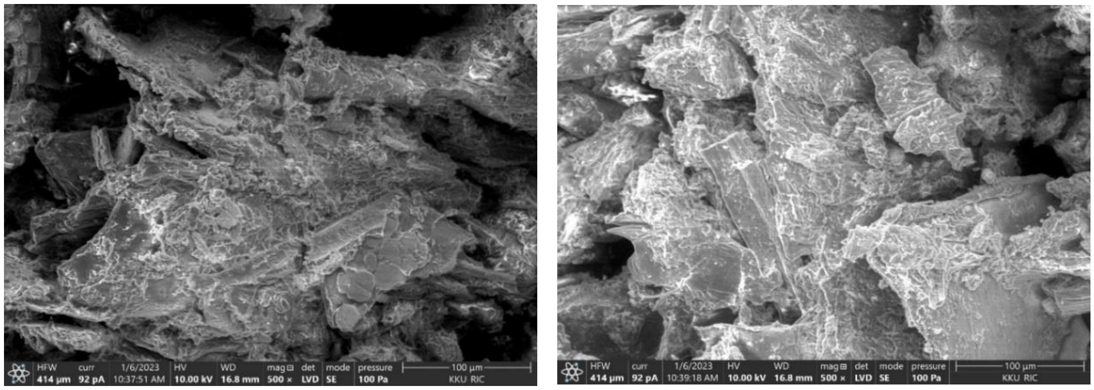


Figure 6: SEM image of the fertilizer.

1.3 Method for Testing Nutrient Release of Fertilizer Pellets from Shrimp Shells

When the fertilizer was tested with soil planted with rice (Khao Khor 79 variety) at different fertilizer application rates, the results are shown in the table below:

Table 3: Growth of rice (RD79 variety) at different fertilizer application rates

Experiment / distance thrive	Fertilizer quantity (gram)	Height of rice plant(cm)	Dry weight of rice plants (gram)	Number of leaves on rice plants (blade)
Phase 1 Growth of stems and leaves	0	49.44±2.41	1.25±0.12	7.22±0.81
	2	54.18±0.51	1.45±0.01	6.95±0.42
	4	60.19±0.80	1.41±0.08	7.14±0.51
	5	64.43±.80	2.35±0.04	9.43±0.07
	8	70.36±0.80	2.31±0.06	11.36±1.12
	10	00.00	00.00	00.00

From the table, it was found that when rice (Khao Khor 79 variety) was grown with different fertilizer application rates, the rice plants showed varying growth. It was observed that rice plants receiving 8 grams of fertilizer had the highest growth after 50 days of planting, with a height of 70.36±0.80 cm, dry weight of 2.31±0.06 grams, and 11.36±1.12 leaves.

Table 4: Soil chemical properties of the soil where the plants were grown after 2 weeks.

Measured parameters	Fertilizer amount (grams)					
	0 grams	2 grams	4 grams	6 grams	8 grams	10grams
Nitrogen (N) values in soil	N	N	P	P	P	M
pH value	7.0	6.5	6.5	6.0	6.0	4.5

From the table, it was found that the soil fertility measurement scale for N (Nitrogen) has three levels:

- N = Too Little
- P = Ideal
- M = Too Much

The soil that received 8 grams of shrimp shell fertilizer coated with gum (jellose) from tamarind seeds had the most suitable chemical properties for plant growth.

Section 2: Testing Fertilizer in Rice Fields (Khao Khor 79 Variety)
Growth measurements were taken by recording the height, number of leaves, and dry weight of the rice at each of the three growth stages:

1. **Stage 1**: Vegetative growth
2. **Stage 2**: Reproductive growth
3. **Stage 3**: Grain development

The results are shown in the following table:

Table 5: Height, dry weight, and number of leaves of rice plants at each of the three stages.

Experiment / distance / thrive	Plantation area	Height of rice plant (cm)	Dry weight of rice plants (gram)	Number of leaves on the rice plant (blade
Phase 1	farmer	64.33±0.80	2.20±0.01	9.26±1.17
	Experimenter	75.29±1.06	2.24±0.02	10.88±1.00

Experiment / distance / thrive	Plantation area	Height of rice plant (cm)	Dry weight of rice plants (gram)	Number of leaves on the rice plant (blade
Phase 2	farmer	86.55±0.83	5.32±0.06	15.49±0.97
	Experimenter	97.08±0.53	6.20±0.01	17.24±1.17
Phase 3	farmer	125.63±5.00	7.34±0.21	20.86±1.35
	Experimenter	131.70±0.96	8.09±0.07	25.00±1.24

actual fields of farmers, the growth of the rice plants varied. However, the Khao Khor 79 rice that received shrimp shell biofertilizer showed the best growth at the third stage, with a height of 131.70±0.96 cm, a dry weight of 8.09±0.07 grams, and the number of leaves being 25.00±1.24 leaves.

Rice Yield Analysis for RD79 Rice

Table 6: Study on the yield of RD79 rice.

Measurement / Weight / control	Seed dry weight 100 seeds (gram)	The number of seeds per spike (seeds)	The length of rice seeds 100 seeds (centimeters)
farmer	3.11±0.13	130.00±2.00	1.05 ± 0.09
Experimenter	3.17±0.12	131.00±2.00	1.06 ± 0.05

From the table, it was found that when growing Khao Khor 79 rice in the actual fields of farmers, the rice yield varied. The Khao Khor 79 rice that received shrimp shell biofertilizer, at the third stage, had an average weight of 100 grains of rice at 3.11±0.13 grams. The average number of grains per panicle was 131.00±2.00 grains, and the average length of 100 rice grains was 1.06±0.05 centimeters, respectively.

Chapter 5

Summary and Discussion of Experimental Results

5.1 Objectives

- To study the production of bio-organic fertilizer from leftover shrimp shells coated with gel extracted from tamarind seeds, and its effect on the growth and yield of RD79 rice.

5.2 Summary of Experimental Results

The study of the ratio of shrimp shells to tamarind seed gel (1:1, 2:1, and 3:1) showed that the mixture could be formed into pellets. The researchers chose the ratio of 3:1 for further experiments. The Scanning Electron Microscope (SEM) images of the fertilizer showed that the mixture contained essential nutrients for plant growth, such as nitrogen (N) 9.70±2.41%, phosphorus (P) 2.44±0.29%, and potassium (K) 0.92±0.08%. The secondary nutrients included magnesium (Mg) 0.60±0.07%, calcium (Ca) 8.86±1.69%, and silicon (Si) 0.48±0.13%.

When the fertilizer was applied at varying rates to rice, the growth of RD79 rice varied. At an 8-gram fertilizer application, after 50 days, the rice had the highest growth, measuring 70.36±0.80 cm in height, with a dry weight of 2.31±0.06 grams and an average of 11.36±1.12 leaves. The soil quality after applying the 8-gram fertilizer was ideal for plant growth.

In the field experiment with farmers, RD79 rice that received shrimp shell biofertilizer showed better growth, with a height of 131.70±0.96 cm, a dry weight of 8.09±0.07 grams, and an average of 25.00±1.24 leaves. After harvest, the rice yield was as follows: the average weight of 100 grains was 3.11±0.13 grams, the number of grains per panicle was 131.00±2.00, and the average length of 100 grains was 1.06±0.05 cm.

5.3 Discussion of Experimental Results

The lack of nitrogen during critical growth stages of rice results in stunted growth and yellowing of leaves, indicating a chlorophyll deficiency. In the experiment, the soil, particularly in Kalasin province where RD79 rice is commonly grown throughout the year, was enriched with organic fertilizer made from shrimp shells and tamarind seed gel. The combination of these materials provided adequate nitrogen and other essential nutrients, promoting robust growth of the rice plants.

The fertilizer, when applied in an 8-gram dosage, resulted in optimal soil chemical properties and significantly improved the growth of RD79 rice. The rice in the field trial showed exceptional growth, with a height of 131.70±0.96 cm, dry weight of 8.09±0.07 grams, and 25.00±1.24 leaves, which aligned with data from the Rice Department (2019). The yield, with an average of 3.11±0.13 grams per 100 grains and 131.00±2.00 grains per panicle, indicates a very high-quality output.

Therefore, the biofertilizer made from shrimp shells coated with tamarind seed gel has proven to be highly effective in promoting the growth and yield of RD79 rice.

5.4 Expected Benefits

The biofertilizer made from leftover shrimp shells coated with tamarind seed gel has shown to significantly enhance the growth and yield of RD79 rice.

References

Warangka Na Sompong and others. (2016). "Extraction of Tamarind Seed Gum (Tamarindus indica L.) Using Microwave and Its Application in Strawberry Jam Products." Faculty of Science and Technology, Thammasat University.

Faculty of Pharmacy, Silpakorn University. (2009-2015). "Herbal Plant Information." http://pharmacy.su.ac.th/herbmed/herb/text/herb_detail.php?herbID=174

Sirikarn Noosing and Warangka Na Sompong. (2016). "Study of the Optimal Conditions for Extraction and Drying of Tamarind Seed Gum and Its Effects on the Physical-Chemical Properties." Faculty of Science and Technology, Thammasat University.

Phaksiri Sinchaikit and Maitree Sutthajit. (2011). "Biochemical Properties and Applications of Tamarind Seeds." Faculty of Medical Sciences, University of Phayao.

Wikipedia. (2022). "Shrimp." https://th.m.wikipedia.org/wiki/%E0%B8%81%E0%B8%B8%E0%B9%89%E0%B8%87

Wikipedia. (2022). "Chitin." https://th.m.wikipedia.org/wiki/%E0%B8%84%E0%B8%B2%E0%B8%97%E0%B8%B4%E0%B8%99

Thanong Phakrachapan. (1991). "Tamarind Seed & Gum." Department of Food Science and Technology, Faculty of Agricultural Industry.

Appendix

Process for extracting rubber (jellose)

Baked tamarind seeds

Peel the tamarind seeds.

Tamarind Seed Powde

After mixing with distilled water and settling for 24 hours

The clear portion was precipitated with 95% ethanol.

Rubber powder (jellose)

shrimp shell

Shrimp shell powder

Fertilizer from shrimp shells coated with rubber (jellose).

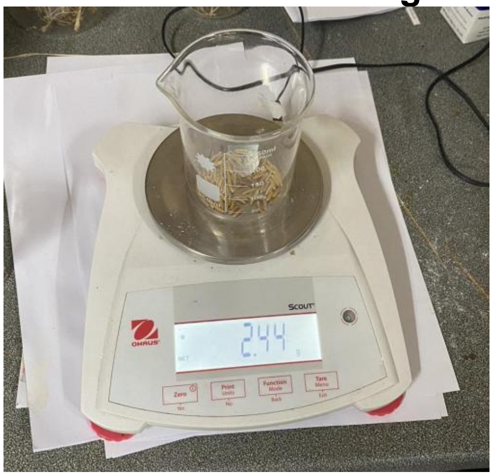
Fertilizer sent for mineral analysis Khon Kaen University

Thermo scientific Quattro S SEM (Scanning Electron Microscope / SEM)

Rice plants at the seedling stage that were fertilized and not fertilized with shrimp shell fertilizer.

Picture A: Rice plant with shrimp shell fertilizer. Picture B: Rice plant without fertilizer.

Measuring the size and weight of rice grains



Weigh the weight of 100 rice grains.

Measure the length of the seed.

Picture of 100 rice seeds

Experimental plot

Plots where fertilizer was trialled

Agricultural plot