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# Natural Farming: The Development of Indigenous Microorganisms Using Korean Natural Farming Methods

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## Abstract

Korean natural farming is a self-sufficient farming system that involves the culturing of indigenous microorganisms (IMO) – bacteria, fungi, nematodes, and protozoa – in place of inorganic fertilizers to produce fertile soil. The culturing and nurturing of indigenous microorganisms is discussed in this publication. Following the guidelines documented in Cho's *Natural Farming*, this publication outlines the protocol, materials, and methods used to culture IMO on a 5-acre farm located in Makaha, Hawai‘i (2010). The materials, methods, and collection sites used to culture IMO may vary from farm to farm, due in part to locality and availability of materials. However, the overall concept of culturing IMO remains the same. In addition, an attempt to quantify the related costs was made to provide some guidance for interested parties.

## Introduction

Soil plays a vital role in our ecosystem; without it, life for many multicellular organisms would cease to exist. In addition, food shortages are driven by soil degradation, as poor farming practices lead to loss of nutrients through erosion and leaching (Tilman et al. 2002). To maximize crop yield, it is imperative that farmers maintain a healthy environment for plants to grow, as the quality of the soil can change the outcome of the harvest. The most common way to replenish the soil is by adding fertilizer to it. However, the maintenance of fertile soil does not come cheap. Fertilizers and other soil additives can be expensive, especially in Hawai‘i, due to the higher costs of shipping. It is vital that Hawai‘i's farmers minimize costs wherever possible. Korean natural farming (KNF) has been proposed as an attractive alternative for farmers who wish to become less dependent on external inputs without sacrificing crop yield (Hoon and Park 2010).

KNF is a sustainable farming system developed by Master Han Kyu Cho from Janong Natural Farming Institute in South Korea. It has been practiced for over 40 years throughout Asia. KNF is a self-sufficient system that involves culturing indigenous microorganisms (IMO) – fungi, bacteria, and protozoa – and reintroducing them into nutrient-depleted soil, thus enhancing soil microbial activity and fertility (Essoyan 2011). There is a symbiotic relationship that occurs between plants and beneficial IMOs; the microorganisms convert nutrients into a form that the plant is able to absorb. In turn, the plants provide food to these microorganisms. This type of closed-loop farming system maximizes the use of on-farm resources and recycles farm waste while at the same time minimizing external inputs. KNF is a multifaceted system that adapts to local conditions (Cho 2010). Introduced to Hawai‘i in 1999, KNF is gaining popularity among farmers in Hawai‘i who are interested in sustainable agriculture (Wang et al. 2012). Farmers who practice this farming method believe that it minimizes their dependence on inorganic fertilizers and pesticides. However, little scientific documentation of the benefits of these practices exists as yet (Park and Duponte 2010).

## Objectives

The objectives for this study were to a) identify some of the resources readily available on a farm site that can be used for the development of IMO, b) demonstrate the chronological development of IMO, and c) provide some estimates of cost and time for the process of developing IMO. This publication outlines the steps used to collect IMO from a farm in Makaha, Hawai‘i. For a detailed guide on how to collect and cultivate indigenous microorganisms using traditional methods, refer to Cho's book *Natural Farming* (2010).

## Materials and Methods

KNF involves a four-step process of capturing, cultivating, and preserving indigenous microorganisms (IMO). These four steps create products that are often referred to as IMO 1, IMO 2, IMO 3, and IMO 4. As previously mentioned, the process of collecting and culturing microorganisms may vary farm to farm due to locality and availability of materials and supplies. However, the principle remains the same. The following materials were used for the collection and culturing of IMOs.

- 0.3 x 0.3 x 0.15m (1 x 1 x 0.5 ft.) lauhala box with cover (a cedar box, plastic container, or ceramic bowl are alternatives)
- 340 g (2 cups) of steamed white rice (preferably on the dry side)
- 20L bucket with holes drilled on the sides (refer to

**Table 1. Natural inputs used to make the IMO (Cho 2010)**

| IMO Inputs | Characteristics | Amount added per 22.68 kg of wheat mill run |
|---|---|---|
| **L**actic **A**cid **B**acteria | Abundant in the whey from yogurt and cheese-making, or can be cultivated with rice wash water (saved from the first rinse of rice in preparation for cooking) and unpasteurized milk. | 30 ml |
| **O**riental **H**erbal **N**utrient | Licorice, angelica, ginger, garlic, and cinnamon are the ingredients used in the preparation of OHN. | 30 ml |
| **F**ermented **P**lant **J**uice | FPJ is made by taking the growing tips of healthy plants—vegetables, herbs, or weeds, mixing them with brown sugar, and allowing them to ferment. | 30 ml |
| **F**ish **A**mino **A**cid | A liquid made from fish waste. Similar to Asian fish sauce used in food preparation, but without the added salt, it is made by mixing fish parts with brown sugar and letting the mixture ferment for a few months. | 15 ml |
| **W**ater-**S**oluble **C**alcium | Made from roasted eggshells soaked in BRV (brown rice vinegar). | 15 ml |
| Seawater | Diluted with fresh water; used to add minerals, for soil treatment before seeding, and to enhance ripening of fruit. | 1L |
| Biochar | Highly porous charcoal. Provides a storehouse for all the nutrients and microbes. | 10L bucket |

Figure 1b and 1c)
- Small mixing container
- Large (4L) glass jar
- Twine
- Semipermeable material (paper towel, cloth, canvas)
- Brown sugar (570 g)
- 22.68 kg bag of wheat mill run
- Shovel
- Mixing container
- 20L of fishpond water
- Measuring spoon (15 ml; 1 tablespoon)
- Natural inputs (refer to Table 1)

## Making IMO 1 – Collecting IMO

The first step to making IMO is to locate an area to collect the microbes. The preferred site to collect IMO is near the rhizosphere of plants whose roots contain sugar. According to Master Cho and other Korean natural farmers, plants in the Bambusoideae (bamboo) family are the ideal choice, as their roots contain a high amount of sugar (Cho and Cho 2010). These sugars attract bacterial-dominated microbes and nematodes. In addition to bamboo, broadleaf trees and leaf molds are other commonly used sites (Cho and Cho 2010). Three specific sites on the farm were selected to collect microbes: near 1) bamboo plant, 2) *Artocarpus altilis* (breadfruit tree), and 3) *Leucaena leucocephala* (haole koa tree). Hence, three separate batches of IMO were made by utilizing three different collection sites. The following procedure outlines the collection and cultivation of microbes from bamboo (Figure 1a).

The lauhala box was filled 1/3 full with hard-cooked rice (use less water to cut back on the amount of moisture). The main goal here is to provide the microbes with a food source. The lauhala cover was placed back onto the box. This allows the microbes to enter while at the same time keeping leaf litter and insects out. The container was then placed close to the root system of the bamboo (Figure 1b) and covered with leaf litter and a bucket containing holes. This acts as a second line of defense to keep animals and excessive amounts of rainwater out. The container was left undisturbed for five days (Cho 2010).

After five days had passed, the container was removed from the site (Figure 1c). A successful collection of microbes presents a white, cloudy covering of mi-

**Figure 1a. Collection site (bamboo tree)**

**Figure 1b. Rice (covered with a bucket) placed close to rhizosphere of a bamboo tree**

**Figure 1c. Removing lauhala basket (containing rice) from collection site 5 days later**

**Figure 2a. Presence of white mycelium on the surface is representation of a successful collection of microbes.**

**Figure 2b. Presence of a green layer covering the rice represents an unsuccessful collection of microbes.**

**Figure 3a. IMO 1**

**Figure 3b. Brown sugar added to IMO 1**

**Figure 3c. Mixing the contents**

**Figure 3d. Mix for 5 minutes or until homogenous.**

**Figure 3e. Mixture placed in glass jar covered with a piece of mesh fabric**

crobes, with little to no presence of red and blue molds (Figure 2a). However, if the rice is covered entirely with a green layer (Figure 2b), anaerobic microbes have accumulated (Cho 2010). If this happens, discard the contents and repeat the process.

### Making IMO 2 – Cultivation of IMO

This step involves the cultivation of IMO. Materials needed for this process included a small mixing container, jar (i.e., glass, ceramic, or clay), porous material (i.e., paper towel, Korean paper, or cloth), a piece of twine, and brown sugar. The inoculated rice obtained from the previous process (IMO 1) was placed into a container (Figure 3a), along with 570 g (1:1 ratio) of brown sugar (Figure 3b). The contents were then mixed for approximately five minutes (Figure 3c). Once homogenized, the mixture was placed into a jar (Figure 3d). A piece of canvas was placed over the opening and secured with twine. The jar was placed in a cool, shaded area out of direct sunlight for seven days. The product of this process is called foundation stock, or more commonly IMO 2.

### Making IMO 3 – Multiplying the IMO

Materials and tools needed to make IMO 3 include 22.68 kg of wheat mill run (or a carbohydrate source), 20L of fishpond water, a 20L bucket, natural inputs/nutrient liquids (refer to Table 1), a measuring spoon, and 15 ml of IMO 2. The wheat mill run was placed in a large container (i.e., wheelbarrow, large bucket, tractor dump bucket, etc.) under a cool, shaded area (Figure 4a). 15 ml of IMO 2 was added to 20L of fishpond water, and the mixture was stirred thoroughly (Figure 4b). The inputs from Table 1 were added to this mixture.

**Figure 4a. Wheat mill run (50 lbs.) placed into tractor dump bucket**

**Figure 4b. Natural inputs mixed into 20L of fishpond water**

**Figure 4c. Pond water mixture added to wheat mill run and mixed till homogenous.**

**Figure 4d. Wheat mill run placed onto the soil and covered with leaves held in place with rocks.**

The contents within the bucket were poured onto the wheat mill run and mixed thoroughly (Figure 4c). The moisture level of this mixture should be between 65 and 75% (Reddy 2011). Soil moisture was determined using the "feel and appearance method" (Klocke and Fischbach 1998). The wheat mill run mixture was then placed directly onto the soil (35.0–40.0 cm high) in a partially shaded area (70% shade and 30% light). It was then covered with leaves and allowed to sit for eight days (Figure 4d).

As the mixture (IMO 3) ferments, the core temperature of the pile increases. To prevent the microbes that are present within/near the core from dying of the high temperatures, the heat must be evenly distributed throughout the pile. Thus, the pile was turned over every two days to bring down the temperature and to mix the microbes. Visibility of white fungi (mycorrhizae) covering the top layer of the IMO is a sign of successful inoculation. At the end of this process, IMO 3 will have formed into clumps (Figure 5a).

## Making IMO 4 – Inoculating the Soil

Making IMO 4 is the final step. Materials needed for this process include IMO 3, a large bucket, soil from the farm, and biochar. In a bucket, break up the IMO 3 (entire inoculated pile of wheat mill run) so that there are no large pieces (Figure 5b). Mix in 10L of biochar (Figure 5c). Next, pour the contents out of the bucket and mix with soil in a 1:1 ratio. The fermentation process is similar to that of IMO 3 (moisture 65–70%, 35.0–40.0 cm high, temperature 40–50°C). The pile was then covered with leaf litter and allowed to sit for another 5 days. IMO is much more effective when inoculated to the soil (Cho 2010). The end product of this process is referred to as IMO 4.

## Application of IMO 4

The final product, IMO 4, should be used as a top dressing. Gently mix 150 kg/0.1 ha (minimum) into the topsoil. For optimal results, cover the inoculated soil with mulch (i.e., bamboo leaf litter, wood chips, etc.). Adding mulch is very effective, as it retains moisture, keeps weeds at bay, and also provides the microbes with protection from direct sunlight. It is recommended that IMO 4 be applied to the soil seven days before seeding or transplanting and two to three hours prior to sunset (Cho 2010). Treating the soil in the late afternoon gives the microbes more time to adjust to the environmental changes, particularly the increase in temperature.

## Discussion

This experiment was designed to cultivate IMO using the equipment and materials available on the farm. The lauhala basket used to make IMO 1 was made with leaves from the hala tree located on the property. The traditional method recommends the use of a cedar box. However, any type of container, including a plastic container or ceramic bowl, etc., will do. In regards to cultivating IMO 1, never attempt to collect IMO during rainy seasons, as too much moisture promotes the growth of pathogenic microbes (Cho 2010). Additionally, the time it takes to cultivate IMO 1 is highly dependent on the weather. The collection process takes 4–5 days in cool weather (~20 °C) or 3–5 days under warmer (>20 °C) conditions (Park and DuPonte 2010).

In reference to the propagation of IMO 3, 22.68 kg of wheat mill run was used as a carbohydrate source for the microbes. As an alternative, macadamia nut shells (preferably ground), spent grains from breweries, wood chips, rice bran, ulu, or kalo skins may be used in place of wheat mill run. The type of nutrient inputs added is entirely dependent on availability. However, no studies have been done to compare the efficacy of the source of carbohydrates used. Natural inputs are important, as they enhance plant growth and IMO proliferation. Eventually, the nutrients in the soil will diminish. When that occurs, more nutrients will need to be added to the soil in order for both plants and microbes to flourish. KNF relies on the use of bio-organic fertilizers such as calcium from egg shells, nitrogen from fish waste, or potassium from the tips of healthy leaves (fermented plant juice). For this study, a nutrient analysis was not performed on each of the inputs used in the production of IMO. However, Maghirang (2011) provided an approximate analysis of some of the natural inputs used to make IMO (Table 2).

**Figure 5a. IMO 3 clumps into aggregates**

**Figure 5b. IMO 3 broken into smaller clumps**

**Figure 5c. Biochar added to IMO 3**

Whether farmers are subsistence or commercial, they take into account a number of factors, such as self-sufficiency, labor intensity, and cost, when selecting a farming method that best suits their needs. Korean natural farming is a great alternative for farmers looking to become self-sufficient and less dependent on external inputs such as inorganic pesticides and fertilizers. KNF is environmentally friendly in that it creates a smaller carbon footprint as compared to conventional farming methods. In some cases, farmers are able to obtain all the materials and equipment needed to cultivate IMO directly from their farms or source them locally. Synthetic fertilizers on the other hand, such as Gaviota 16-16-16 (distributed by BEI Hawaii), are imported to the Hawaiian Islands (http://www.beihawaii.com/company_info.html). However, these inorganic fertilizers require no preparation and can be applied to the soil at any time. In contrast, IMO need to be cultivated before application; hence, additional labor is required to make them.

Not including the length of time needed to prepare natural inputs, it takes approximately 25 days to make IMO 1 through IMO 4 (Table 3). Repeating the process takes roughly 11–15 days. The 340 g of rice and 570 g of brown sugar used in this experiment made well over 700 ml of IMO 2. Only 15 ml of IMO 2 was used per batch of IMO 3. Any unused portion of IMO 2 can be stored between 1 and 15°C and reused at a later day (Cho 2010). The jar should remain well ventilated (semi-permeable lid/cover) and be monitored over time for the presence of bubbles in the medium, which mean the microbial population is declining.

The overall cost associated with the cultivation and propagation of IMO is quite comparable to the cost of inorganic fertilizers (Table 4). All the materials and equipment needed for this experiment were found on site except for three items: Calrose rice, C&H golden brown sugar, and 22.68 kg of wheat mill run ($41.76, Paakea Feed and Farm). The calculations showed that it costs roughly $44.31 to make ~45 kg of IMO 4. At an application rate of 150 kg/0.1 ha (150 g/m$^2$), IMO 4 costs $0.14/m$^2$ for the initial batch and only $0.13/m$^2$ thereafter (using the foundation stock, IMO 2). In comparison, a 9 kg bag of Gaviota 16-16-16 costs $23.82. At a recommended application rate of 49g/m$^2$, it costs $0.13/m$^2$. The cost difference between the two is very minute. However, this estimated cost does not take into account the additional three hours of labor required to make IMO. Finding a cheaper alternative carbohydrate source could substantially reduce the overall cost.

**Table 2. Proximate Analysis of Fermented Inputs (Maghirang 2011)**

| Nutrient (mg/kg) | Fermented Fruit Juice | Fermented Plant Juice | Fish Amino Acids | Oriental Herbal Nutrient |
|---|---|---|---|---|
| Nitrogen (N) | 429.47 | 855.06 | 1166.34 | 405.16 |
| Phosphorus (P) | 61.87 | 122.72 | 193.44 | 74.84 |
| Potassium (K) | 12017 | 3934.2 | 314.6 | 522.3 |
| Calcium (Ca) | 307.23 | 913.03 | 377.92 | 181.03 |
| Magnesium (Mg) | 119.55 | 333.64 | 80.58 | 111.58 |
| Sodium (Na) | 51.15 | 128.19 | 426.4 | 78.58 |
| Iron (Fe) | 15.07 | 52.24 | 19.73 | 87.19 |
| Copper (Cu) | 0.75 | 0.87 | 0.94 | 0.81 |
| Manganese (Mn) | 2.19 | 4.54 | 1.45 | 4.13 |
| Zinc (Zn) | 1.97 | 3.74 | 5.84 | 2.04 |

**Table 3. Ingredients and Timeline for Developing Indigenous Micro-organisms (IMO) (Maghirang 2011)**

| Input | Ingredients | Culturing/Propagation Period (Days) | |
|---|---|---|---|
| | | Initial Process | Additional Process (Using IMO 2 Foundation Stock) |
| IMO 1 | - 340 g of rice | 4–5 | n/a |
| IMO 2* | - 570 g brown sugar | 7 | n/a |
| IMO 3 | - 22.68 kg of wheat mill run<br>- 20L of pond water<br>- Natural inputs*<br>- 15 ml of IMO #2 | 7–10 | 7–10 |
| IMO 4 | - 10L bucket of biochar | 4–5 | 4–5 |
| Total preparation time | | 22–26 | 11–15 |

*** IMO 2 foundation stock can be stored (1–15°C) for future use**
*** Natural inputs added include lactic acid bacteria, oriental herbal nutrient, fruit plant juice, fermented fruit juice, fish amino acid, and water-soluble calcium**

**Table 4 Cost breakdown between IMO and inorganic fertilizer**

| Costs Comparison Between IMO and Conventional Fertilizer (Inorganic) | | | | | |
|---|---|---|---|---|---|
| Ingredient | Cost per Whole Unit Purchased | Amount Used for 1 Batch | Adjusted Cost | Application Rate | Cost per $m^2$ |
| IMO | | | | | |
| 6.8 kg bag of Calrose rice | $11.16 | 340 g | $0.56 | 0.15 kg/$m^2$ | |
| C & H golden brown sugar 907 g | $3.19 | 570 g | $1.99 | | |
| 22.68 kg bag of wheat mill run | $41.76 | 22.68 kg | $41.76 | | |
| Amount of IMO made per batch | ~45 kg | | | | |
| Total cost | $56.11 | | $44.31 | | $0.13*–$0.14 |
| Inorganic Fertilizer | | | | | |
| Gaviota 16-16-16 9.07 kg | $23.82 | n/a | n/a | 0.05 kg/$m^2$ | $0.13 |

***It costs $0.14/m² to make the 1st batch, then $0.13/m² thereafter (using the IMO 2 foundation stock)**

In conclusion, the cultivation and propagation of IMO may be somewhat labor intensive. The cost is analogous to synthetic fertilizers available on the market, when labor cost is excluded. The cost to make IMO 4 can be significantly reduced if all the materials and equipment needed to cultivate and propagate IMO can be sourced directly on the farm.

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