

## **A guideline for quality control of paddy (rice) in post-harvest processing, drying, milling, and storing warehouse**

### **I. Why do we have to control mold during the stage of post-harvest, drying, milling, and storage?**

Mold is frequently existed and grown in our environment, such as on surfaces of organic materials, air surrounding us, and soil of farmland. The fungal spores are easily carried by wind or attached with equipment tires or animals, insects, or human to spread around. They can easily enter the buildings for rice milling and storage warehouse. One of the problems for spore and mycelium of fungal structures is small and invisible to our naked eyes. Thus, the removal of the mold in natural environment is very difficult, and it is so important to integrate the proper preventative procedures at production, post-harvest, drying, milling and storage.

Once the fungal spores landed on the surface of the paddy, and these can germinate rapidly when temperature and humidity become a favorable condition for their growth. The second stage of fungal growth is extending the hyphae of mycelia to find a source of nutrients to rapidly grow their fungal body. Some fungal species produce toxins called *Aflatoxins* that is a public health concern due to their carcinogenic property. *Aflatoxins* are produced by *Aspergillus* species<sup>1</sup> that mainly contaminate the cereals, including rice, maize, and groundnuts.

Most of the mold on the surface of paddy can be easily removed to minimize contamination through the proper processing practices, including drying, storing, milling, and packaging. However, when the fungal body of hyphae intrudes inside of rice and produces the mycotoxins, this is difficult to remove the toxic compound even rice is cooked thoroughly. Therefore, following proper control procedures are so important to prevent an invisible growth of fungal body.

The preventative procedures to create the controlled environment, which is unfavorable to grow mold, must be important for the quality control of the paddy (rice).

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<sup>1</sup> Mainly from *A. flavus* spp., and *A. parasiticus* spp.

## II. Examples of preventative procedures are listed to suppress a mold growth by controlling the physical environment.

A model called “the disease triangle” is a conceptual model that was first introduced<sup>2</sup> in the 1960s by McNew and Stevens. The model illustrates the interactions between the environment, the host (plant), and an infectious (a biotic) agent (Figure 1.). The existence of a disease caused by a biotic agent requires the interaction among a susceptible host and a favorable environment for disease development. Conversely, a disease can be prevented upon an elimination of any one of these three causal agents. The fungi are the predominant kingdom in phytopathology, and they are highly dependent on environmental factors to contribute a development of disease.

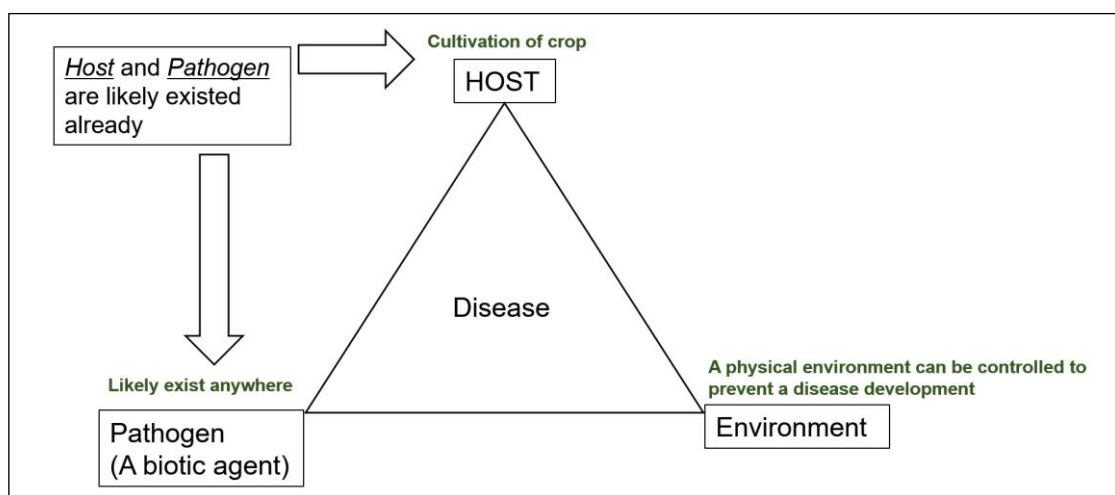


Figure 1. A conceptual model of the disease triangle

Since mold is commonly existed in the environment, it should consider in a presence at the storage warehouse, the machinery for threshing and milling, and the drying stage for paddy.

**Sanitation** is a key management practice to eliminate the pathogen from infecting the specific host. Controlling the relative humidity and wetness are another key management practice to create **unfavorable environmental**

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<sup>2</sup> McNew, G.L. 1960., pp 19-69, The nature, origin, and evolution of parasitism. Plant Pathology, an Advanced Treatise, J.G. Horsfall and A.E. Dimond, eds. Academic Press, NY.

Stevens, R.B. 1960. pp 357-429, Plant Pathology, an Advanced Treatise, Vol. 3., J.G. Horsfall and A.E. Dimond, eds. Academic Press, NY.

**conditions** to grow mold. Finally, a development of host resistance to the specific pathogen by breeding program would reduce the pathogen infection.

**1. The list of measures at the processes of harvesting paddy.**

- 1) When a rice paddy is adequately ripened for its harvest, an amount of harvestable paddy per day should be matched with an ability of the threshing and drying process; therefore, the harvested paddy can undergo a drying process as quickly and reasonably as possible.
- 2) The paddies, which are immediately after harvesting, contain a lot of moisture, and this condition could contribute a favorable environment for mold to grow. If the harvested paddies left in the paddy field for several days, the moist condition in the field could also cause a mold to quickly spread around the paddies (host).
- 3) The paddy contains a lot of moisture should not leave it inside of a combine harvester's tank and a flexible container bag for prolonged period. The harvested paddies should undergo a drying process as quickly as possible.
- 4) Check the operation status of machinery such as a combine harvester and a threshing machine before in use. The equipment should inspect regularly and repair them, if necessary, for ready to use for the harvesting activity.
- 5) Packaging materials and tools, such as the containers and storage bags, should be clean and dry to use for the post-harvest and drying processes.
- 6) The loading platform (a pickup bed) of vehicle must keep a clean condition without soil, dust, and crop waste to eliminate a causal agent for mold to grow. Those debris can potentially contaminate the paddy.
- 7) Postpone for harvesting paddy when the rice crop is wet by the immediate rainfall.
- 8) For a better quality-control procedure, a lodging rice by some environmental conditions should harvest separately from the rice under a normal condition. The rice that is affected by pests and diseases should also harvest separately from a rice without any pest and disease problems. These low-quality paddies should undergo threshing and drying processes separately and should separate from the good quality paddies
- 9) During a process of harvesting, a worker and a handler should be carefully attention to not let the paddies directly touch the wet ground and soil.
- 10) When the drying and conditioning paddy, a handler should avoid direct contact with the soil surface and keep it on the plastic sheets (tarpaulin) that

are in the condition of dry and clean.

- 11) Before drying and conditioning the paddy, please check the moisture content of the paddy. If a moisture meter is locally available, please bring a sample to check the moisture content and keep a result recorded.

## **2. The list of measures at the preparation processes of drying paddy.**

- 1) Before drying and conditioning the paddy, a handler should check all equipment and tools properly functioned. The area and location of drying and conditioning should also consider it and avoid contacting a wet surface and soil.
- 2) A harvested paddy should not leave them inside of a combine harvester's tank and a flexible container bag for prolonged period. The harvested paddy should undergo a drying process as quickly as possible.
- 3) After drying and conditioning processes are completed, the storage area (room) should be clean, and a handler should consider using a new storage bag whenever possible to avoid contacting with pathogen. If the handler uses the recycled storage bag repeatedly, please make sure it is not a wet, dirty, and moldy condition. If you find a moldy storage bag, please discard the affected bag immediately and sanitize the surrounding storage area.

## **3. The list of measures during the processes of drying paddy.**

- 1) The paddies, which are immediately after harvesting, contain a lot of moisture and should undergo a drying process as soon as possible.
- 2) If a worker and a handler consider doing a solar drying method on the plastic sheets (tarpaulin), please be careful of the following points:
  - ✓ Please spread the paddy thinly on the surface of plastic sheet or drying yard (a concrete floor).
  - ✓ Please turn over the paddy frequently to avoid building a humid condition.
  - ✓ Please be careful with a high air humidity of weather condition.
  - ✓ Please check the moisture content of paddy that is under 14.0% to complete the drying process.
- 3) After completing the drying process, a paddy that stored the heat energy should bring in the shade area to cool it down first. The ideal air temperature is 25°C or below.
- 4) Please check the moisture content of the paddy before storing into the

storage bag. The adequate moisture content of the finished product is below 14.0% for paddy.

- 5) Before storing into the storage bag, please remove some of empty grains, small stones, and debris, if that are possible.
- 6) During drying processes, the paddy should avoid contacting the ground with wet soil.

#### **4. The list of measures at the processes of storage.**

- 1) The warehouse floor and equipment for drying and storage should clean regularly and should become a habit for a regular inspection.  
For example, paddy(rice) husks, rice brans, and house dusts can easily accumulate inside of the building and the machinery, which could become a breeding ground for mold. Thus, the regular cleaning should be a key disciplinary rule for a warehouse management.
- 2) An equipment like a rice milling machine, a stone remover, and a paddy cleaner must regularly inspect all moving parts and clean inside of the machinery to remove paddy husks, rice brans, and other debris.
- 3) For preventing an excessive heat and humidity build up, the warehouse shall manage with an active and passive ventilation system to keep the inside of storage room dry.
- 4) The feeding inlet of a rice milling machine should be covered with a lid whenever it is not in use. This practice could result to prevent a dust accumulation and an invasion of small animals inside of the machine.
- 5) If the storage bags and flexible container bags get accidentally wet, mold can grow under the favorable condition to infect the paddy and milled rice. These storage materials should be stored in a place where they can be protected from the water logging. Keep them in the dry condition.
- 6) Must provide a preventative measure for entering wildlife and pests into the warehouse.

If wildlife or pests enter the building freely, they will not only infest on paddy or milled rice, but also they could potentially bring in unwelcomed molds as considered a disease vector. The warehouse manager should separate between the stationary working area and the grain storage room to minimize a frequency for entering the storage room by workers. The worker must be mindful of the closing door every time entering the grain storage room. Installing a net with the mesh size of 2 cm<sup>2</sup> or smaller to prevent entry of

wildlife and large pests through ventilation openings, and windows.

- 7) Should clean and maintain the surrounding area of warehouse and rice milling area. The weed management to control the surrounding area can reduce a pest pressure, and the practice also reduce a disease pressure to prevent a mold infection.
- 8) For maintaining a ventilation and avoiding a moisture build up, the paddy or milled rice inside of the storage bags or flexible container bags should not be placed on the floor directly. Instead, the storage bags and flexible container bags should be placed on a wooden or a plastic pallet to prevent the mold growth.
- 9) For maintaining a paddy quality inside of the warehouse, the room temperature, relative humidity, temperature of the paddy, and moisture content of the paddy in the storage room must be regularly inspected and recorded on the logbook.  
\*Please pay special attention for storing the paddy during the wet season because the relative humidity is often high, and it is a favorable condition for mold to grow.
- 10) If the milled rice or paddy is stored in storage bags or flexible container bags, please inspect the bag periodically for any signs of water damage, dirt, or tears. In addition to a visual inspection for the milled rice and paddy, please check with a smell of the rice or paddy for the presence of mold. Please also check the temperature of stored paddy and rice periodically for an accidental fermentation by a mold growth.
- 11) In case of the mold infestation was discovered, the storage bag with mold growing rice or paddy must be separated from the rest of the rice to prevent further spreading of the contamination. Please do not leave the contaminated rice or paddy inside or around the warehouse and discard it appropriately to prevent further spreading of the contamination.

## **5. The list of measures at the processes of milling and shipping.**

- 1) Before milling and packaging the milled rice for a scheduled shipment date, please make sure that the milling machine is carefully inspected for all moving parts and is properly functioned.
- 2) Please be sure to clean and remove any paddy husks, rice brans, and dusts inside of the milling machine before and after the each use.

\*The paddy husks, rice brans, and house dusts can easily accumulate

inside of the milling machine, which could become a potential breeding ground for mold. Thus, the regular cleaning should be a key disciplinary rule for milling and shipping to provide a quality rice to the retailers.

- 3) Please be sure to check the milled rice by visual inspection with any signs of abnormalities, such as a pest damage during storage or mold growth. Please pay an extra attention to the sample of milled rice that give off a peculiar smell like mold by the sniffing test.
- 4) In case of the mold infestation was discovered, please stop the milling process and clean thoroughly inside of the milling machine. The contaminated rice should separate from the rest of rice and dispose it properly.

## **6. The importance of record keeping.**

To ensure the effect of the daily routine work more efficient and ascertain, the below mentioned 1) ~ 4) processes could be helped.

- 1) Please write down the work steps on the list, and an operator should check the work progress by marking the checklist.
- 2) Keep the record for the daily routine work and the work diary, which would help to relate the effectiveness of the work. Examples: information such as harvest date, amount of paddy harvested, drying and processing dates, moisture content before and after drying, storage start and end date, milling date, milling yield ratio, and shipping date should be written by the workers.
- 3) Please keep all records such as the work logbooks, inspection results, invoices, receipts, and vouchers. If the abnormalities occur from the final product of rice, these stored records will help to determine the causal agents and will be able to properly respond to inquiries from customers to whom you have shipped the product already.  
\*In principle, all work logbooks should be kept for at least one year. If the storage period for paddy is longer than the current production year, the logbooks and other related records should be kept for an extended period.
- 4) For farmers, please keep a record for the logbook such as a fertilizer input data, pesticide application, material purchasing date, and other important production diaries. This record would help to properly communicate with the buyers, handlers, millers, and warehouse managers to establish the reliable relationships as a part of the good agriculture practice (GAP).

## Production/Post-harvest Management Check Sheet

Harvesting		√
①	The amount of harvestable paddy per day should matches with the ability of the threshing and drying process. Thus, the paddies can dry as quickly and reasonably as possible.	<input type="checkbox"/>
②	Check the operation status of machinery such as a combine harvester and a threshing machine before in use. The machineries are fully inspected and ready to use for the harvesting activity.	<input type="checkbox"/>
③	Packaging materials and tools, such as containers and bags, should be clean and dry to use for harvesting paddies.	<input type="checkbox"/>
④	The loading platform of vehicle must keep a clean condition without soil, dust, and crop waste to eliminate a causal agent for mold to grow.	<input type="checkbox"/>
⑤	Postpone for harvesting paddies when the rice crop is wet by the immediate rainfall.	<input type="checkbox"/>
⑥	A lodging rice by some environmental conditions should harvest separately from a rice under normal condition. The rice that is affected by pest and disease should also harvest separately from a rice without any pest problems. These affected paddies should separately undergo the drying processes than the rest of paddies.	<input type="checkbox"/>
⑦	A worker should be careful not to let the paddies directly touch the wet ground and soil during the harvesting process.	<input type="checkbox"/>
⑧	A worker should avoid the paddies directly contacting with the soil surface. The paddies should keep on the clean and dry plastic sheets (tarpaulin) to minimize contacting with the wet ground and soil particles.	<input type="checkbox"/>
Drying Process		√
①	Check the moisture content of the paddy. If a moisture meter is available, please bring a sample to check the moisture content and keep a result recorded.	<input type="checkbox"/>
②	Check all equipment and tools for drying and conditioning that should properly functioned. Repair equipment and tools, if necessary, prior to in use.	<input type="checkbox"/>
③	Clean inside of the equipment such as threshing machine, drier, wind fan, and tools such as a drying plastic sheets (tarpaulin) prior to in use.	<input type="checkbox"/>
④	Use a new storage bag whenever possible. If a person uses the used storage bag repeatedly, please make sure it is not wet, dirty, and moldy condition. If you find a moldy storage bag, please discard the affected bag immediately and sanitize the surrounding storage area.	<input type="checkbox"/>
⑤	After harvesting paddies, they should undergo a drying process as soon as possible and following a schedule plan for post-harvest processing and drying.	<input type="checkbox"/>
⑥	Please check the moisture content of the paddy before storing into the storage bag. The adequate moisture content of finished product is 14.0% or below for paddy.	<input type="checkbox"/>
⑦	<p>If a person considers doing a solar drying method on the plastic sheets (tarpaulin), please be careful of the following,</p> <ul style="list-style-type: none"> <li>✓ Please spread the paddy thinly on the surface of plastic sheet or drying yard (a concrete floor).</li> <li>✓ Please turn over the paddy frequently to avoid building a humid condition.</li> <li>✓ Please be careful with a high air humidity of weather condition.</li> <li>✓ Please check the moisture content of paddy that is under 14.0% to complete the drying process.</li> </ul>	<input type="checkbox"/>
⑧	After completing the drying process, a paddy, which stored heat energy, should bring in the shade area to cool it down first. The ideal air temperature is below 25°C.	<input type="checkbox"/>
⑨	Before storing into the storage bag, please check the moisture content 14.0% or under by using the moisture meter.	<input type="checkbox"/>
⑩	Before storing into the storage bag, please use a paddy cleaner to remove the debris, stones, and the immature and damaged grains.	<input type="checkbox"/>



⑪	During the drying process, please avoid contacting wet surface and soil particles as much as possible.	<input type="checkbox"/>
<b>Storage</b>		√
①	The warehouse shall manage with an active and passive ventilation systems to keep the inside dry and to minimize the excess heat buildup.	<input type="checkbox"/>
②	The storage bags or flexible container bags should not be placed on the floor directly. Instead, they should be placed on a wooden or a plastic pallet to maintain the ventilation and air flow. Also these materials should be stored in a place with a dry condition.	<input type="checkbox"/>
③	The regular cleaning and inspection should be implemented, and that are the key disciplinary rule to follow a good warehouse management.	<input type="checkbox"/>
④	For maintaining the paddy quality inside of the warehouse, the room temperature, relative humidity, temperature of the stored paddy, and moisture content of the paddy in the storage room must be regularly inspected and recorded.	<input type="checkbox"/>
⑤	Must provide a preventative measure for entering wildlife and pests into the warehouse that is intended to use for a paddy storage room.	<input type="checkbox"/>
⑥	Please inspect the bag periodically for any signs of water damage, dirt, or tears. Please check with a smell of the rice or paddy for the presence of mold.	<input type="checkbox"/>
⑦	In case of the mold infestation was discovered, the storage bag with mold growing rice or paddy must be separated from the rest of the rice to prevent further spreading of the mold contamination. Please do not leave the contaminated rice or paddy in or around the warehouse and discard it properly.	<input type="checkbox"/>
<b>Milling and Shipping</b>		√
①	Please be sure to clean and remove any paddy husks, rice brans, and dusts inside of the milling machine before and after in use.	<input type="checkbox"/>
②	Please be sure to check the milled rice by visual inspection and sniffing test for detecting any abnormalities, such as a peculiar smell like mold and damaged by pests during the storage period.	<input type="checkbox"/>
<b>Warehouse and Equipment</b>		√
①	Warehouse floor and equipment for drying and storage should clean regularly and should become a habit for a regular inspection.	<input type="checkbox"/>
②	Warehouse shall manage with an active and passive ventilation systems to keep the inside dry.	<input type="checkbox"/>
③	The feeding inlet of rice milling machine should be covered with a lid whenever it is not in use to prevent an invasion of small animals inside of the machine.	<input type="checkbox"/>
④	Please inspect the equipment for drying and storing such as a storage bag, tarpaulin, pallets, threshing machine, and milling machine. Also please keep them stored in the dry place.	<input type="checkbox"/>
<b>Record Keeping</b>		√
①	Please write down the work steps on the list, and an operator should check the work progress by marking the checklist.	<input type="checkbox"/>
②	Keep the record for the daily routine work and the work diary for the harvesting date, drying process date, moisture content, and storage start and end date, milling date, milling yield ratio, and shipping date.	<input type="checkbox"/>
③	Please keep all record such as work logbooks, inspection results, invoices, receipts, and vouchers for at least one year.	<input type="checkbox"/>
④	For farmers, please keep a usage logbook for the fertilizer, pesticide, and other inputs. This effort would contribute towards to the “Good Agriculture Practice” (GAP).	<input type="checkbox"/>