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ECHO Asia Notes

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ECHO's Mission is to equip people with resources and skills to reduce hunger and improve the lives of the poor.

ECHO's Vision is to honor God through sustainable hunger solutions.

The Amazing Effects of Rice Straw: Recycling Crop Residues to Improve the Soil

By Winfried Scheewe, German Development Service (DED), Center for Studies and Development of Cambodian Agriculture (CEDAC)

Editor: Winfried Scheewe represents DED, a leading European development service for personnel cooperation, serving as the Marketing Advisor to CEDAC http://www.cedac.org.kh/home.asp based in Phnom Penh. From 1990 until 2006, he helped several NGOs in the Philippines, promoting sustainable agricultural practices. He is also the author of 'Nurturing the Soil - Feeding the People.'

An earlier version of this article was published in Philippine Agriculture Monthly (October 2004). Winfried also offered a presentation on the effects of recycling rice straw at the September 2009 ECHO Asia Agricultural Conference.

How the recycling of crop residues improves the soil

Does rice straw have any value? Looking at the practices of most farmers, it seems not! The burning of rice straw is a common sight during the harvest period in many parts of Asia. Yet a number of farmers think otherwise. One of them is Isidro Prado from Alba in the municipality of Tago, Surigao del Sur, Philippines. He does not consider rice straw as

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trash to be disposed of in the easiest way. Instead he recognizes rice straw as essential for maintaining the fertility of his rice field. About eight years ago, he learned that returning the rice straw could help to overcome the problem of zinc deficiency that was prevalent in his rice field at that time.

Prado, now 69 years old, started cultivating the rice field he inherited from his parents in 1969. For about 15 years he cultivated his rice field like most farmers: using high yielding varieties (HYV), fertilizers and pesticides. Although he considered a yield of about 40 *cavans* (one *cavan* equals 50 kg or 110 lbs.) from his 0.38 hectare (0.94 acre) field acceptable, he felt lucky to have even five sacks of *palay* (unhusked rice) left over for consumption; barely enough to last his family a few months. Unfortunately, most of his produce went to the money lender who asked up to 10 *cavans* as payment for each 1,000 Philippine pesos (1 US dollar = P 47.2) of borrowed capital.

A zinc deficiency became apparent in Prado's fields during the early nineties. Within a couple of years yield went down to 12 to 17 sacks, an equivalent of about 30 *cavans* per hectare. During that time the rice plants always looked somewhat sickly, but the worst result was that most seed heads were not filled with grain.

The condition of his land improved when in 1996 he joined a farmers' group served by the Tago Center for Sustainable Agriculture (TCSAI), a newly formed NGO. The NGO workers encouraged Prado to return rice straw to his field after each harvest. They also introduced several traditional and newly bred lines of rice from the MASIPAG network (Magsasaka at Siyentipiko para sa Pag-unlad ng Agrikultura - Farmer Scientist Partnership for Development, Incorporated). These rice varieties grew well and brought about yields comparable to the HYVs, although Prado no longer applied chemical fertilizers.

Within two years (or four croppings) the yield of his rice crops was back to normal. The signs of zinc deficiency were gone. He soon realized another big advantage: because he no longer needed to buy fertilizers and pesticides, he needed less capital. Now, Prado needs to borrow only P 2,000.00 per cropping, for which he has to pay an equivalent of seven sacks of *palay*. Thus he is able to keep most of his rice for consumption. He covers most of his cash needs by selling copra (dried meat or kernel of coconut) and banana

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or kernel of coconut) and banana.

Due to this experience, Prado keeps on spreading the rice straw in his field after every harvest. He says it is best to do it immediately after harvest. "If you wait longer, the straw becomes hot and it is more difficult to broadcast it," he explains. Besides, the straw starts to develop molds which cover the straw with an unpleasant dust. Once a year, he adds about 20 sacks of rice hulls from the nearby rice mill as additional soil conditioner.

Many farmers are reluctant to scatter rice straw in the field, because they expect problems during land preparation. "Not so," says Prado, "but you have to let the rice straw decompose for about one month on the surface." An extension worker once told him that this way microbes involved in the decomposition process will even add nitrogen to the soil. "If you incorporate the rice straw immediately and plant again, the microbes that decay the straw would take away nitrogen from the young crop. Besides, methane gas will be released which disturbs the young rice plants."

In addition to the reduced expenses as well as the more filled and tastier grains, Prado realized another important benefit. He no longer has to work with farm chemicals. Before, whenever he had to spray pesticides he felt very exhausted and even sickly afterwards. Even though several of his neighbors continue to use pesticides, pests do not seriously affect his rice.

To be sure of a good harvest, Prado usually plants at least three different rice varieties. At the time of writing, he was testing two varieties in smaller plots. In another small portion he was planting a glutinous rice variety called Tapol, which his family uses for special occasions.

Asked what he would recommend to other farmers, Prado replies that it would be good if farmers could stop burning the straw and utilize it instead on their farms. "Considering that the straw of an average harvest contains 25 to 40 kg (55 to 88 lbs.) of nitrogen, they are really burning money," he reasons.

What may be even more important than the nitrogen is the energy (carbon) contained in the straw. Soil microbes convert most of the carbon into humus, which

ensures the supply of nutrients to the next crop. Energy from the straw also enables soil organisms to better contribute to the maintenance of good soil structure, allowing for better aeration and enabling the soil to absorb and hold more water. Thus, Prado considers recycling of rice straw an essential step towards reducing the costs of rice farming and improving the situation of farmers.

The value of rice straw

Per metric ton, rice straw typically contains 5 to 8 kg (11 to 17.6 lbs.) nitrogen, 0.7 to 1.2 kg (1.4 to 2.64 lbs.) phosphorous, 12 to 17 kg (26.4 to 37.4 lbs.) of potassium and 40 to 70 kg (88 to 154 lbs.) silica. When the straw is burned, the carbon, which comprises 40 percent of the straw, goes immediately into the atmosphere and increases the CO2 content, thus contributing to the problem of global warming. Otherwise, it could have supplied soil organisms with energy.

Likewise, 93 percent of the nitrogen content is lost. Therefore, on average about 30 to 40 kg (66 to 88 lbs.) of nitrogen per hectare is unnecessarily released into the atmosphere. In addition, 25 percent of the phosphorous and 21 percent of the potassium are lost during the burning. Heat also renders the silica in the ash less soluble than in fresh straw.

Where does the soil nitrogen come from?

For eight years, Isidro Prado has no longer applied nitrogen fertilizer to his fields. Yet, on average, he obtains between 4,000 and 4,500 kg (8,800 to 9,900 lbs) of palay per hectare.Assuming that one metric ton (2,200 lbs.) of harvested rice contains about 12.5 kg (27.5 lbs.) nitrogen, the cereals harvested from one hectare (2.47 acres) remove about 54 kg (118.8 lbs.) of nitrogen. The straw left in the field contains around 30 kg (66 lbs.) of nitrogen. Thus, the harvest from one hectare represents about 84 kg (184.8 lbs) of nitrogen. But with the retention of the rice straw, probably most of the 30 kg (66 lbs.) nitrogen in the straw from the previous harvest will have been reincorporated into the soil.

Additionally, soil scientists claim that biological nitrogen fixation related to the decomposition of the straw can potentially supply an additional 20 to 25 kg (44 to 55 lbs.) of nitrogen. There remains a gap of 25 to 30 kg (55 to 66 lbs.), from the nitrogen that is removed with the crop (i.e., grains and straw) during harvest. Although a small part of this nitrogen comes with rainwater, this is strong evidence

that various nitrogen-fixing microorganisms in the paddies supply most of the balance.

This is made possible through the association of bacteria living on the surface of roots, giving rice plants (as well as various other grasses) access to nitrogen that certain bacteria fix from the air. *[Editor: Choudhury and Kennedy cite the role of plant growth-promoting rhizobacteria (PGPR) such as Azotobacter, Clostridium, Azospirillum, Herbaspirillum, Burkholderia and Rhizobium, in improving the ability of the rice plant to assimilate soil N]*. It is essential that the soil be well aerated for such bacteria to thrive. Therefore, if the situation allows, rice fields should be flooded and drained alternatively. Additionally, these bacteria require sources of energy, such as straw, to function efficiently. If the soil is deprived of straw and other types of organic matter, nitrogen-fixation processes cannot occur.

These effects were obvious on Isidro Prado's farm when he transitioned away from several years of intensive application of synthetic fertilizers. With his rice field losing fertility and the crop suffering severely from zinc deficiency, it was not until he began to recycle the rice straw that conditions improved. Now Prado regularly returns the straw to the field to enhance the fertility of his rice field.

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Preserving Bamboo with Borates

By Thomas Singer, the Rain Tree Foundation, Chiang Mai, Thailand

Editor: Based in Chiang Mai Thailand, Thomas Singer serves as technician with Meribah Ram Pump, the appropriate technology component of the Rain Tree Foundation.

Working together with Thai Care, the children's ministry of the Rain Tree Foundation, Meribah Ram Pump is engaged in various community development projects in northern Thailand. A major focus is to make simple, sustainable technology, such as ram pumps and bio sand water filters, available to those who have limited access to water and electricity.

Bamboo plays a key role in our work as well. Meribah enhances local livelihood opportunities by promoting the production and sale of bamboo products such as handicrafts, and has also constructed a coffee shop almost entirely out of bamboo.

Bamboo is widely available in the area and local people understand its use, including for the construction of traditional homes. But because of damage from bamboo pests, such as borer beetles and fungi, such homes must be rebuilt nearly every two years.

A related problem includes the scarcity of bamboo due to overharvesting. Unfortunately, as those who can afford it rebuild their homes with concrete, skills for constructing traditional bamboo houses are likely to be lost.

In response, we have determined that bamboo treatment and preservation offers an opportunity to help:

- prevent over harvesting of bamboo and create sustainable bamboo utilization;
- preserve traditional building techniques;
- offer durable bamboo housing and products; and

- encourage the production of bamboo handicrafts and other marketable products.

Our web research about bamboo preservation options led us to the Environmental Bamboo Foundation (EBF), based in Bali. The foundation's website offers the downloadable *Vertical Soak Diffusion Treatment Manual* (select "Treatment Manual" from the main page), an excellent source of information that explains practical bamboo preservation procedures.

With information from the EBF manual, we were able to utilize the boric acid/borax formula and replicate other key steps. We have also improvised certain variations of our own, including the use of a solution bath in which culms (bamboo poles) are soaked horizontally as opposed to having the solution injected into them vertically.

Having successfully adapted EBF's bamboo preservation technique to our work in Thailand, the following is an overview of key materials and steps, including our own observations and adaptations.

Required facilities and tools for bamboo preservation with borates

- A watertight vat, trough or pool (protected from the sun and rain) for soaking the bamboo in borate solutions. The size of treatment containers may vary according to the demands. Our vat, measuring 6 m (19.7 ft.) long x 1.5 m (4.9 ft.) wide x 1 m (3.3 ft.) high, is designed to handle large amounts of bamboo to be used for construction purposes.
- Metal grate that can be placed atop the soaking vat.
- Eye protection.
- Rubber gloves and boots.
- Water.
- 200 liter (52.8 gallon) plastic container for mixing and storing the solution.
- Dye.
- Plastic containers for mixing and measuring materials.
- Handsaw.

- Iron T-bar with a spearhead welded to the end (length depending on the bamboo to be treated).
- Wooden stick for mixing solution.
- Hydrometer (an instrument used to measure the specific gravity or relative density of liquids).
- Brushes (or coconut husks) for cleaning.
- A piece of cloth stretched over a frame, used for skimming debris off the surface of the solution.
- **Tim-Bor** *[Editor: Tim-Bor is a commercial wood preservative that works as an insecticide and fungicide, utilizing disodium octaborate tetrahydrate, a natural borate compound, as the active ingredient]* or **boric acid and borax** (used in combination as a substitute for Tim-Bor).
- Well-ventilated space unexposed to sun or rain, for drying the bamboo poles.

Harvest of Culms

The EBF manual stresses that the best season to harvest culms is the period immediately **after the rainy season** when starch content in the bamboo sap is low (starch is a favorite food for bamboo pests). This season occurs in November and December in northern Thailand.
Conversely, it is not a good idea to harvest poles during the period that shoots are being produced, when starch content is at its peak.

The EBF manual also recommends using **3- to 5-year-old** bamboo. Younger culms are too weak, while poles older than five years tend to be too hard, having inner culm walls that may be impermeable to the treatment solution.

Instead of using a machete to cut the culms, we have discovered that cutting bamboo cleanly **with a saw** will keep capillaries in the wood open, allowing the solution to penetrate better.

Preparing the solution

- If **Tim-Bor is available**, mix 25 kg (one bag) with 225 liters of water to produce a "10% weight for weight solution."
- Instead of purchasing Tim-Bor, our large batches of **borate solution** are made by slowly adding 50 kg of **boric acid** and 75 kg of **borax** to 700 liters of **water** while stirring the solution. Based on this ratio of boric acid, borax

and water, depending upon the amount of solution needed per situation, the amount of borates mixed proportionately with water can be adjusted. When all crystals are dissolved, you will have a 17% boric acid/borax weight (or mass) solution that is equivalent, in borate concentration, to a 10% Tim-Bor weight solution.

Editor: EBF's bamboo treatment manual offers limited information about the availability of Tim-Bor in Indonesia and Thailand. Related to the comparative expense of using either Tim-Bor or the boric acid/borax mixture to treat bamboo, depending upon the location in Thailand, Tim-Bor costs approximately 85 baht ($2.58 US) per kg or 2,125 baht ($64.39 US) for a 25 kg bag. A 25 kg bag of boric acid costs approximately 1,500 baht ($45.45 US) and a bag of borax of equal weight costs approximately 950 baht ($28.78 US).

To better manage the composition of the solution, it is easier to mix smaller volumes of higher concentrated solution in a container (e.g. 200 l) and then pour the solution into the pool, adding the volume of water needed to attain the correct concentration of the Tim-Bor or borax/boric acid solution.

Editor: The EBF describes Tim-Bor as "more environmentally friendly than other wood preservatives currently used" and superior to boric acid "because it diffuses and penetrates bamboo or wood better and faster." However, the Tim-Bor label prescribes caution in the use of the product, specifically warning against ingesting or inhaling the material and cautioning users to avoid contact with eyes or clothing. The same precautions should be applied to all borate solutions.

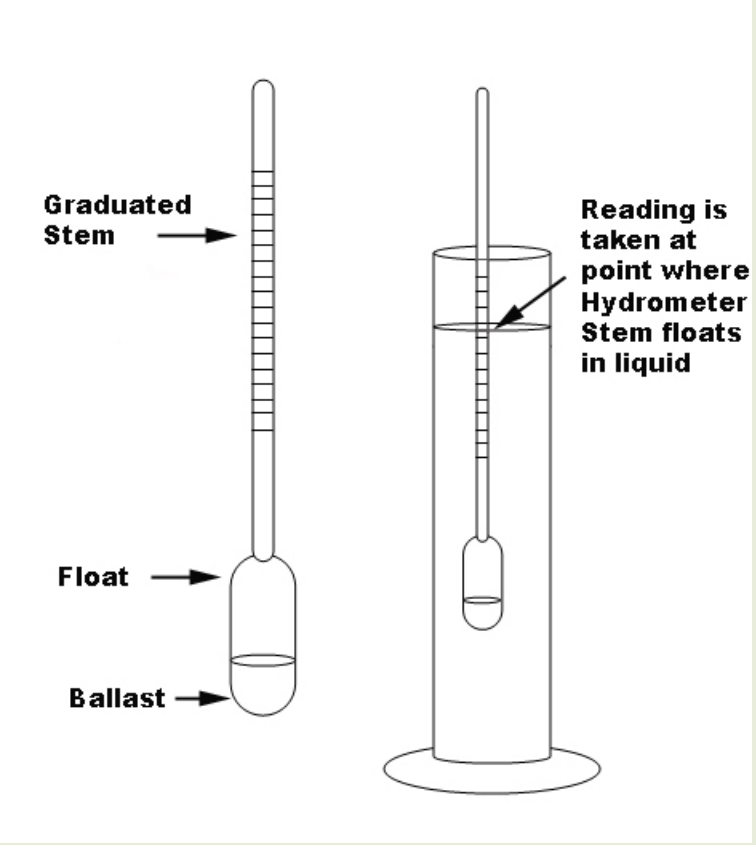
In our experience, adding warm water to the container aids in dissolving Tim-Bor or boric acid/borax powder. However, before checking the composition of the solution in the pool with a hydrometer (see below), the liquid must have cooled down completely.

Tinting the solution

While mixing the solution in the container or vat, add adequate amounts of dye, such as red or green, for easier identification of treated poles.

Measuring the solution

To monitor the level of borates in the treatment solution, the EBF manual recommends using a **salt measuring hydrometer** "under normal temperatures of your region" as opposed to measuring during either extreme hot or cold weather conditions. We have found that the optimum air temperature range to measure the solution is 20-25 degrees C (68-77 degrees Fahrenheit).



To test with a hydrometer, slowly add the borate solution to a test container (bucket, etc.), so that you avoid air bubbles in the solution prior to lowering the hydrometer into the solution. Before releasing the instrument, allowing it to partially float, give the hydrometer a quick twirl by spinning its top shaft. This action will help deflect air bubbles which can accumulate around the hydrometer, affecting its buoyancy and resulting in a false reading.

A hydrometer is read similar to a thermometer. Note number where the solution crosses the scale. A well-calibrated hydrometer should have a reading of **1.045** (plus or minus 0.005).

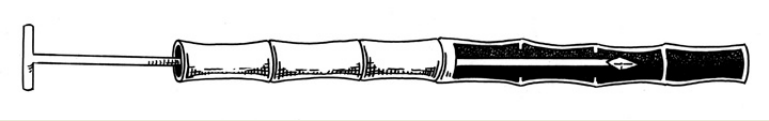
Preparing the bamboo poles for the treatment

The EBF manual recommends the following:

- Thoroughly clean the outside of the bamboo culms with either water and brushes, coconut husks and sand, or a product similar to Scotch Brite.
- Prepare a long rod with a spear head welded to one end. The spear head should be approximately 10 cm long with a diameter of 2-3 cm at the base

(depending on the width of the bamboo poles). This modified iron rod can be used to punch holes easily through the node diaphragms separating the internodes. *[Editor: see adjoining illustration of a cut-away view demonstrating technique for hollowing bamboo culms]*. Piercing the diaphragms will prevent clogging from inside of the culm and allow the solution to move freely throughout the interior. Larger diameter holes are recommended to prevent air bubbles from forming during the filling procedure. Fortunately, larger holes will not diminish the strength of the culm.

- To facilitate the hollowing process, place one end of the bamboo against a sturdy wall and force the iron rod into the other end, punching holes through all of the nodes.



Treatment

The EBF injects borate solution into culms arranged in a vertical position. However, for convenience, we prefer to use the following soaking method:

- Add borate solution to the soaking vat. We have found it best to add enough solution to fill the vat approximately 1/3 full. Then arrange the bamboo poles into the container until the displaced solution rises almost to the top of the vat.
- While placing poles into the vat, be careful to displace as many air bubbles as possible. Also, keep the culms submerged by placing **weights on top of the poles**. Several 50-liter containers full of water work well as weights.
- Allow the bamboo to soak for at least **two weeks**.

Removing the poles and reusing the solution

- To save the borate solution for reuse, remove the bamboo poles before placing a metal grate on top of the vat. Immediately stand the freshly treated bamboo on top of the grate for at least one hour, to allow as much solution as possible to drain out of the poles back into the vat.
- Use a simple screen to remove debris and other materials suspended in the solution. A screen can be made from cloth, such as an old tee-shirt, stretched

across a small frame.

- The borate solution can be used over and over. *[Editor: according to the Tim-Bor label, wastes resulting from the use of the product may be disposed of on site or at an approved waste disposal facility. However, the pesticide is toxic to fish and wildlife. Tim-Bor or Tim-Bor solutions that are spilled or applied to plants or cropland may kill or seriously retard plant growth. The label also warns against applying the product or solutions directly to surface water and discharging the effluent into streams, ponds or other bodies of water or into sewer systems]*.
- Before reusing a batch of solution, check the borate level with a hydrometer. If the reading is **less than 1.040, add more solution**. Should the scale show a reading **more than 1.050, add more water**, checking and adding water until the optimum concentration is reached.

Drying and storing

In a well ventilated, covered area, allow the bamboo to dry in a **prone position for 4-6 weeks** (length of time depending on the humidity). This must be done in the shade, as direct exposure to hot sun while drying can split the culms.

Testing

A simple way to test the success of the treatment is to capture some bamboo borers and place them into a closed (but not airtight) container along with two pieces of bamboo; one treated and the other untreated. After a few days any untreated bamboo will show obvious signs of infestation. This is the simplest, most effective means of monitoring the efficacy of the treatments and should be repeated with each finished batch.

Occasionally we find a few holes made by borers in treated wood. However, we have learned that this results from a few remaining bugs which are actually dying from the borax treatment. Fortunately, there will be no additional infestation as the treated bamboo remains unpalatable to the pests.

Summary

Our method is only one of many techniques that can be used to preserve bamboo. Other approaches include the vertical injection method recommended by EBF;

pressure treatment; and smoking.

With borate treatments, bamboo can reportedly last 15 to 20 years or longer. Over the past two years we have implemented the borate soaking method to treat bamboo used to build two houses as well as to produce furniture and handicrafts. As the work remains pest free, we invite others to see for themselves how such treated bamboo lasts longer.

Editor: Thomas Singer can be contacted at thomas@raintree-foundation.org.

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ECHO Agricultural Conference for Northeast India

The *ECHO Agricultural Conference for Northeast India*, the first of its kind in the region, will be hosted by NEICORD (North East India Committee on Relief and Development) in collaboration with the ECHO Asia Regional Office.

The conference, organized for those engaged in agriculture development in Northeast India, will focus on sharing among participants, particularly with regard to improvement of hill cultivation, eco-forestry, SRI and preserving the environment. The conference will include plenary sessions on important issues provided by excellent resource persons. Participants will be able to network and exchange skills and knowledge.

Date: 6-8 October 2010
Venue: CBCNEI (Baptist Centre) Guwahati

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