FEED THE FUTURE
The U.S. Government's Global Hunger & Food Security Initiative

PALLET DRYER MANUAL

IMPROVED DRYER FOR LEGUMES, COFFEE, COCOA, AND GRAINS, DESIGNED BY UC DAVIS

AUGUST 2022

FEED THE FUTURE INNOVATION LAB FOR HORTICULTURE

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HORTICULTURE INNOVATION LAB

UC DAVIS UNIVERSITY OF CALIFORNIA

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INTRODUCTION

The UC Davis pallet dryer was designed to provide efficient drying even in hazy or partially cloudy conditions. Constructing the dryer is simple, and it can be built from low-cost materials found locally in markets and shops around the world. The objective of this manual is to provide the knowledge needed to build and use the pallet dryer, along with the basic principles to dry grains, fruits, vegetables and other foods. This manual will be useful for growers, farmer cooperatives, trainers, development implementers, researchers, and others.

There are two key and unique characteristics of the pallet dryer:

1. The fan ensures continuous airflow above and below the product, thus increasing the speed of drying compared to other designs.
2. The dryer's large heat-collection area ensures high temperatures and rapid moisture removal.

HOWTO USETHIS MANUAL

This manual has been divided into an introduction followed by two main sections:

SECTION 1: HOWTO BUILDTHE PALLET DRYER

SECTION 2: DRYING CROPS WITH THE PALLET DRYER

BACKGROUND

Aflatoxin and fumonisin contamination of basic grains and pulses is widespread in the developing world, and is suspected of being a primary cause of high levels of childhood stunting in the humid tropics. Although some contamination occurs in the field, a major source of aflatoxin is storage of grain at high moisture content.

The UC Davis DryCard is a simple tool that allows farmers and traders to determine whether grain is dry enough to store. The problem for many farmers, particularly smallholder farmers, is that they do not have a satisfactory means of drying grain that is not yet dry enough for safe storage.

Present technologies are either very simple or relatively sophisticated. Simple solutions, such as drying on the ground or the roof leaves grains and pulses susceptible to contamination, to moisture from rain and dew, and to insect, bird and rodent attack. More sophisticated solutions, usually dryers using electricity, gas, or biofuels, are expensive and only appropriate to larger-scale commercial farming operations.

WHAT IS A PALLET DRYER?

Aware of the need for a simple and efficient dryer for grains and other bulk-handled commodities, we wondered if we could develop a modification of the UC Davis chimney dryer, which has proved to be so successful for drying of fruits, vegetables, and even fish. The requirements that we felt should be met by such a dryer are that it needs to have relatively large capacity (100 kg minimum), provide protection from rain, birds, and rodents, be portable, inexpensive, and constructed, as much as possible, with locally-available materials and technologies. To meet these requirements, we designed the UC Davis Pallet Dryer, a solar-heated bin dryer.

The dryer comprises a layer of insulation on the ground, then a black substrate (plastic or fabric). At the center of one end are stacked two pallets (widely available in all but the poorest or most isolated communities). Over the pallets is placed a sheet of clear polyethylene that stretches to the edges of the black base sheet, and is held taut at the corners with elastic ropes attached to stakes. The clear plastic over the center pallet is cut out, so that heated air can flow through it from the solar collector. The pallets supports a bin containing the product to be dried. The bin is constructed from another pallet, and a sheet of plywood or similar material that is cut to make the sides and lid of the bin. The lid, sized to cover the bin, is fitted with a 60 watt solar panel and a 59 watt, 12V fan (rated at 300 cfm) that pulls air from the solar collector through the product being dried.

The dryer provides a low-cost but efficient solar dryer for use with grains, pulses, and other agricultural commodities that need to be furtheer dried after harvest and before storage. It is well suited to use with crops such as maize, peanuts, chick-peas, beans, and even specialty items like coffee and cacao.

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SECTION 1

HOW TO BUILD A PALLET DRYER

Steps to build a Pallet Dryer using low-cost, easily available materials

THREE MAIN COMPONENTS OF THE PALLET DRYER

The dryer design has two elements:

1. **Solar Collection Area**
2. **Box for Drying**
3. **Fan and Solar Panel**

INSTRUCTIONS

Although this is a relatively simple structure, working with an experienced builder is recommended. Alternatively, if you do not have access to a carpenter or skilled builder, the dryer can be built with a team of 2-3 people in about half a day,.

MATERIALS NEEDEDTO BUILDTHE PALLET DRYER

Item description	Label in figures	Number of pieces	Size (W x H x L)
Wood and Pallet for Box			(total: 56.09 m)
Wood for Box	A	2	1.25 m x 61cm x 1.27 cm
	B	2	1.0 m x 61 cm x 1.27 cm
	C	2	3 cm x 3 cm x 1.22 m
	D	2	3 cm x 3 cm x 1.16 m
	E	4	3 cm x 3 cm x 41.5 cm
	F	1	1.25m x 1.04 m x 1.27 cm
Pallet	G	1	1 m x 1.22m x .17m
Mesh or Hardware Cloth	H	1	1 m x 1.22 m
Support/Rising Stand Using 2 Pallets Stacked			
Pallets	I	2	1 m x 1.22m x .17m
Solar Panel and Fan			(total: 11.6 m)
Solar Panel 12V 30W	J	2	
Fan 12V 25W fan (75 m3/h, 45cfm at 2.5mm, 0.1 in.)	K	2	
Connecting Wire	L	2	
Solar Collection Area			
A sheet of clear polyethylene plastic		1	3 m x 4 m
A sheet of black plastic		1	3 m x 4 m
Insulation – dried grass or hay, rice hulls, peanut shells, or commercial insulation such as polystyrene board or even fiberglass batts		1	
Bungee Cords		4	
Stakes		4	

In this manual, all instructions are to build a Pallet Dryer on a standard pallet measuring 1 meter by 1.22 meters by .17 meters tall. Measurements need to be adjusted based on the size of the pallet or base user is utilizing.

PRIOR TO SETTING UP THE DRYER, PREPARE PALLETS AND BIN

1. Disassemble one pallet (Pallet A) to provide pieces for subsequent steps. You will have several boards of uniform thickness, and several thicker structural members.

2. For two pallets (Pallet B, Pallet C), cut short lengths of the reclaimed boards to fill the gaps between the pallet slats on the top side of one pallet and the bottom side of the other pallet. Pallet B with the filled slat gaps on the bottom will form the base of the bin, and Pallet C will be underneath the clear plastic. The photographs below show a pallet before (left) and after (right) modification.

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3.. Cut the hardware cloth slightly larger than the pallet and attach it to the unfilled side of Pallet B that will be used to make the bin, folding down the sides to ensure that it fits snugly and stapling or nailing it in place

4. Cut the sheet of plywood into five pieces, one 4' x 4', 4 four 1' x 4'. For a deeper bin more plywood is required. For example an additional sheet 4' x 4' would provide material for a 2' deep bin.

5. Construct the bin by screwing (and gluing) the plywood sides to the sides of Pallet B (cutting to ensure a good fit. Standard pallets are 40" by 48", so two of the sides will have to be trimmed to 43" (assuming the plywood is ½" thick). The bin should have the hardware cloth inside, and the filled edges underneath.

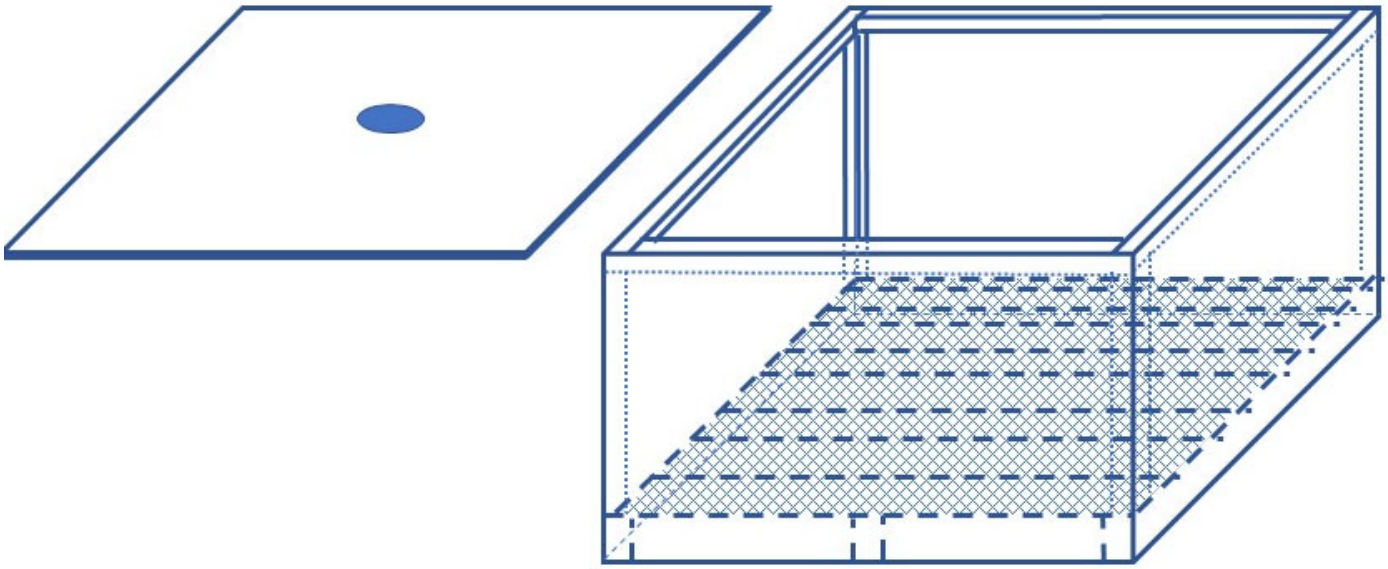
6. Reinforce the inside corners and top edge of the bin with lengths of 2"x2" lumber cut to fit. You could use the big pieces from the disassembled pallet (ripped to size) for this purpose too. Nail or screw and glue them in place.

7. Cut the lid to fit the top of the bin and cut an appropriate-sized hole in the middle of the lid so that you can attach the 12V fan.

8. Attach the solar panel to the bin lid. If there is a risk of theft, the panel can be connected with machine screws through its flange with the nuts on the inside of the bin-lid so that it cannot easily be removed.

9. Connect the solar panel to the fan with appropriate-sized wire nuts or other technique. If the fan does not operate when connected to the solar panel, reverse the wires.

10. If desired, attach hinges to one edge of the lid and a hasp to the opposite edge. The hinges and the matching component of the hasp will be attached to the bin to ensure that it closes tightly. A rope between the bin and the lid will prevent it from opening too far.

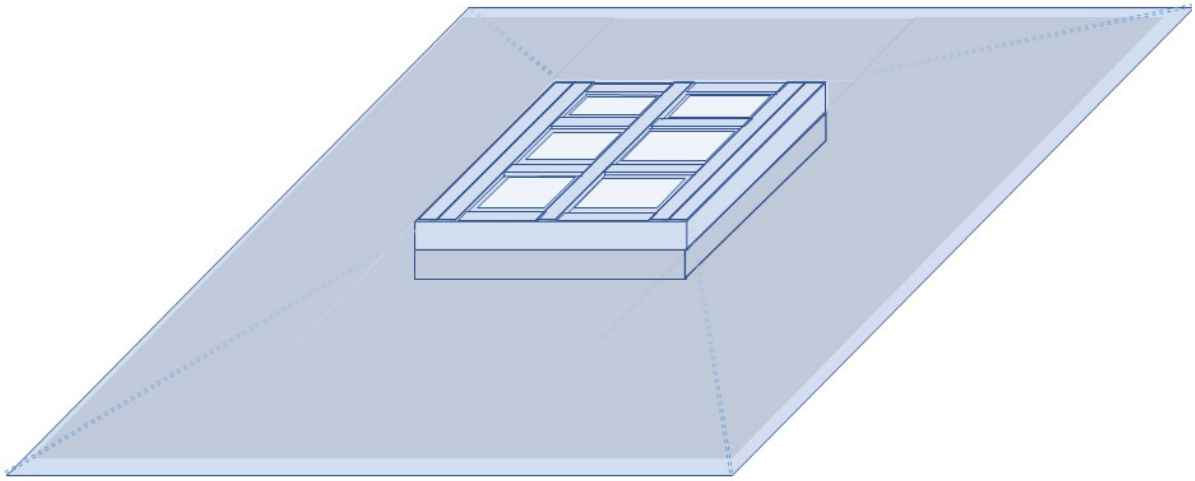


SETTING UP THE DRYER

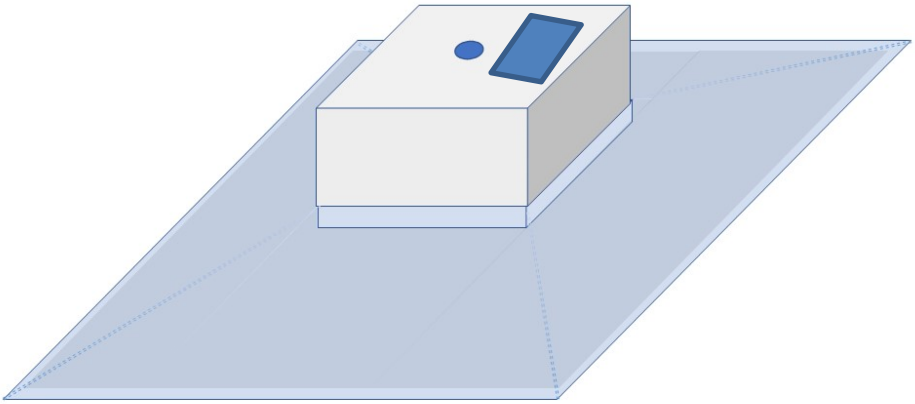
- Mark out a 12’ by 10’ rectangle in a suitable flat area, away from the shade of trees, buildings, etc…. If possible orient the rectangle North to South, with the long dimension running N-S.
- Place insulation on the marked rectangle. If using organic mulch – straw, grass, rice hulls, etc., provide at least 2” depth of material. If the ground is moist, place a sheet of plastic underneath organic insulation materials.
- Place the unmodified pallet in the middle of the 10’ edge of the black plastic, at the North end and 12” from the edge.
- Place the remaining modified pallet on top of the first pallet, with the modified edges up

- Lay the clear plastic on top of the black plastic.
- Fasten each corner of the clear plastic between two short battens made from the pallet boards, using nails or screws. Attach a screw-eye to the outside edge of the top batten on each corner.
- Stretch the clear plastic taut using bungee cords attached to the hook-eyes, and to the stakes.

- If not already present, cut large squares in the clear plastic over the modified pallet to allow warm air to flow up through the bin.



- Place the bin on top of the modified pallet, making sure that the edges align so that there is a good seal between the bin and the pallet.



USING THE DRYER

Place the product to be dried in the bin, and cover the bin with the lid. Ensure that the lid is tightly sealed to the bin. The hinge/hasp system is one method. Weather-stripping around the edge of the bin is another possibility. In early experiments we screwed the lid to the bin. Weights can also be used to press the lid tightly to the bin.

To ensure adequate air flow, place a brick, block of wood, or pipe under each of the three long edges of the clear plastic solar collector.

The dryer will continue to operate even in cloudy conditions. To protect the fan from rain, you can place a small "tent' over the fan. This can be made from a bent piece of sheet metal or from plywood boards nailed together. There should be enough space above the fan to allow air to escape freely.

To monitor progress of the drying, you can use a thermometer The temperature of the exit air will rise above ambient once the grain is close to dry. Another possible technique is to place a dry-card in front of the fan. Monitor RH by measuring the color of the

ADVERSE WEATHER CONDITIONS

The dryer works in cloudy to sunny conditions, and even occasional rain showers are not a problem. However, drying should not be attempted during periods of continuous rain or heavy clouds.

STORING DRIED PRODUCT

Properly dried commodities can be stored for several months to a year. Dried products should be stored in a cool, dry and dark area. After drying, the product should be allowed to cool a short time and then packed into dry, airtight containers or sealed plastic bags or hermetic storage. Do not be afraid to pack the dried product tightly together. Storing at cool temperatures increases storage life of dried products.

The best method for accurately determining safe product dryness for storage is to measure the relative humidity of the air in the dried product storage container. Mold will not grow when equilibrium relative humidity in the air around the sealed product is lower than 65 percent. One inexpensive method for measuring equilibrium relative humidity is to use a **DryCard™** indicator (more information at https://horticulture.ucdavis.edu/drycard).

ADDITIONAL RESOURCES

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