The University of St. Thomas, St. Paul, MN

January 2010 Mali Seed Potato Team Trip Report

Faculty Supervisor: Dr. Camille George

Senior Design Students:
Ryan Chapman, Brett Mernin, Milo Oien-Rochat, Nick Peterson, Nick Shannon

A comprehensive, experimental, analytical, numerical investigation of village-based seed potato storage in Borko, Mali

Itinerary and Meeting Notes
5-22 Jan 2010

Abstract

The Mali Agribusiness Center in conjunction with the University of St. Thomas assisted the village of Borko, Mali to establish a seed potato crop. Other crops this village currently raises (onions, garlic, and tobacco) are stored in the local, hot, and dry environment. Conversely, seed potatoes need to be stored in a cold, humid environment. The villagers in Borko needed a creative cooling method that was economically efficient for their new seed potato crop. To tackle this difficult problem, the project was divided into major categories including cooling, power generation, controls, and structural components. Within each sub-section of the project, brainstorming was conducted to unearth all possible solutions.

During January of 2010, three members of the University of St. Thomas team traveled to Borko, Mali to conduct interviews with the villagers to see how their preferences would align with possible solutions. Ultimately, an entirely passive cooling system was selected to minimize cost while maintaining minimum levels of cooling and humidity necessary for healthy seed potato storage. This evaporative cooler is unique in that it will utilize steel for structural integrity and steel mesh to maximize surface area for cooling. A water pump and several fans (if necessary) will be powered by a small array of solar panels and batteries. All materials needed for successful construction are available locally. As shown by the collected data, the design selected is as efficient as traditionally designed evaporative coolers while maximizing the surface area for cooling.

11 January 2010

Subject: Notes and Information gathered at Meeting at IER (Institute Economique Rurale)

Mme. Aissata Thera (IER), Professor Belco Tamboura (IPR/IFRA), and Adama Berthe (IPR/IFRA) originally supplied 3,000 seed potatoes (1,500 Sahel variety and 1,500 Clauster variety) to the village, which is about ¼ of a planted hectare. The villagers want to move up to 1 hectare and plant 12,000 seed potatoes in the future. Recently, Aissata went to Borko for four days to bring the potatoes and apparently their presence was a bit of a surprise to the mayor and the chief. The villagers chose 6 different farmers to be in charge of planting the 2 different types of seed potatoes, and took that group out into the field to teach them how to plant the seeds. Within 1 month of planting the seeds they received an update that the sprouts were taking hold in the ground.

Currently there is one cool place near one of the creeks where they store garlic and onions in trees for three months at a time, although the temperature and humidity of that location are unknown. They (Aissata, Belco, and Adama) have tried to get a Peace Corps volunteer into the village to help supervise some of the new things that were happening. This fell through because the village failed to provide some living conditions that the Peace Corps required for their volunteers, and they are still hoping to get someone into the village without having to sponsor anyone directly themselves. Aissata would be able to train a Peace Corps volunteer or any other volunteer for this position.

The Generation one seed potatoes will be coming out of the ground in March 2010towards the end of the dry season. Right now they are simply planning on storing the potatoes in fibrous bags, and Aissata said that someone may have to return in the spring to get the potato storage started. Aissata will need to be involved in any training that is done, whether it is with the volunteers or with the farmers. The key to an effective storage container for them is for it to be physically and economically sustainable with all pieces in place. It was mentioned that we need to consider all factors that will need to be in place for this to be a success.

Any wilt that is found in a seed potato field will render that whole field worthless, so there needs to be great isolation protection for healthy potatoes from any other potatoes or products in the village for these potatoes to be used for planting or consumption. Tomatoes and potatoes will share some common diseases, including bacterial wilt, so it is important to make sure that these diseases are not transmitted through shared water sources. Besides potatoes, garlic, onions, and cassava are the main crops in the village.

12 January 2010

Subject: Data Collection and Meeting at IPR/IFRA (National Agricultural University) where tubers are being developed and a storage container is already constructed.

Traveled in the morning to Katibougou where the university is located. We introduced ourselves to the director of IPR/IFRA and met with Adama Berthe. Adama is in charge of growing and creating the initial crop of 80,000 nuclear generation seed potatoes. He showed us his tissue culture lab in which he developed the tubers as well as the greenhouse where he plants them. He grew the tubers

in January and then placed them in pasteurized soil within the greenhouse. The seed potatoes are harvested, cut up and replanted. He checks the tubers every 2 weeks for any sign of rot or disease. He then showed us the storage facility which was recently constructed for seed potatoes. The facility was funded by the World Bank, and can hold 13 tons and cost 23,000.000 CFA or US$51,111 (exchange rate = 450 CFA/US$). The interior dimensions of the building are 7.8 m long 3.8 m wide and 2.3 m tall. The climate is controlled with 2 RivaCold Refrigeration units.

Refrigeration Unit (tag specifications inside unit) (2 Units for container):

RivaCold s.r.l.
Made in Montecchio (PV) Italy
Code RCV2450606ED
Drawing" 022200
PS: 25(18) Bar TS -10(-40)/100 Deg C
Lot No: 000353/ZL
CAT O. 97/23/CE
Gr. 2 refrigeration fluid

(tag specifications outside unit):

Volt/Ph/Hz 400/3/50
W 11625
Win 6067
W defrost 6600
Gas R404A
PS Hp 30 Bar
TS Hp -10/100 Deg C
Comp TAG4573ZR- T
HP 6.25
In(A) 15.4
PS(LP) 74(18) bar
TS(LP) -10(-40)/100 Deg C
S/N 09192345

RivaCold
Via Sicilia, 7-6 I 020 Montecchio(PV) Italy
Tel +39-0721-919911
La. Fax +39-0721-490015 www.rivacold.com
email: info@rivacold.com

The refrigeration units draw 2.4 amps at 220V AC when on full. It is controlled by an Aerostar thermostat and RivaCold Blocksystem control unit. There were four 18 inch interior fans which produced a wind velocity of 19.5 mph. The interior walls were at 4.5 °C and the exterior walls were at 37°C. The mini tuber potatoes measured 2 cm to 5 cm long, 2 cm to 3 cm wide, and 1 cm to 3 cm thick. Their mass averaged 16 g per potato and 12.5-15 cubic cm per potato. This results in a density of 1.067-1.28 g/ml.

After taking all the measurements, we had a quick meeting with Adama in his lab. He explained to us that they stored some seed potatoes inside last year at 11-12°C and they experienced 45% losses. They plan on going in and out of their new storage container approximately every 2 weeks for inspection, and there should be enough room between racks in the storage facility for a grown person to walk. If one tray of potatoes should start to get a disease, that entire tray should be removed from the storage facility. Inside of the facility, there should be some light so that the potatoes can been seen, but it should be diffused so that the potatoes store better. Other facilities have used layers of straw that can be wetted and will only allow certain amounts of sunlight through to the building. This model in Segou has produced 20% losses over 5 months for certain crops. A specialist to maintain this building will eventually be necessary, and Adama hopes that this person can be found in Bamako.

13 and 14 January 2010 not accounted for (travel to Mopti?) Mopti is 6 hours from Bamako

15 January 2010

In the morning, in Borko, we helped the Sociology students conduct their interviews by taking notes of the responses the farmers, leaders, and women gave to us.

After the interviews, Ryan took some solar radiation measurements. Dr. George says they are some of the highest readings she has seen in her career. They are listed in the table below:

Time	Direction	Reading (mV)	Value (Watts/m^2)
11:28 AM	Vertical	208	1040
	East	193	965
	West	167	835
3:00 PM	Vertical	110	550
	East	67	335
	West	214	1070
4:45 PM	Vertical	6	30
	East	4	20
	West	8	40

January 15 afternoon solar radiation readings at various times during the day at three different directions.

After lunch we met with the man in the village who is in charge of taking care of the diesel generator. This man has no formal training of any kind in regards to the generator. The generator is powered by a Mitsubishi S4Q2-61 SD engine and consumes 1-2 liters of diesel fuel per hour. He has changed the oil a total of 3 times with the last time being 5 months ago. He has never changed

the air or fuel filter. The generator has been there a total of three years. He also informed us of other important things in regards to the buildings. There is no one in the village who has any technical training to care for anything mechanical. All of the amenities within the buildings which were built 3 years previously worked at the beginning of construction. It all stopped working before the Germans left. This is mainly because the well which the water pump is hooked up to for the water tower has gone mostly dry. He estimates that it will cost 60,000 to 75,000 CFA per month for someone to care for a building.

The last thing we accomplished on this day was an interview with the farmers in Borko.

We asked them several questions with regard to our design. Here are the questions and answers:

1. Can you only build with mud bricks or are other materials used as well?

    A: Cement can be used, price varies. Mud is used because it is free. Stone is also used but costs 75 CFA or US$0.17 to have cut square.

2. Will outside help be needed for construction and how much will that cost?

    A: No, all villagers can help in the construction. One is a skilled construction worker the rest are unskilled. The skilled construction worker asks for 1,500 CFA or US$3.33 a day.

3. What is the final mass of the tubers?

    A: Mass unknown. Total amount expected to be 15,000 tubers.

4. Other options for storage?

    A: Possibly ship them to Bamako or Bandiagara

5. Ideas for storage?

    A: Did not understand that potatoes are not stored like garlic. Were confused about why the potatoes needed to be stored cold and humid instead of hot and dry like garlic or onions.

16 January 2010

We arose at 5 a.m. and travelled in the SUV to Mopti in order to drop off Aissata at the bus stop so she can go back to Bamako. We then sat down at about 9 a.m. with Adama for some coffee while we waited for the market to open. Adama stated on behalf of IPR/IFRA that they would be willing to take 40% losses (from tests at IPR/IFRA in 11-12 deg C) of the potatoes during the storage time if it meant a significantly smaller amount of electricity. A quick computation found that to buy solar panels in the West and ship them to Africa (enough for a refrigeration system) would cost around $8,000 for the parts alone. Adama also stated that we could start with a smaller prototype in the village just to get it working and see if our solution would give small losses without electricity. This will be done using only evaporative cooling and storing the potatoes in orange nylon bags

instead of a refrigeration system and the wooden trays like what is used at IPR/IFRA. After coffee, we searched the Mopti industrial market for available materials and costs. The results are as follows:

Item	Unit/Size	Cost (CFA)
PVC pipe	40 mm diam, 6 m long	3,000
Round steel tube	22 mm diam, 6 m long	2,000
Square steel	20 mm by 20 mm, 6 m long	2,000
Corner steel	30 mm, 6 m long	4,500
Steel mesh	1 m^2	3,500
Roll orange plastic hose	?	10,000
Yellow hose w/mesh reinforcement	?	28,000
Car battery ISO 9001	?	?
Sheet metal	6/10 mm, 2 m^2	6,500
Sheet metal	7/10 mm, 2 m^2	7,500
Sheet metal	8/10 mm, 2 m^2	8,250
Cement	50 kg bag	17,000
Exterior white paint	5 gal	27,000
Interior white paint	5 gal	18,000
Copper tubing	5/16 inch, 20 m	10,000
Halogen bulb and ballast		6,000
Plaster	20 kg bag	6,000
Electrical wire	1/5, 80 m	5,000
Electrical wire	2/5. 80 m	7,000
Electrical wire	4 mm, 80 m	17,000

Above found at AGF, Quincaillerie Generale, Ste Abdrahamane Guitteye et Freres, B.P. 54 Tel 4430047 Cell 5743978, Mopti. Another Number: 76266767

Foam mat	15 cm thick, 1.8 x 1.9 m	42,000
Foam mat	5 cm thick, 1.4 x 1.9 m	11,000

Above found at: Matelas Fofy En Vente lci

Rebar	12 mm, 12 m	5,000
Wood	50 cm wide, ? thick, 5 m	10,000
Wood	30 cm wide, ? thick, 5 m	10,000

Above found from various street vendors in Mopti.

On the drive home from Mopti we decided that it would be a good idea to construct a small zeer pot structure in the village for testing while on location. We constructed it before dark and its dimensions were approximately 1.0 m x l.0 m x 0.5 m tall. We wetted the entire structure and placed 2 wet burlap sacks on top. The testing log for the two days is as follows (temperatures are in Celsius):

Date	Time	Internal Temperature	Add Water?	Ambient Temp/RH	W/B Temp
1/16	5:30 PM	30.6	Yes	30.6/7.1%	12.1
1/16	8:00 PM	24.0	No	29.0/No Info	No Info
1/16	10:15 PM	22.2	Yes	27.0/8.3%	11.4
1/17	7:30 AM	20.3	Yes	28.3/8.3%	8.1
1/17	9:45 AM	19.0	No	No Info/No Info	No Info
1/17	12:00 PM	No Info	Yes	No Info/No Info	No Info
1/17	1:45 PM	20.6	No	34.1/2.6%	13.0
1/17	4:00 PM	22.9	No	33.9/2.2%	12.1

17 January 2010

The day began with a tour of the village with farmers and city leaders to see current storage techniques. Currently, certain crops such as garlic and onion are stored in small reed-woven mats in the branches of trees. This environment is described as follows:

RH: 6.4%
Temperature: 27.4 C
WB Temperature 10.8 C
Tree Temperature 25.0 C

We continued on to look at some of the natural springs in the area of the village that they use for irrigation and for laundry. The water temperature was between 28 and 30.5 C. The natural springs flow from east to west down the mountains and through the village, and the largest and closest spring is .75 km from the village. All 32 springs are currently being used for something for the village, and they have the same flow rates at all times of the year. The sand that they use for their mud bricks comes from a dry creek bed near the river. A silt test was conducted on the sand using a #200 sieve and it was found that the sand is 98% pure.

Also completed today was a second set of solar radiation readings. These are listed in the table below:

Time	Direction	Reading (mV)	Value (Watts /m^2)
7:20 AM	Vertical	8	40
	East	11	55
	West	5	25
9:45 AM	Vertical	129	645
	East	201	1,005
	West	49	245
12:15 PM	Vertical	200	1,000
	East	182	910
	West	121	605

January 17th morning solar radiation readings taken at various times at three different directions.

Note Higher readings of 232 mV were found throughout the day without taking official observations of such. This corresponds to a value of 1,160 Watts/m^2.

Today we began actually sketching and planning some retrofit designs. There are three major options: 1) A single large zeer pot design, 2) Several smaller zeer pots, 3) A zeer pot style hallway which pre treats the incoming air. All three of these designs will need some source of electricity. Most likely that will be solar panels that charge batteries with a diesel generator backup. Also, each design incorporates the existing water tower near the present structure. Other additional parts that would be needed are several fans for intake and exhaust of air as well as one or two water pumps to pull water from a stream to the water tower. The exact storage method is still undecided but we are thinking of having steel poles running across the room where farmers can come in and hang nylon bags of their potatoes on those poles.

Measurements were taken on the existing building which could be possibly retrofitted.

Subject: Measurements and specifications of stone building with room likely to be used for potato storage.

Room Length: 8.51 m Room Width: 4.40 m
Room Height: 2.75 m (to drop ceiling) Door: 46" x 86"
Walls: 13" Thick
Window: 57.5" x 45.5"
Attached Utility Room Length: 3.10 m
Attached Utility Room Length: 1.96 m

Available Air Conditioning Units:

Model No.: Sharp AU-A24FV (*Present in room)
Serial No. 6603163
Ext Fan Size: 18"
Voltage: 220-240 V
Frequency: 50 HZ
Phase: Single
Max Input: 3,400 W
Rated Input: 2,680-2,840 W
Rated Current: 13.2-13.7 A
Refrigerant: R22 (1320 g)
Operating Pressure:
    Hi: 2.6 Mpa
    Lo: 1.5 Mpa

Model No.: Sharp AU-A12FV (*2 Available)
Serial No. 6633008
Ext Fan Size: 14"
Voltage: 220-240 V
Frequency: 50 HZ

Phase: Single
Max Input: 1280 W
Rated Input: 1090-1120 W
Rated Current: 4.8-5.0 A
Refrigerant: R22 (920 g)
Operating Pressure:
Hi: 2.6 Mpa
Lo: 1.5 Mpa

Model No.: Sharp AU-A18FV (*2 Available)
Serial No. 6617751
Ext Fan Size: 18"
Voltage: 220-240 V
Frequency: 50 HZ
Phase: Single
Max Input: 2300 W
Rated Input: 2010-2150 W
Rated Current: 9.3-9.7 A
Refrigerant: R22 (920 g)
Operating Pressure:
Hi: 2.6 Mpa
Lo: 1.5 Mpa

18 January 2010

We left from Borko today. The first leg of the trip back to the major cities was from Borko to Djenne. Along the way we visited several cultural stops including the Mosque in Djenne. This included not only a bus trip, but crossing the Bani River in pirogue style boats. The second leg of the journey was from Djenne to San.

19 January 2010

Today we ventured from San to Segou, We ran into to bus troubles along the way. A tire blew out about half way between the two cities. That took about 2 hours for us to change the tire and then take the old blown out tire to a shop to be fixed. This was mainly a tourist day as we went to the market in Segou.

20 January 2010

Today was the only day for us to finalize our presentation. We removed the unnecessary items and added the information we collected from Borko. Tomorrow we have meetings scheduled with the Millennium Village Project at 10:00 AM and with the World Bank at 3:00 PM.

21 January 2010

We presented in the morning to the Jeffrey Sachs Foundation which represents the Millennium

Village Project.

Meeting notes:

(Editors note: documentation did not provide names, organizations, and contact information of persons attending this meeting)

The Millennium Center was created in 2006 with the help of Columbia University, with another Malian site in Timboctou, all working together to transform the conditions of farmers. They say that one of their missions is to take the best of innovation from universities and research and apply it to farmers in the field. Present at this meeting were 12 international experts from the fields of community development, community health workers, agribusiness, business enterprise, economics, education, and water and sanitation. Our professor, a part of CTI which identifies wasted food in the world and tries to do something about it, shared a bit about what is being done with the University of Saint Thomas Senior Design projects. We presented to them our problem, some of our ideas for a solution, and our technical model. It was received very well, but they are more interested in technologies which are proven and can be implemented immediately. The Millennium Project is looking for interns and students to come be a part of this movement and learn the business of it. In general, they are willing to take innovations and adapt them for the farmers they are working with.

In the afternoon we met with a representative from the World Bank

(Editor's note: names and organizations of persons attending this meeting and contact information was not documented).

He did not speak any English so everything had to be translated. Mme. Aissata Thera (IER) and Professor Belco Tamboura (IPR/IFRA) informed him of our trip to Borko and everyone from St. Thomas's role in the project. Aissata informed us that the storage span may be shortened below six months. We gave our presentation to the representative which was received very well. He is very interested in the project and is looking forward to seeing our final design in the spring. Professor Tamboura and/or Mme. Thera will present our final design to him in May. He also informed us that there are other sources of funding such as the PCDA and ICM in case the World Bank is not able to support it.

22 January 2010

Last day in Mali. Packed our bags and headed out of the hotel. We visited a museum and a zoo, ate dinner, then traveled for the airport.