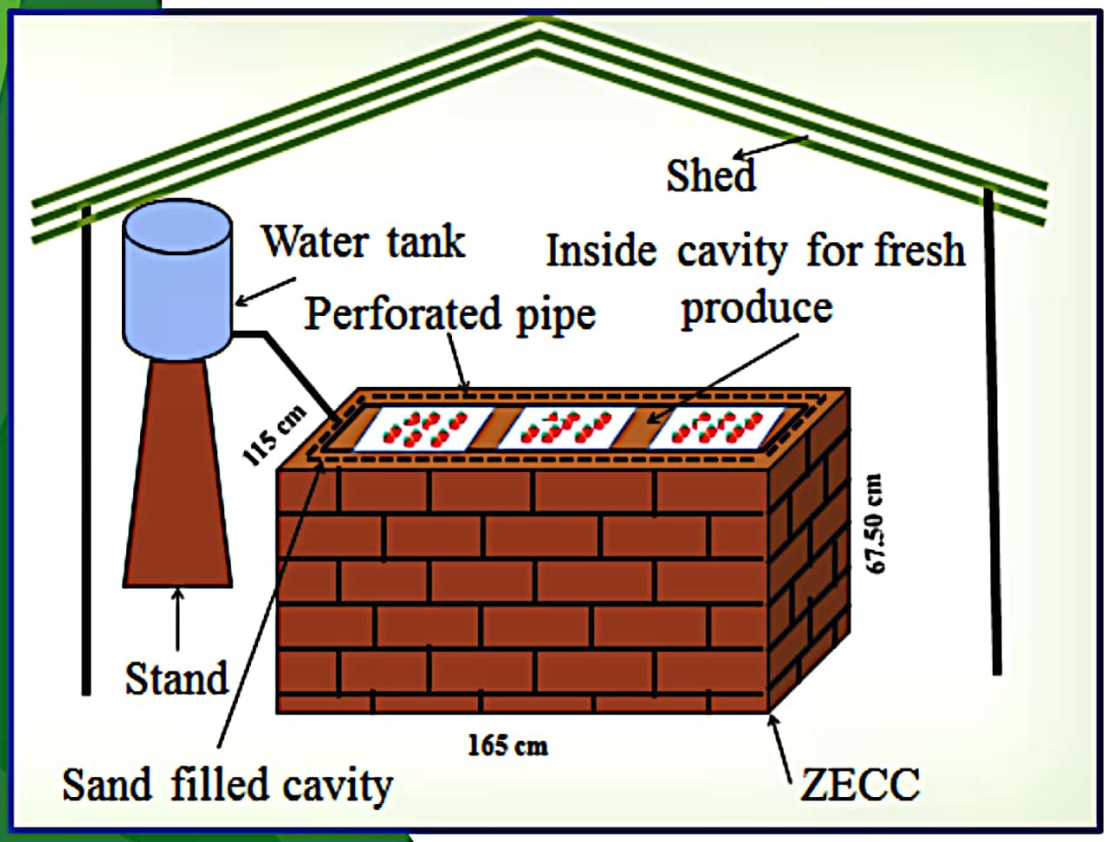
Pakistan Science Foundation
Natural Science Linkages Program

EVALUATING THE POTENTIAL OF ZERO ENERGY COOL CHAMBER (ZEEC) FOR HORTICULTURAL CROPS



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Introduction

Horticultural crops being rich in vitamins, minerals and nutrients are essential for human health and wellbeing. These crops are highly perishable in nature and quickly deteriorate after harvest due to inadequate postharvest handling practices and non-availability of storage facilities. In developing countries like Pakistan, postharvest losses are particularly high in case of summer fruits and vegetables, since temperature is the major determinant in the shelf-life of fresh produce. Refrigerated storage is the best option but is energy intensive, requires huge initial investment and is not easy to install. Moreover, existing energy crises in Pakistan limits the adoption of cold storage technology. Small land holdings and financial constraints of growers confine the use of high capital venture. In the absence of proper storage facility, the farmers usually sell their produce in local market soon after harvest.

Low cost ecofriendly Zero Energy Cool Chambers (ZECC) are currently being used in many countries including India, Japan, Tanzania and Ghana for on-farm storage of horticultural produce. However, this technology has not been introduced in Pakistan yet. Vehari is located in Southern Punjab where socioeconomic condition of farmer is poor and most of the farmers are vegetable growers. Moreover climate of Vehari is also hot and dry which results in more postharvest losses to the small scale growers who did not afford expensive cold storage facilities. To address these issues a low cost, ecofriendly ZECC is constructed at COMSATS University Islamabad, Vehari Campus by the funding of Pakistan Science Foundation, under Natural Science Linkges Program.

In ZECC, sand is filled between two brick walls, one nested inside of the other (as shown in the Figure 1). The sand is watered through a drip line connected to water cistern. The top cover of ZECC is made from gunny bag mounted on an iron frame. The whole structure is covered with the shed (made from metal or wood and straw) to prevent from sunlight, rain and storms. The ZECC, function on the principle of direct evaporative cooling, where heat is removed, as moisture evaporates from the sand. The evaporative cooling effect causes a decline in temperature and rise in the relative humidity inside the chamber, conditions that increase the shelf life of many fruits and vegetables. The rate of evaporation of water is highly dependent on the ambient humidity. When the ambient humidity is higher, there is a less significant reduction of the interior temperature.

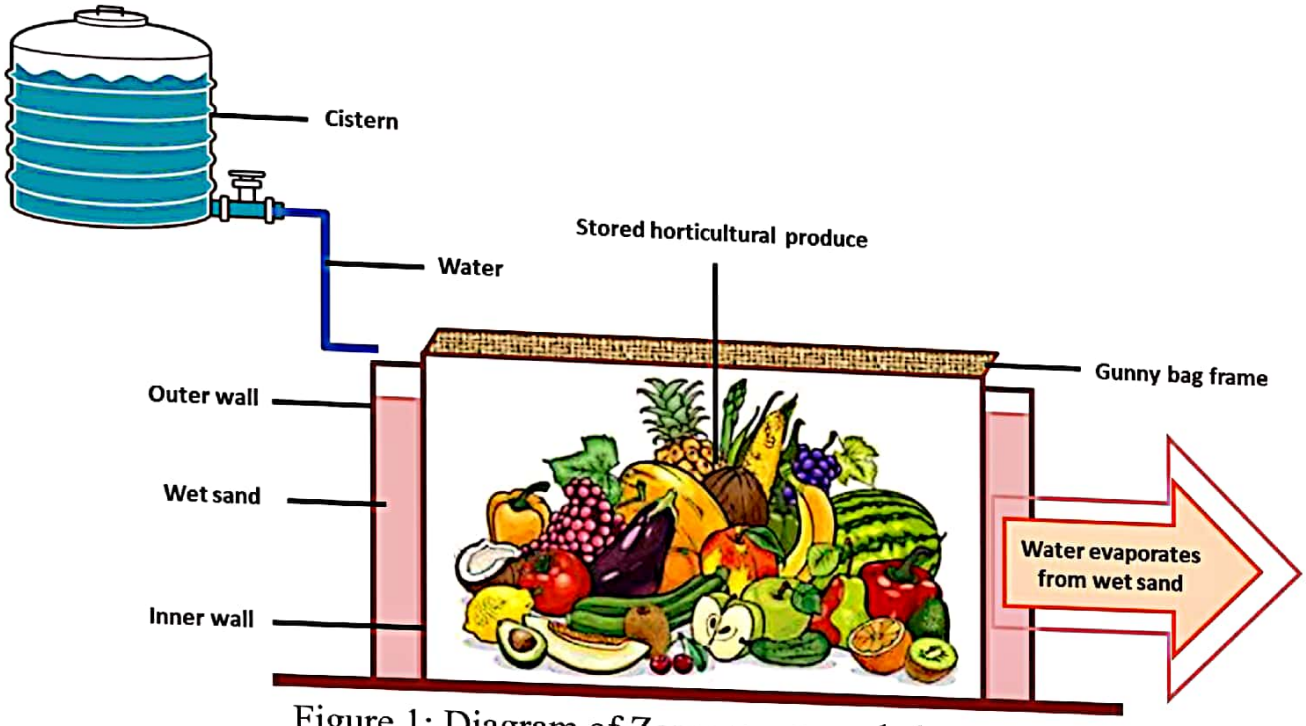

Figure 1: Diagram of Zero energy cool chamber

Objectives

- To design, fabricate and utilization of ZECC for short term storage of fruits and vegetables.
- To evaluate the storage behavior of horticultural crops inside zero energy cool chamber.
- To disseminate this technology to small farmers and retailers.

Socio-economic significance

- Beneficial for small scale farmers and retailers.
- Decrease postharvest losses and increase income of the growers.
- Low cost, environment friendly and energy efficient technology can be easily adopted by the small scale growers.
- In future ZECC can be used for demonstration purposes to reduce postharvest losses and can also be used for conducting research studies.

Expected out come

- Zero energy cool chamber will be helpful in improving/analyzing the shelf-life performance of fresh produce.

- Small farmers and retailers can easily construct zero energy cool chamber at very low cost in vicinity of their houses/shops or in fields to pre-cool and store their produce for few days before sale. In this way, they can avoid the clutches of the middlemen and will not be forced to make any distress sale.
- Adopting this technology will reduce postharvest losses and improve food security in the region.

Experimental results

Horticultural crops (fruit, vegetables and flowers) along with various postharvest treatments (packaging materials and chemical treatments), were kept in ZECC as well as at ambient conditions in laboratory. Shelf-life performance and physico-chemical quality was evaluated. ZECC was beneficial in reducing mass loss and maintaining overall fresh produce quality during storage for various durations.

Table 1:Interaction of storage conditions and treatment on mass loss (%) and shelf-life (days) of horticultural crops.

Storage conditions	Control	Polyethylene	Perforated Polyethylene
	Mass loss (%) and shelf-life (days)		
	Strawberry (*5% loss in mass is end of shelf-life*)		
ZECC	2.95b (*>3 days*)	0.68c (*>3 days*)	1.15c (*>3 days*)
Ambient conditions	15.26a (*< 2 days*)	1.79bc (*>3 days*)	2.32bc (*>3 days*)
	Bell pepper (*8% loss in mass is end of shelf-life*)		
ZECC	4.035b (*>12 days*)	0.54c (*>12 days*)	0.99c (*>12 days*)
Ambient conditions	11.05a (*< 7 days*)	1.05c (*>12 days*)	3.22b (*>12 days*)
	Orange (*5% loss in mass is end of shelf-life*)		
ZECC	4.69b (*18 days*)	0.48b (*>20 days*)	1.72b (*>20 days*)
Ambient conditions	20.03a (*<5 days*)	2.23b (*>20 days*)	15.27a (*>20 days*)
	Tomato (*4% loss in mass is end of shelf-life*)		
ZECC	4.96bc (*15 days*)	1.50c (*>18 days*)	0.89c (*>18 days*)
Ambient conditions	11.32a (*<10 days*)	6.52b (*<18 days*)	7.10ab (*<18 days*)

Table 2: Effect of storage conditions on mass loss (%) and shelf-life (days) of various crops

S. No.	Crop	Mass loss (%)		Shelf-life (Days)	
		ZECC	Ambient conditions	ZECC	Ambient conditions
1	Banana (5%)*	9.23	16.38	3	One
2	Strawberry (5%)*	1.6	6.4	>3	<2
3	Orange (5%)*	2.29	12.51	18	<5
4	Guava (5%)*	8.69	18.66	3	<3
5	Bell pepper (5%)*	4.03	11.05	12	4
6	Hot pepper (8%)*	21.75	52.75	One	<one
7	Cucumber (5%)*	1.92	10.86	>4	2
8	Tomato (4%)*	2.45	8.31	4	8
9	Potato (7%)*	4.23	8.79	40	20
10	Spinach (3%)*	5.0	20.2	One	<one
11	Turnip (5%)*	6.23	32.15	>7	3
12	Carrot (8%)*	10.19	37.58	12	6
13	Bitter gourd (5%)*	28.20	47.64	One	<one
14	Okra (5%)*	42.54	70.15	One	<one

* Man loss (%) for end of shelf life

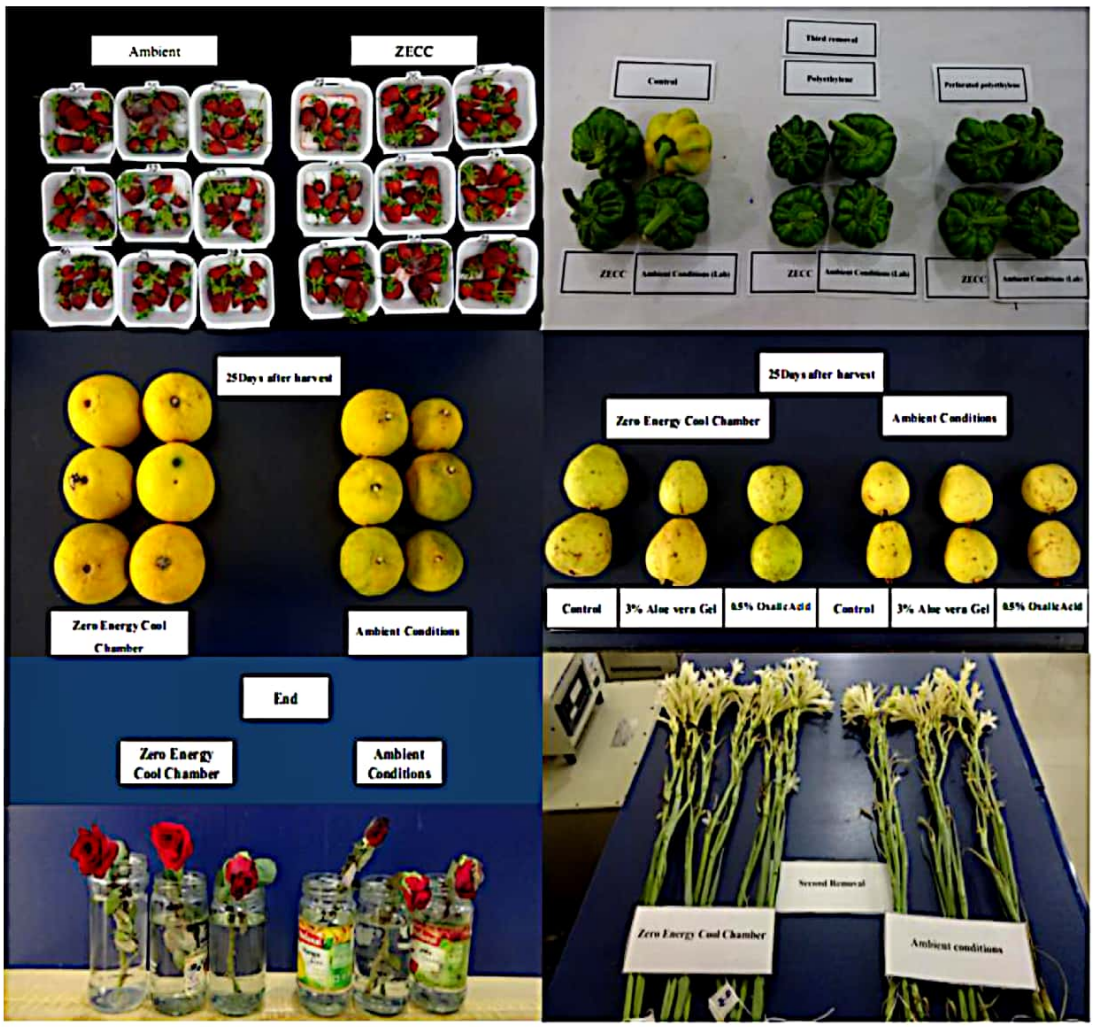

Figure 2: Pictures from experiments conducted during this project.

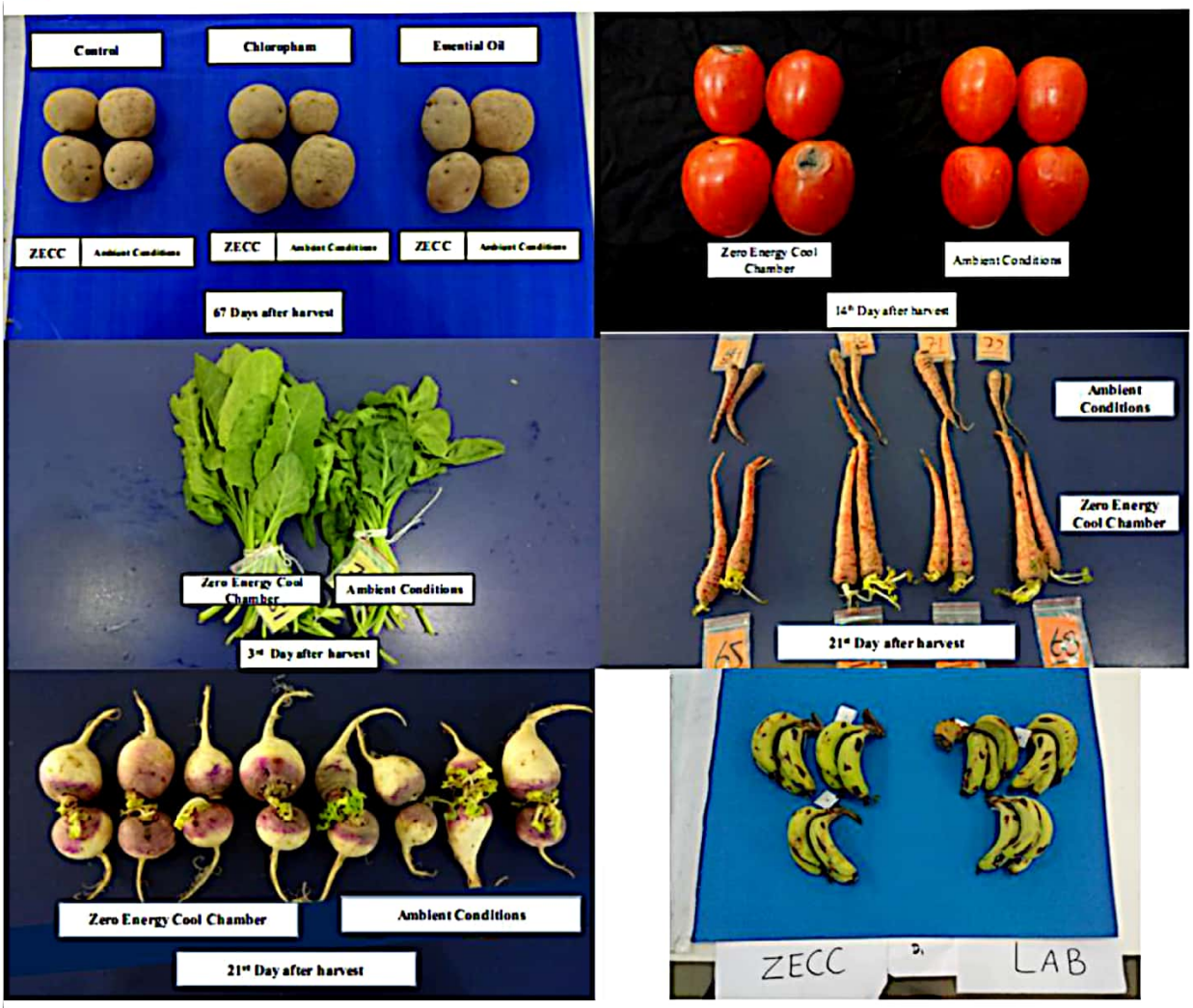

Figure 3:Pictures from experiments conducted during this project.

Construction of zero energy cool chamber (ZECC)

- Select leveled site, under shade and near water supply.
- Mark dimensions of ZECC with measuring tape or keep three empty crates and build wall around them having a distance of one brick or four finger of hand between crates and wall.
- Construct second wall again having a distance of one brick or four finger with the first wall.
- The height of the ZECC should be more than two staked crates.
- Fill the cavity between the two walls with wet sand.
- A frame of perforated plastic pipe is kept on the sand, connected with a water filled barrel kept on raised stand, to provide continuous supply of water to keep the sand moist.

- Covering of ZECC can be made from wooden/iron frame having mash/khaskhas/date palm leaves woven mat.
- Make a shed over the chamber to protect it from rain and sunlight.

Construction of zero energy cool chamber.

Advantages of ZECC

- Small farmers can construct it easily by locally available cheap material on their fields.
- It does not require electricity to operate.
- It maintains 4-5°C low temperature and 35-40% high relative humidity as compared to ambient conditions.
- It can be used for short term storage of fresh produce by reducing mass loss and improving shelf life.

Limitations of ZECC

- Disease incidence in ZECC is more as compared to ambient conditions during long term storage.
- ZECC is less functional during rainy season due to high humidity in atmosphere.

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