DSTE PROJECT REPORT

STUDIES ON OPTIMISING STORAGE CONDITIONS FOR VEGETABLES IN ZERO ENERGY COOL CHAMBER UNDER COASTAL CONDITIONS

PRINCIPAL INVESTIGATOR

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ACKNOWLEDGEMENT

The major factor limiting the cultivation of vegetables by marginal and small farmers is the perishable nature of vegetables which forces the farmers to sell the harvested produce immediately to whatever prices offered to them, ultimately resulting in reduced net profit to the growers. Establishment of a cold chain facility is though considered ideal to overcome this issue, it would take a long way to establish such a system in our country to the extent of benefitting even the small and marginal farmers scattered in areas which are far off and not well connected to the major markets. The problem is further made complex with prevailing energy crisis and energy cost.

Considering the present circumstances developing and popularising any storage technology which is cheaper and does not depend on non renewable energy sources and high technologies could largely benefit the small and marginal farmers in on farm storage of their produce for a shorter period so that they could accumulate their harvested produce over few days and take it to the market for getting a reasonable price.

Realising the importance to test and popularise such a technology to the farmers the **Department of Science, Technology and Environment (DSTE)**, Government of Puducherry had readily accepted the project proposal on "S**tudies on optimising storage conditions for vegetables in zero energy cool chamber under coastal conditions**" at PAJANCOA &RI and sanctioned a Grant in Aid of Rs.**50,000**/-. I owe my special gratitude to them.

I place on record my sincere thanks to **Dr. G. Mohamed Yassin**, Professor and Head, Department of Horticulture and the co-principal investigator of the project for his guidance and motivation in submission and execution of the project.

My thanks are also due to the **Dean** of this Institute, my department colleagues and all the other members of **staff** who have directly and indirectly contributed for the success of this project. I also extend my thanks to Mr. P. Rajkumar, the Post graduate scholar of this Department for his timely help.

PRINCIPAL INVESTIGATOR

Place: KARAIKAL
Date: 13.05.2014

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PROJECT REPORT ON

"STUDIES ON OPTIMISING STORAGE CONDITIONS FOR VEGETABLES IN ZERO ENERGY COOL CHAMBER UNDER COASTAL CONDITIONS"

FUNDED BY THE DSTE (GOVERNMENT OF PUDUCHERRY)

I. INTRODUCTION

India is the second largest producer of vegetables having 8.50 million ha under vegetable crops, with a production of 146.55 million tonnes. Potato, tomato, brinjal, bhendi, cabbage, cauliflower, peas, onion, tapioca and sweet potato are the major vegetables gown. Among the horticultural crops, vegetables begin to deteriorate immediately after harvest due to their high moisture content and lack of on farm storage further aggravates this problem. The **refrigerated storage of fruits and vegetables is considered to be the best** method of storage, but it is **capital and energy intensive**. Hence the present trend worldwide is to develop a suitable **low cost cooling system for storage of fruits and vegetables**. Refrigerated storage is not environment friendly too.

In order to overcome the problem of on farm storage, low cost **environment friendly** Pusa **Zero Energy Cool Chambers** have been developed. The importance of this low cost cooling technology lies on the fact that it **does not require any electricity or power** to operate and all the materials required to construct the cool chamber are available **easily at cheaper cost**. Even an unskilled person can install it at any site, as it does not involve any specialised skill. Most of the raw materials used in cool chamber are also reusable.

The zero energy cool chamber works on the **principle** of **evaporative cooling – a gift of nature**, which happens when air, which is not already saturated with water vapour passes over a wet surface. Water evaporates into air raising its humidity and the same time cooling the bed. Pusa Zero energy cool chamber can retain the freshness of the fruits and vegetables for a short period. **Small farmers can easily construct these chambers near their houses or fields** to store their harvested produce. In this way, the **farmers can store their produce for few days and send the bulk of the commodity to the whole sale market** so that they will not be forced to make any distress sale in the local market because in India 90 per cent of horticultural produce is sold in fresh form. The involvement of middle men in making this distress sale increases the price of horticultural produces by 60-100 per cent in retail outlets compared to the growing areas.

The strategy of on farm storage of vegetables harvested daily in small quantities over few days and sending them to distant markets without solely depending on the local market can definitely augment the income of the farmers. The cool chamber can reduce the temperature by few degrees and maintain a high relative humidity compared to ambience, thereby helping in enhancing the freshness of the produce. Keeping this in view the present proposal was submitted to test the efficacy of the Zero Energy Cool Chamber under coastal condition of Karaikal so that the same could be advantageously taken to the farmers for adoption.

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II. OBJECTIVES

The Zero Energy Cool Chamber was developed by Dr. S.K. Roy during 1980's at the Indian Agricultural Research Institute, Pusa, New Delhi and has been field tested and redesigned over the past few years to improve its function. Though this technology of on farm storage of fruits and vegetables for shorter periods had been developed long back, the efforts to **popularise this technology** world over is snowballing only in the recent past amidst increasing environmental concern and rising cost of power. This is almost similar to earthen pots widely used to chill water. Transfer of heat due to evaporation of water from the surface of the cooling vessel ultimately leads to cooling the atmosphere within the vessel. The water contained in the sand between the two brick walls evaporates towards the outer surface of the outer wall, where the drier outside air is circulating. By virtue of the laws of thermodynamics, the evaporation process ***automatically causes a drop in temperature of several degrees, cooling the inner container and preserving the vegetables inside***.

Keeping this in view the proposal was submitted with the following objectives.

- To establish zero energy cool chambers at this Institute to serve as a model cum demonstration unit for the students and the farmers.
- To study the storability of various vegetables under zero energy cool chamber.
- Dissemination of this on farm storage technology based on the experimental results to vegetable growers of the region aiding them to avoid distress sale of vegetables in the local markets and to get a reasonable price for their produce.

III. BUDGET ALOTTED

Rs.**50, 000**/- Grant in Aid

IV. PROJECT DURATION

One Year (2013-14)

V. METHODOLOGY ADOPTED

V.1. SITE SELECTION

The construction of Zero Energy Cool Chamber (ZECC) requires an area free of water stagnation at any time and hence an elevated area which is free from such water stagnation was identified near the Horticulture Department in the Eastern Block of the Institute and was utilised for construction of the chamber after necessary cleaning.

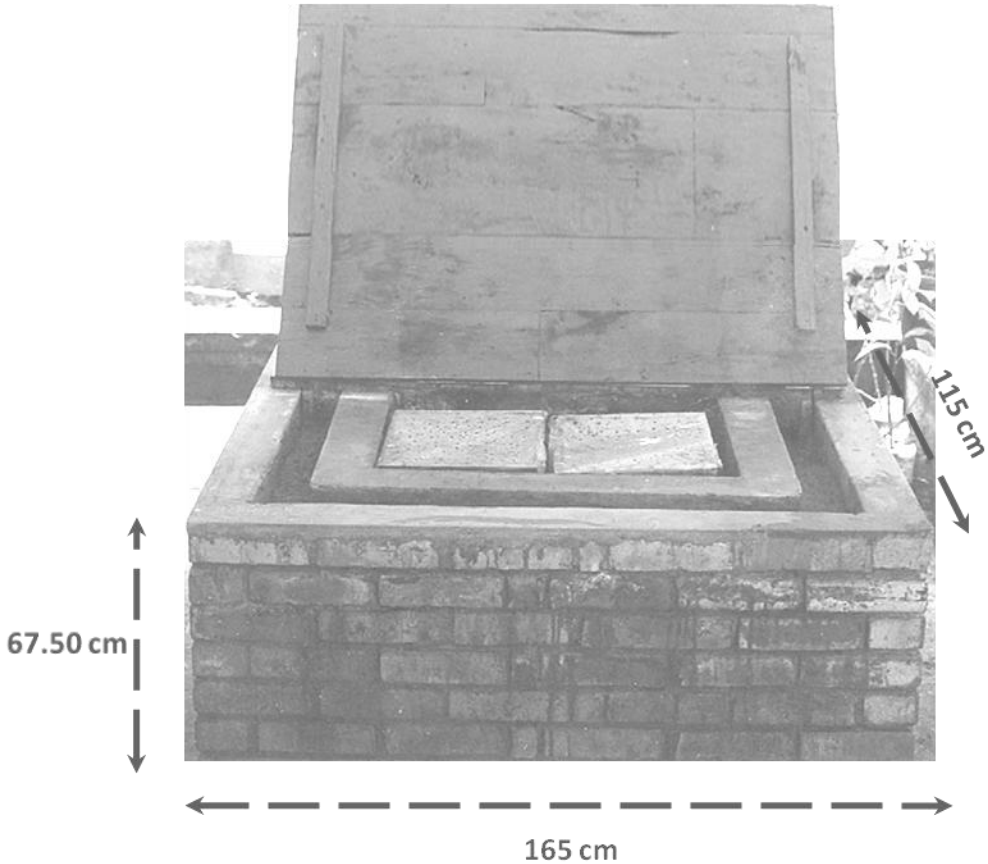
V.2. NUMBER OF CHAMBERS

3 ZECC of measurement 165 cm x 115 cm x 67.50 cm were constructed and utilised for the experiment.

V.3. MATERIALS AND METHODS

- ✓ Floor of the chamber was made with the help of bricks of size 165 cm x 115 cm.
- ✓ A double brick wall structure on the floor to a height of 67.5 cm leaving a space of 7.5 cm in between the two layers was constructed.
- ✓ The space in-between the two walls of the structure was filled with fine sand
- ✓ A protective cover for the inner chamber was made with wooden frame and GI netting and a latch was also provided to the lid.

- ✓ A thatch shed over the chamber was erected to protect it from direct sun or rain and the protective netted cover over the top was also covered with plaited coconut leaf to increase humidity inside the chamber during storage.



After construction of the chamber the following procedures were adopted.

- ❖ The walls of the chamber was made wet and the sand in between the double wall was saturated with water.
- ❖ Fresh vegetables to be stored were weighed and taken in perforated plastic crates, placed inside the chamber
- ❖ The chamber was closed and the netted cover was again protected by placing plaited coconut leaf
- ❖ The walls of the chamber as well as the sand filled in the gap of the double wall structure were watered twice daily to maintain high relative humidity inside the chamber

- The experiment on storability of vegetables in zero energy cool chamber was taken up during the month of March as its efficiency would be high when there is high temperature with low relative humidity outside.
- Vegetables *viz*., bhendi, brinjal, lab lab (garden bean), bitter gourd and radish were used for the study.
- The vegetables of known weight were taken in **plastic crates** and were placed inside the chamber after saturating the sand with water. The chamber was closed and a sheet of plaited coconut leaf was placed over the netted protective cover of the chamber to maintain the relative humidity. The temperature and relative humidity inside the chamber was monitored periodically using a hand held portable RH / Temperature meter. Simultaneously a control sample in each of the vegetables were also maintained in ambience to compare the effectiveness of ZECC.

V.4. OBSERVATIONS RECORDED

- The physiological loss in weight of the produce under storage was measured on daily basis
- The weight of rotten and unmarketable vegetables either due to development of fiber or pithiness were also measured during storage on daily basis
- The temperature and the relative humidity inside the chamber and its deviation from ambience were recorded at periodical interval on the days of storage using a hand held portable RH / Temperature meter

VI. BUDGET UTILISATION

VI. 1. QUARTER WISE FUND UTILISATION

I quarter	- **Nil**
II quarter	**- Rs. 13,929**
III quarter	**- Rs. 11,645**
IV quarter	**- Rs. 24,426**

VI.2. PATTERN OF UTILISATION

S.No.	Particulars of Expenditure	Amount	
		Rs.	P.
1	Purchase of materials for construction of the chamber (3 No.)	9150	00
2	Labour for construction work	4500	00
3	Purchase of materials for providing protective cover	2997	00
4	Labour for providing protective cover	1200	00
5	Cost of material for providing thatch shed	5500	00
6	Labour for providing thatch shed	2000	00
7	Purchase of plastic crates	7200	00
8	Purchase of materials for providing water supply to the chamber	3060	00
9	Purchase of vegetables for conducting the experiment	3746	00
10	Purchase of stationeries and preparation of report	4230	00
11	Institutional charges paid to the Institute	3750	00
12	Miscellaneous	2667	00
	Total	**50,000**	**00**

VII. EXPERIMENTAL RESULTS

The loss in weight of the stored vegetables (PLW) is an indication of moisture loss from the produce which render the vegetables unmarketable as they lose the lusture and crispiness. The moisture loss from horticultural produce is not a mere loss of weight rather it is a loss of appearance, taste and even nutrients from the produce which ultimately results in economic loss of the produce. So, any storage method for perishables like vegetables should aim at minimising the moisture loss and respiration from the produce so as to enhance their keeping quality and marketability. This would be possible by reducing the storage temperature and the relative humidity of air surrounding the produce in the storage atmosphere. The salient findings of the study are presented here.

1. A temperature difference of 3^{o} C to 9^{o} C and an increase in RH by 10 to 18 per cent in side the ZECC was recorded at various periods. A maximum of 9^{o} C reduction in

temperature and an increase in RH of about 18 per cent in comparison to ambience could be achieved inside the chamber at 2.00 pm (Table 3).

2. The PLW recorded for bhendi inside the Zero Energy Cool Chamber (ZECC) after 7 days of storage was only 15.28 per cent as against 35.12 per cent recorded in control (open room storage). Considering the PLW (4.39 per cent) and proportion of over matured (fiber rich) unmarketable fruits (6.73 per cent) together bhendi could be well stored in the ZECC for 3 days (Table 1 and Table 2).
3. The PLW observed for brinjal stored in ZECC was only 10.13 per cent even at the end of 7 days of storage, while it was 17.75 per cent in control (Table 1). Considering the PLW (8.09 per cent) and rotten / unmarketable fruits (5.32 per cent) together it could be concluded that brinjal has a storability of 5 days in ZECC.
4. In case of bitter gourd the PLW was only about 9.57 per cent even after a storage period of 5 days and considering the weight loss together with loss of produce due to rotting (8.57 per cent) it could be stored for a period of 5 days under ZECC.
5. The garden bean was found to have a storability of 3 days in ZECC (PLW of 9.21 per cent and 8.37 per cent of unmarketable pod) whereas radish could be well stored for a week with a PLW of around 11 per cent without the loss of freshness.

VII. CONCLUSION

One of the major constraints faced by marginal and small farmers engaged in cultivation of vegetables is the perishability of the produce which force them to sell the produce to whatever prices offered in the nearby market point. Taking the produce to a distant market is not feasible owing to the small quantity of sundry vegetables being harvested every day. On the other hand the consumers are also paying a high price for a poor quality produce as there is no cold chain market facilities established in all the places.

Considering the above constraints, the farmers growing multiple vegetables each on a smaller area should have some alternate technologies for storing their produce at least for a shorter period so that the everyday harvest could be accumulated and taking a bigger volume of the produce once in few days to the market becomes an economically viable option for the grower and the consumer is also benefited by the supply of fresh and nutritious vegetables.

Table 1. Physiological loss in weight (per cent) of vegetables in storage

CROP	DAY 1		DAY 2		DAY 3		DAY 4		DAY 5		DAY 6		DAY 7	
	INSIDE ZECC	AMBIENCE	INSIDE ZECC	AMBIENCE	INSIDE ZECC	AMBIENCE	INSIDE ZECC	AMBIENCE	INSIDE ZECC	AMBIENCE	INSIDE ZECC	AMBIENCE	INSIDE ZECC	AMBIENCE
Bhendi	1.11	1.11	2.37	3.88	4.39	7.14	6.24	17.34	7.54	19.97	10.23	27.10	15.28	35.12
Brinjal	2.39	3.00	3.13	5.90	4.51	8.46	6.27	10.85	8.09	12.97	9.42	15.12	10.13	17.75
Bitter gourd	2.41	4.14	3.53	6.19	3.94	10.11	6.46	15.41	9.57	16.42	12.77	27.12	14.12	32.05
Lab lab	4.64	6.04	6.85	11.94	9.21	18.42	15.24	24.88	25.99	42.79	-	-	-	-
Radish	1.29	3.10	3.38	5.38	4.42	7.49	5.30	9.59	7.00	13.09	9.03	18.54	11.82	21.41

Table 2. Percentage of rotten / unmarketable vegetables in storage

CROP	DAY 1		DAY 2		DAY 3		DAY 4		DAY 5		DAY 6		DAY 7	
	INSIDE ZECC	AMBIENCE	INSIDE ZECC	AMBIENCE	INSIDE ZECC	AMBIENCE	INSIDE ZECC	AMBIENCE	INSIDE ZECC	AMBIENCE	INSIDE ZECC	AMBIENCE	INSIDE ZECC	AMBIENCE
Bhendi	-	-	4.00	10.35	6.73	12.20	2.80	7.25	27.63	32.15	36.99	19.71	49.32	22.35
Brinjal	-	-	-	-	1.58	4.99	3.43	8.23	5.31	12.01	6.89	14.13	14.57	27.80
Bitter gourd	2.41	6.36	2.17	7.27	3.94	10.25	4.97	11.46	8.57	15.95	10.19	20.98	15.12	24.15
Lab lab	2.13	9.02	5.38	13.39	8.37	18.83	11.80	27.05	15.16	29.52	-	-	-	-
Radish	-	-	-	-	-	-	-	-	9.79	16.54	11.52	19.25	11.77	19.25

Table 3. Comparison of temperature and relative humidity observed during the experimental period

S.No.	TIME	AMBIENCE			INSIDE THE CHAMBER		
		RH (%)	TEMPERATURE		RH (%)	TEMPERATURE	
			^oC	^oF		^oC	^oF
1	10.00 am	75.20	29.90	84.10	88.20	26.60	80.30
2	12.00 noon	70.10	33.40	89.90	86.60	27.30	82.10
3	**2.00 pm**	**65.50**	**36.20**	**98.50**	**83.60**	**27.10**	**81.70**
4	4.00 pm	74.30	35.10	96.70	89.30	27.50	81.40

(Recorded on 08.03.2014 using portable Humidity / Temperature meter model HT 3004)

The ZECC developed at IARI is a no energy requiring low temperature storage structure which could help in keeping most of the tropical vegetables afresh by few days after harvest. In the present study the bulk of the vegetables were taken in plastic crates and were placed inside the ZECC and the study revealed that the vegetables *viz*., Bhendi and lab lab (garden bean) could be stored for 3 days, brinjal and bitter gourd for five days and radish for 7 days with minimum loss of weight, appearance and loss of produce during storage.

The added advantage of the structure is that it is environmentally friendly and even the farmers themselves could construct it with locally available recyclable materials. Thus the ZERO ENERGY COOL CHAMBER could serve as a viable and feasible on farm storage structure for storing perishables by farmers without any recurring expenditure on energy source as it works on the basis of evapourative cooling. This could be a solution for the vegetable growers of this region especially during periods of dry weather with high temperature and low relative humidity in the atmosphere.

1. CONSTRUCTION OF ZERO ENERGY COOL CHAMBER

SELECTION OF RAISED AREA

BASEMENT AND FLOORING

DOUBLE WALL CONSTRUCTION

FIT TO KEEP CRATES

COMPLETED STRUCTURE

PROTECTIVE LID PROVISION

2. PREPARING ZERO ENERGY COOL CHAMBER FOR STORAGE

ZECC READY FOR STORAGE

FILLING SAND IN THE INTERSPACE

THATCH SHED FOR SHADE

PROTECTIVE NET COVER AND LATCH

COVERING WITH PLAITED LEAF

SATURATING FILLED SAND

3. STORAGE STUDIES ON VEGETABLES

STORAGE STUDY WITH BHENDI

ESTIMATING PLW IN STORAGE

RH MEASUREMENT INSIDE THE CHAMBER

LAB LAB IN STORAGE

RADISH, BITTER GOURD AND BRINJAL IN ZECC