

Experimental Investigations on Custom-made Porous Clay Capsule Assembly as Water Saving Technology for Small-Scale Farming

Neelkanth J. Bhatt ¹, Rajendra Gatesaniya ² and Baldev Kanzariya ³

¹Department of Civil Engineering, Government Engineering College, Rajkot, Gujarat, India.

²Department of Civil Engineering, C.U. Shah College of Engineering and Technology, Wadhwan, Gujarat, India.

³Applied Mechanics Department, Lukhdhirji Engineering College, Morbi, Gujarat, India

Abstract — In the vast rural areas agriculture with its allied sectors is the largest livelihood provider in India. It is also a major contributor to the Gross Domestic Product (GDP) of India. Sustainable technologies are essential for holistic rural agricultural development. Almost 60 percent of the rural farmers in India are characteristically cultivators of small plots, cultivating land less than 1.0 hectare in size and are facing severe constraints of too little access to advanced technologies and productive farming technologies. Irrigation sector being the largest consumer of water resources, with the ever-increasing demand for food and fibers the selection and adoption of appropriate irrigation technologies by the small and marginal farmers for greater sustainable production and better resource utilization cannot be overlooked. In this context, the present study aimed at examining the applicability of 'custom-made porous capsule assembly' (CPCA) as potential small-scale water-saving irrigation technique. On-farm experimentation on the plants of Green Peas and Tomatoes at a farm located at village Jeeva near Dhrangadhara City of Surendranagar District of Gujarat were carried out by fabricating a 'custom-made porous capsule assembly' (CPCA), which was capable of storing up to 8.50 liters of water for studying its various aspects for comparison with the farmers' regular practice of hand watering the basins. The results revealed that when compared to basin method of irrigation by farmers' regular practice of hand watering 55.95 % of water saving was possible with CPCA. Whereas the increase in yield of Green Peas with CPCA was 35.90 % and that for Tomatoes under CPCA was also 8.53 %. The Benefit-Cost ratio for the CPCA was found to be 1.38. The CPCA is quite eco-friendly and if the capsules can be manufactured in large quantity the cost of CPCA can be reduced considerably and higher benefits can be attained. The water saving when tied with the improved yield makes the CPCA highly profitable for the farmers who are facing the problems of water shortages and for those trying to eke a living out of their small land-holdings. The simplicity and the manageability of CPCA can immensely add to an enabling environment for farmer adoption. The proposed method has the potential to contribute to poverty alleviation among the small farmers and can serve as an effective tool for affordable small-scale irrigated agriculture.

Keywords- Localized Irrigation, Porous Clay Capsules, Small-Scale Farming, Water Saving, Yield Improvement.

I. INTRODUCTION

Globally, almost 70 percent of fresh water is exploited by irrigation for growing crops. Since climate change is projected to redirect or wipe out many water sources, agriculture itself will become much more intricate for many vulnerable countries [1]. Nearly 60 percent of the rural farmers in India are typically cultivators of small plots, cultivating land less than 1 hectare in size and are experiencing stern constraints of inadequate access to advanced technologies and productive farming technologies. Consequently, low-cost systems that are technically less puzzling and uncomplicated should be designed to suit the small and medium farmers who represent a very large number of farmers in India [2]. There are a wide array of methods for Small-Scale Irrigation ranging from totally indigenous methods to methods that use imported material that is locally fabricated to suit respective requirements. As a consequence of the unrelenting increase in population and the variation in the geographic availability of water the best water management practices with location-specific technology are now inevitable for sustainable rural and agricultural development. A modernized 'old' system can be taken up more unpretentiously by farmers given that it is much closer to traditional practices [3].

Across the world, depleting water table and rise in salinity owing to the indiscriminate use of chemical fertilizers and pesticides have made water conservation imperative for farmers. Over the years, numerous water harvesting and conservation methods have been adopted in agriculture to recharge and conserve groundwater. It is also evident from the policy of Government of India that there is a need for the introduction of water-saving techniques for agriculture sector for bringing more and more area under irrigation in the country and to economize the use of water and increase the productivity per drop.

Each and every irrigation method has got its own merits, demerits, and limitations. Depending upon water availability, cropping pattern, water quality, soil types, topography, climate and socio-economic status of the farmers the irrigation practices are different from region to region. The farmers must, therefore, try to choose such method that is most close to their tradition and most importantly suiting the local physical conditions.

Though globally the thrust is always on reducing dependency on labour for agricultural activities, for countries such as India where labour force is ample, the emphasis ought to be on complete utilization of these labours. Moreover, Cornia, 1985 [4] has also recommended promotion of more labour-intensive techniques as a policy intervention tool for

the achievement of joint targets of increasing food output, yields and labour absorption in the agriculture sector.

According to Cornia, 1985 [4] 'water fertilizer-labour-intensive' technology has been followed in the East-Asian agriculture; its results in terms of land yields and employment have been very satisfactory. Furthermore, the author has also noted that if rural employment programs are to be successful as anti-poverty devices and as stimuli to agricultural growth, they should focus on the creation of durable assets the benefit of which should accrue to those who have actually built them.

In Gujarat, about 88 percent of the total available water resources are being used for irrigation [5] and the available quantity of water per head is quite low when compared to international standards and for this reason irrigation sector which is the largest consumer of water shall have to be made more efficient.

In this context, by this study, it was desired to examine the applicability of 'custom-made porous capsule assembly' (CPCA) as potential small-scale water-saving irrigation technique. On-farm experimentation was undertaken by fabricating a 'custom-made porous capsule assembly' (CPCA), which was capable of storing up to 8.50 liters of water for studying its various aspects for comparison with the farmers' regular practice of hand watering. On-farm experimentation was carried out by employing irrigation through CPCA on the plants of Green Peas and Tomatoes at a farm located at village Jeeva near Dhrangadhara City of Surendranagar District of Gujarat. The experimental farm is approximately 25 Kms. from the Dhrangadhara city of Surendranagar district of Gujarat.

II. STUDY AREA

2.1. Location :

Surendranagar district is situated between 22.00° to 23.04° North Latitude and 69.45° to 72.15° East Longitude which is the central region of Gujarat, in the Saurashtra peninsula. The maximum temperature is 45.6° centigrade and the minimum temperature is 7.8° centigrade. The average rainfall in the district is 760 mm. The geographical area of the district is 10,489 Sq. Km. The district comprises of 10 talukas. The district is also one of the largest producers of 'Shankar' cotton in the world and is the home to the first cotton trading exchange in India [6].

2.2. Current Agricultural Practices :

In Surendranagar district out of 702044 hectares of cultivated land, only 17.62% happens to be irrigated land. The most important source of irrigation is Tube well/ Borewell.

Groundnut, Bajara, Cotton, Sesame, Castor, and Pulse are 6 main Kharif Crops grown over an area of 617248 Ha. Cotton is the main crop covering 66.31 % of the area under Kharif crop Wheat (Irrigated & Un-irrigated), Cumin and Funnel are 3 main Rabi crops grown over an area of 132312 Ha.

Main horticulture crops in Surendranagar district are spices (mainly cumin), vegetable and fruits (mainly papaya and mangoes). Spices are grown over an area of 65680 Ha, followed by vegetables with an area of 9153 Ha and fruits being grown over an area of 3450 Ha.

2.3. Soil :

The pH of the soil in Surendranagar District is neutral. The electrical conductivity too of the soil is quite low. Besides, the organic carbon, nitrogen and phosphorus content of the soil is also diminutive. Moreover, potash content in soil is high. As a result, on the whole, the soil fertility indices are not good from the point of view of agriculture [7].

III. METHODOLOGY

Porous clay capsules were used with a plastic bucket to fabricate CPCA. One clay capsule inside and the other outside the bucket was connected with a plastic tube with a threaded steel socket. Fig. 1 shows the CPCA assembly. Table 1 shows the details of the Porous clay capsules used for the present experimentation.



Fig. 1 Custom-made Porous Capsule Assembly

Table 1 Details of Porous Clay Capsule used for CPCA

Parameters	Dimensions
Inside Diameter (cm)	3.0
Outside Diameter (cm)	5.0
Length of Capsule (cm)	17.50
Porosity (%)	59.80

The hollow porous clay capsule that was used for the assembly of CPCA was made of 'Than-Clay' - a nearby place which has world famous clay that is most commonly used by the ceramic and pottery industries of the state. Sawdust and coal were used to prepare the mixture and then using a hydraulic ram the porous clay lump was squeezed to size and allowed to dry for 3 days before it was fired in a kiln.

The CPCA was then installed on the farm by digging 25 cm deep holes which housed the lower outer clay capsule fully into the soil. The earth was then leveled by filling the hole with the soil and was made ready for the sowing of seeds by applying a little water and organic manure to the soil. Seeds of Green Peas (*Pisum Sativum*) were then planted on two opposite sides of the CPCA and on the other two opposite sides of the CPCA transplanted Tomato (*Solanum lycopersicum*) were also planted.

Basins (9 Nos.) were also dug and planted for facilitating comparison of CPCA to 'Basin Irrigation' method commonly resorted to by the farmers of the region.

Seeds of Tomato (*Solanum lycopersicum*) and White Kidney beans (*Phaseolus vulgaris*) were planted around the 'Wick Assembly' and basins. The seeds were purchased from the market of Dhrangadhara city. Three to four numbers of seeds were used for plantation on one side around 'CPCA as the seeds that were purchased had 75 % of germination probability specified by the supplier/manufacturer.

The CPCA was then filled with water and subsequently were filled periodically to supplement the required moisture to the soil for crop growth. Initially, till germination stage, the water was applied on daily basis but later the water was applied at varying interval of 3-8 days depending upon the availability of water.

The porosity of the porous clay capsules was found out by the laboratory experiment. The porous clay capsules were oven dried at 105° C for 24 hours and weighed. The porous clay capsules were then saturated by immersing them in a water tank for 72 hours and weighing the same. From the difference, in weight, the void volume and accordingly the porosity was found out.

Observations on water application to individual CPCA and basin were recorded for the entire duration of the experimentation. Accordingly, the yield of the vegetables was found by collecting and weighing them.

Using the data of actual cost incurred for seeds, CPCA, labour etc total expenditure per acre for irrigation with CPCA was worked out. Similarly, using the market survey method the monetary benefits accrued by selling the yield at market price the total benefits from the method of irrigation employed for the experimentation was computed. From these computations, the benefit-cost ratio (B/C) was worked out.

IV. RESULTS AND DISCUSSION

4.1. Water Saving:

Water saving in agriculture is the need of the hour. Table 2 shows the average water consumption per installation by both methods of irrigation employed at the experimental farm.

From the scrutiny of the observed data of water consumption the fact that emerges is when compared to basin method of irrigation by farmers' regular practice of hand watering 55.95 % of water saving was possible with CPCA.

Table 2 Irrigation Water use

Method of Irrigation	Total water Consumption in liters
CPCA	540.90
Basin	1228.0

Since the farmer's regular practice of hand watering the basins is based on his previous experiences and his personal knowledge, understanding, and perception about the prevalent circumstances during the crop period; it is quite likely that the water requirement for the basins method will be higher than any other methods employed for the present experimentation.

Under CPCA the water was very slowly released to the soil in the root-zone of the crop. Therefore, the plants would have utilized water most effectively, while water applied manually to the basin by the farmer is lost through percolation, seepage, and evaporation. As a result, considerable water saving was attained with the use of CPCA.

The Saurashtra region is underlain by hard basaltic rock and has very limited storage potential. The fact that about 80% of the irrigated land still depends on groundwater for their irrigation needs. The water that can be saved by employing CPCA can be used to produce additional food and fiber for the region.

4.2. Yield :

The yield of crops under different irrigation methods is presented in Table 3. The yield per plant of Green Peas and Tomatoes were higher when irrigation by CPCA was employed. The increase in yield of Green Peas with CPCA was 35.90 % and that for Tomatoes was also 8.53 %.

Table 3 Crop Yield

Method of Irrigation	Name of the Crop	No. of Plants grown	Yield in Kg.	Yield per Plant in Kg
CPCA	Green Peas	10	5.60	0.560
	Tomatoes	10	9.92	0.992
Basin	Green Peas	10	4.128	0.412
	Tomatoes	10	9.145	0.914

Though, the yield of a particular crop depends on several factors, nonetheless the application of required water directly at the root-zone has been an important factor that contributed to yield improvement. As suggested by Blum, 2009 [8] the effective use of water and not water-use efficiency is the target of crop yield improvement under water deficient environment.

The water-saving, when coupled with the improved yield, makes the CPCA highly fruitful for the farmers who are facing the problems of water shortages and that are trying to eke a living out of their small landholdings.

4.3. Sustainability and Economics :

The CPCA method of irrigation does neither require electricity for its operation nor does it requires any technical know-how on the part of the farmer for its effective functioning. It can be easily fabricated by even an unskilled farmer. The simplicity and the manageability of CPCA can immensely add to an enabling environment for farmer adoption.

However, the task of fabrication, installation and filling and re-filling of CPCA with water is a labour intensive task. The CPCA is quite eco-friendly and if the capsules can be manufactured in large quantity the cost of CPCA can be reduced considerably.

CPCA is difficult to use in rocky soils at the same time the broken capsules can disrupt the irrigation operation and reduce the productivity. Some plants with extended root systems are difficult to cultivate using this technology. In some areas, it may be difficult to purchase or manufacture the clay capsules. The use of CPCA is only applicable to small-scale agriculture.

The Benefit-Cost ratio for the CPCA was found to be 1.38. The cost as well as benefits largely depend on the local market and may vary from region to region. Also, the experimentation was done in accordance with the minimum distance between two crops as specified by standard agricultural practices. The cost may also vary with variations in planting distance.

V. CONCLUSIONS

Experimental investigation on CPCA has revealed that the method can be successfully employed to achieve both water saving and yield improvement in agriculture. The method can help small and marginal land-holder farmers facing problems of water shortage to raise crops for their livelihood. The proposed method has the potential to contribute in poverty alleviation among the small farmers and can serve as an effective tool for affordable small-scale irrigated agriculture.

ACKNOWLEDGEMENT

The authors acknowledge Shree Ranchhodbhai Kanzariya for letting the authors to carry out experimental work in his farm; moreover also for dissemination of his experiences in addition to his help in the present experimentation.

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