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DESIGN AND OPERATION OF DRIP IRRIGATION SYSTEM TO ORCHARD BY USING STORED RAIN WATER (*JALLER GOLA*) THROUGH CHARGEABLE BATTERY AND SOLAR PHOTOVOLTAIC WATER PUMP

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Abstract: Study was undertaken at the Instructional Farm of Faculty of Agricultural Engineering, Bidhan Chandra Krishi Viswavidyalaya, Nadia to examine the possibility of *Jaller gola* (Water Silo) as a water storage structure and drip system was used to use this storage water for irrigating orchard. The chargeable electric and solar battery were used as the sources of power. The cost of storage water in both cases were estimated as Rs.0.67/ lit. The chargeable and solar chargeable battery drive pump set had discharged 6864.75 lit and1971.52 lit water in a continuous run of 3.75 hr and 2.90 hr respectively which were sufficient for cultivation orchard in an area of 0.45 ha and 0.33 ha .These practices of water storage, cultivation and irrigation may be great hope of better agriculture practice and way of livelihood development of water scarce and poverty struck regions of western part of West Bengal.

Keywords: Drip system, electric chargeable battery pump, orchard, solar chargeable battery pump, water silo (*Jaller gola*).

Introduction

The plateau fringe of the Chhotonagpur in the western part of the state of West Bengal contains the parts of Birbhum, Bardhaman, Purulia, Bankura and West Midnapore districts. Drought or water scarcity in summer months is quite common in this region. In general the rainfall and relative humidity are less and temperatures are higher in comparison to other districts of the state. Due to undulated topography, residual soil formed by the weathering effect of bed rocks and Due to insufficient water intercepting structure, the major portion of the rainfall flows away as uninterrupted runoff. Further, high evaporation and seepage losses from stored water lead to cause continued water deficit, poor crop productivity and poverty. With respect to average annual rainfall (1100-1400 mm) of Purulia and other districts of extended Chotonagpur plateau in the state of West Bengal may be good enough for sufficient water for growing crops if it is stored effectively and used through efficient method of

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irrigation. The farm ponds, check dams and dug wells are the conventional method of water harvesting structures. High evaporation and seepage losses in farm ponds cause huge loss of water. Due to inadequate soil conservation practices and deforestation check dams get silted and require frequent desalination Biswas et. al. (1999).

Drip irrigation is a low pressure, low volume irrigation system which is suitable for high-return value crops such as fruit and vegetable crops. If managed properly, drip irrigation can increase yields and decrease water, fertilizer and labour requirements. However, it needs power to operate the system. The area here in under consideration is so under developed that most of the villages have not access the electricity properly to run the pump set efficiently. The use of diesel pump set is costlier. The farmers of these areas are mostly scheduled caste and tribes having small land holdings presumably unable to afford power operated drip irrigation unless provided with free of cost or subsidized considerably. As a suitable alternative to diesel or electrically operated pump set, the solar photovoltaic and chargeable battery water pump set may be tried. However, its practicality, economy and performance need to be examined. With the above in view, and the study was undertaken with the objectives of estimating the water requirement of orchard crops under drip system ii) design and construction of *Jaller gola* (water silo) for storing estimated volume of water and iii) evaluating the performance of drip system operated by chargeable battery and solar photovoltaic pump.

Materials and methods

Experimental Site

The present study was undertaken to address the water scarcity problems of Purulia district or area of similar characteristics. However, due to unavoidable circumstances the study was carried out in Nadia district. The experimental set up had made as if the replica of the set up of Purulia.

The experimental site was at the Instructional Farm of Faculty of Agricultural Engineering, Bidhan Chandra Krishi Viswavidyalaya, in the district of Nadia in new alluvial agro climatic zone of West Bengal during the year 2012-13. The location of this farm is 23° 18' N & 78°43' E. The soil of this farm was silty loam. It is suitable for sloppy land where the runoff water of higher elevation land can be collected at lower elevation land by constructing farm pond (*Jaller gola*). But in the present study the farm pond was constructed and for immediate study, the farm pond was filled with rain water and partially with tube well water. The size of the area under the study was 45 m x 45 m.

Estimation of Water Requirement under Drip System

In this study, lemon crop was taken to irrigate under drip irrigation system. The spacing was taken as 4.5 m x 4.5m. The water requirements of crops under drip system was calculated by the equation of ET_{crop}= E_{pan} x K_p x K_c x wetted area fraction. Where, ET_{crop} = water requirements of crop in mm, E_{pan} = pan evaporation in mm, K_p = pan factor and K_c = crop coefficient

Construction of *Jaller gola* (Water Silo)

A *Jaller gola* (water silo) was constructed with the specifications of top length(L)=30 meter, top width(T)=5 meter, depth(d)=2 meter, side slope=1:1 ,bottom length(l)=26 meter and bottom width(b)=1 meter .The designed *Jaller gola* has shown in **Figure 1 and 2.**

Making of Polythene Lining and Cover of *Jaller gola*

Normally, the polythene sheet of required size is used to avoid jointing. However, if the polythene sheet of desired size is not available, the required length and width can be achieved by jointing the polythene film pieces together. There are various methods of jointing polythene to make it completely waterproof. In this study the thermal welding (heat sealing) method was followed. Initially an electric heat sealer was tried to do the job. It was found that the heat sealer was unable to make quick joint due to its capacity of much less width of coverage. To serve a wider width of jointing a conventional electric iron was used for jointing the polythene sheet.

The width of the lap joint was 100 mm. Poly tetrafluorethbylele (PTEF) impregnated glass-cloth or cellophane sheet was used between the polythene sheet and the heating elements to avoid the risk of the film sticking to the electric iron at high temperature. The temperature of the electric iron was adjusted and maintained at a constant maximum level.

The bottom and side surface of the *Jaller gola* were made properly leveled and expanded to some extent to have desired sides slopes and to place the polythene to give the definite shape. In doing so, care was also taken for removal of undesirable substances (stones, woods etc.), from the surfaces of the *Jaller gola* so that these could have injured the polythene when in use and causes to seepage loses of water. The top of the *Jaller gola* was covered by transparent polythene (150 gauges) in support of a bamboo made structure.

Set up of chargeable battery and solar photovoltaic water pump

The chargeable battery pump set consisted of 0.1 kw motor and pump of designed maximum capacity 1600 lph at 2800 rpm and 15m head. A 12 volt rechargeable storage battery was used as source of power to operate the motor. The solar photovoltaic pump was set up with the combination of 0.25 hp motor and pump. A 12V solar photovoltaic rechargeable battery was the source of power to operate the DC motor. To examine performance of the both pumps, the pumps were operated till the battery got exhausted. During this process the electric characteristics of the battery in terms of volt, ampere and the head and discharge of the pump were recorded at 15 min interval.

Results and discussions

Water Requirement of crop under drip system

In this study lemon crop was taken to irrigate under drip irrigation system. The pan evaporation during the month of December to May in Nadia when irrigation was required approximately 2.0, 1.75, 2.0, 4.0, 5.0 and 5.0 mm /day respectively. Assuming the pan factor is 0.8, crop coefficient is 0.9 and percent wetted area for orchard/fruit crops is about 30% (Vermeiren and Jobling,1980). The water requirement of irrigated months have tabulated in **Table 1.**

Discharge rate of solar photovoltaic water pump and chargeable battery

The fully recharged (solar) battery (40 Ah) was used to operate the pump. The pump could discharge for 2hour 55minute at varying discharge rate. The pump was operated at constant 0.65 m delivery head and 0.25 m suction head. In case of chargeable battery, the fully charged battery (90 Ah) was used to operate the pump. The pump could discharge for 3.75 h at varying rate. The electric charged battery was used to operate the pump for the period till the charge was exhausted to run the pump. **Figure-3** has showed the discharge rate of both pumps. It was found that the average discharge rate of chargeable battery and solar photovoltaic water pump were 0.5085 litre /sec and 0.1875 litre /sec respectively.

Jaller gola

The length of the available land was approximate 35 m. In consideration to this, the size of the *Jaller gola* was taken 30 m x 30 m with sides slope of 1:1 and depth 2m. The water storage capacity was found 176 m^3. The side slopes could be taken steeper with scope of more water storage in same area.

Polythene Lining and Roof Cover

The polythene used on the sides and bottom, were good quality which may be considered reasonably thick 800 gauge for lasting about 10 years under unless get damaged the attack of rodent which is very often a problem in this area. The polythene sheet both of sides and top cover were grounded along the boundary of the *Jaller gola* covering the low height bound around so that water in the *Jaller gola* was free from scope of evaporation as well as scope of muddy water through runoff could enter the *Jaller gola.*

Volume of Earthwork

The excavation volume of earthwork for making *Jaller gola* was 176 m^3. The soils on excavation was suitably placed on the boundary of the *Jaller gola* and adjacent area for filling and make a pathway. The existing PWD rate was Rs.212.98/m^3 of excavation and spreading of soil (Rs. 106.49 for excavation and Rs. 106.49 for spreading). The cost of construction of *Jaller gola* was Rs. 37484/-

Polythene: For lining the sides of *Jaller gola* 245 m^2 (800 gauge) polythene was required costing Rs.8414/.The cost of polythene (150 gauge) to cover the *Jaller gola* was Rs. 3391/-

Supporting Structure of Top of *Jaller gola* : Cost of bamboo = Rs.7425/-, Labour wages = Rs.1670/- , Misc. = Rs. 500/- , Total = Rs.9595 /-

The total cost for making the *Jaller gola* was = (37484+8414+3391+9595) = Rs58884/-

Drip system: Main pipe (dia. 25 mm, 45 m length) = Rs. 1800 @ Rs. 40/m, Lateral (dia.12 mm 450 m length) = Rs. 2700 @ Rs. 6/m, Dripper (4 1ph, 400 pieces.) = Rs. 1000 @ Rs. 5/ piece, Filter & other accessories = Rs. 1000/-, Labor & misc. expenses= Rs. 1000/- ,

Total = Rs. 6500/-

Cost of water: Longevity of *Jaller gola* (assumed) = 10 years, Cost of *Jaller gola* = Rs. 58884/-, Annual investment = Rs. 58884 /10 =5888.4, Interest on investment @ 10% =58884x 0.1 =5888.4, Total amount cost = (5888.4 + 5888.4) = Rs. 11776.80/- **,** Cost of water = Rs.11776.8/ (176 x 1000) lit. = Rs.0.67 / lit. It may be stated that the storage cost of water Rs. 0.67/lit. is quite reasonable.

Scope of using chargeable battery and solar photovoltaic water pump for drip irrigation

The chargeable battery water pump was found capable of discharging 6864.751it. of water at a stretch. The battery was fully charged by electric battery charger for about 7 hours. The pump will be suitable for constant discharge during operation and the solar photo voltaic water pump was found to capable of discharging 1971.52 lit of water at a stretch without charging during the full pumping. The battery was fully charged by the two 0.69 m x 0.65 m solar module for about 5 sunshine hours. Therefore, the pump will be suitable for constant discharge during bright sunshine hours more than 2 hours without sunshine.

Let us supposed that orchard of 4.5m x 4.5m spacing was cultivated where pan evaporation, crop coefficient, pan factor & wetting percent were taken as 5 mm, 1.0, 0.8 and 30 respectively. Thus each plant requires 30 lit / day /plant.

The daily operating capacity of the chargeable battery water pump setup was 3.75 hours. Using the average discharge rate of 1830.6 1it / h, it discharged the volume of 6864.75 lit. water only for one time recharge. This 6864.75 lit. of water is sufficient to irrigate 229 numbers of plants or 0.458 ha area. The irrigation capacity of an area of 0.458 ha which is suitable for most of the farmers of West Bengal.

Assuming an average of 3.0 hours direct pumping when sunshine was available and 2.90 hours post sunshine. The daily operating capacity of the solar photovoltaic water pump setup was 5.9 hours. Using the average discharge rate of 675.18 lit./h, it discharged the volume of 3988.56 lit. water. This 3988.56 lit of water was sufficient to irrigate 133 number of plants or 0.33 ha area. An area of 0.33 ha which is suitable for the farmers of West Bengal.

The *Jaller gola* (Water Silo) may be an economy suitable technically feasible practice of water storage in scarce adverse geological and geographical area. It may be constructed at Purulia and tested its applicability in term of practice along with the use of chargeable battery and solar photovoltaic pump in drip irrigation.

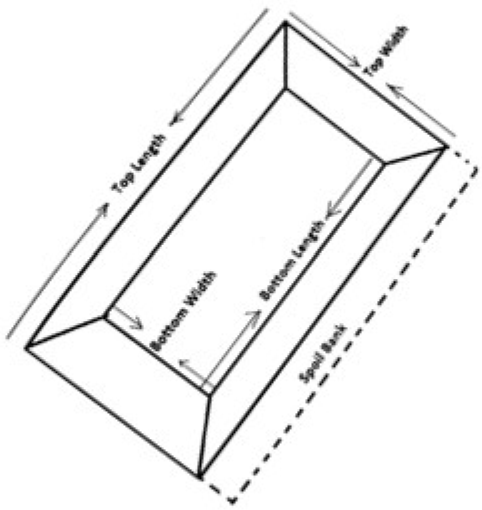

Fig.1 Top view of *Jaller gola*

Fig.2 View of constructed *Jaller gola* at the site

Table 1: Water requirement of irrigated months in Nadia district

Month	K_p	K_c	E_{pan} (mm)	ET_{crop}(lit/plant/day)
Dec	0.8	0.9	2.00	8.748
Jan	0.8	0.9	1.75	7.640
Feb	0.8	0.9	2.00	8.748
March	0.8	0.9	4.00	17.196
April	0.8	0.9	5.00	21.870
May	0.8	0.9	5.00	21.870

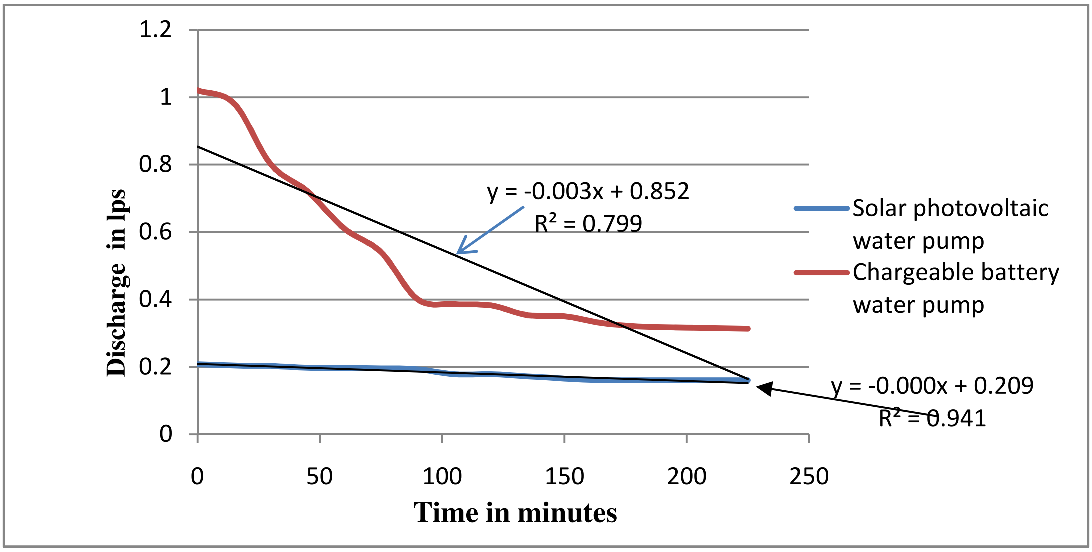

Fig. 3: Time v/s discharge relationship of both pumps

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