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Treadle pump: A Low-Cost Irrigation option for Marginal Farmers

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ABSTRACT

Population of marginal farmers in India is bound to increase due to the continued division of farm holdings. Characteristically, marginal farmers are having more family labours but the production and productivity of their land holdings are low. The foremost reason behind this is the erratic rainfall and lack of assured supplementary irrigation during long dry spells. This paper presents the scope and applicability of a diaphragm based treadle pump in Bihar where groundwater is abundant and available at shallow depths round the year. Therefore, this pump could be very useful for marginal farmers in improving production and productivity of their tiny piece of land, as it uses human power and can be operated by male and female of age group 32- 45 years and could lift water from a depth, ranging from 0-30 feet. The water saving technologies such as bucket kit, drum kit etc. could be used with this pump to irrigate the crops with high water productivity.

Keywords: Treadle pump, groundwater, marginal farmers, irrigation

INTRODUCTION

India is a land of small and marginal farm holders (Gururaj, 2017). In Bihar alone, there are about 16.1 million farm holdings of which about 14.7 million farms are of the marginal category with operational holding size ranged between 1.0 to 0.25 ha (Agricultural Census, 2011). As per the estimate, there is about 3 lakh new marginal farms are being added every year due to the continued division of farm holdings. The production and productivity of these marginal holdings are often been risky and relatively of low return due to erratic rainfall and lack of assured irrigation supply (Lobell *et al.*, 2008; Held *et al.*, 2005).

Marginal farmers, in general, are having surplus family labourers but they are often been poverty stricken due to lack of employment opportunites (Dipika and Nandi, 2014). Marginal farmers have limited capacity to invest in agricultural inputs such as quality seeds of high yielding varieties and fertilizers. If, somehow they manage to get these inputs for improving production and productivity of their tiny land for a fair return, but due to lesser support from the ecosystem and poor capacity to purchase groundwater the assured irrigation is almost a distant dream for them. The lack of simple and affordable fuel driven water lifting technologies, suitable for the production conditions and needs of marginal farmers, undermines the serious efforts in achieving food security (Rahman, 2015). However, if a simple and low-costwater-lifting technology is provided to them, then there will be a definite improvement in their economic conditions, as this technology would be providing assured water supply to them to meet supplementary irrigation requirements (Rahman and Singh, 2014). With assured irrigation water supply, the marginal farmers could diversify the cropping pattern to include high value vegetable crops such as peas, tomatoes, rape, cabbage, Irish potatoes, fresh corn and pumpkins etc. to sell it in the market for good return (Singh and Pandey, 2014).

MATERIALS AND METHODS

A technology which is simple and handy uses human power, called treadle pump (TP), could be one of the most viable and affordable option for marginal farmers for extracting groundwater pond water for irrigation. Treadle pump is based on a simple principle and capable to lift water up to a height of 30 feet. Since, the discharge of treadle pump is low, therefore, this can be used with low cost shallow bore well or dug well. The discharge of TP is sufficient for small farm irrigation by using family labours. The only criterion to meet is that the water should be available at shallow depth. However, if we see the groundwater availability in Bihar, Fig. 1 and 2, then it is quite perceptible that, the groundwater

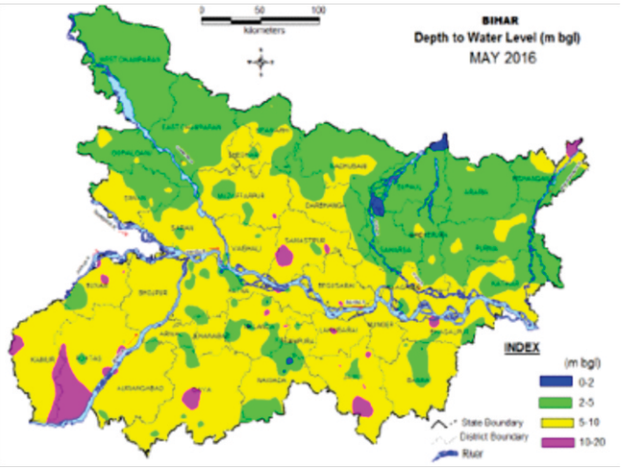

Fig. 1: Depth of water below ground level (bgl) in pre-monsoons in different districts of Bihar (CGWB, 2017)

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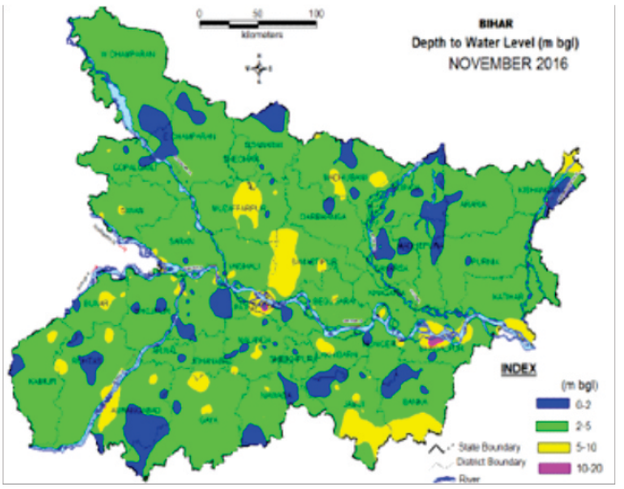

Fig. 2: Depth of water below ground level (bgl) in post-monsoon in different districts of Bihar (CGWB, 2017)

availability is shallow and ranging between 7-33 feet below the ground level (bgl) in pre-monsoon period and 7-16 feet (bgl) in post monsoon period. Therefore, the applicability of treadle pump is reasonably good and rationally viable option for groundwater abstraction in Bihar. Further, by a single treadle pump, more farmers could be benefitting them, as diaphragm based treadle pumps are of low weight and could be transported on the head.

Treadle pumps can be installed quickly and is made operational with simple priming. Further, the water-saving technologies such as bucket kit drum kit etc. can also be connected with this pump to irrigate crops efficiently for improving water productivity, as these are required low operating pressures.

A reasonably fit person of age group 20 - 40 years can produce a steady power output of around 75 watts for long periods however for developing countries like India it is ranging around 30-40 watts (Fraenkel, 1986). This power is transferred to the pump when the operator stands with one foot on each treadle and pushes them up and down in a reciprocal motion. Since this is a natural movement for the human body, therefore, it can be sustained for several hours, if the parameters of stroke length and the cadence are matched with the ability of the operator. Treadle pumps are the most suitable and economical option not only to supply water for small-scale irrigation but also for drinking purposes.

To test the performance of a treadle pump and the operational capacity of the persons belonging to this area, a diaphragm based treadle pump was selected for this purpose, shown in Fig. 3.

The tests were performed at the Pressurised Irrigation Laboratory of ICAR Research Complex for Eastern Region, Patna. The design attributes of the selected diaphragm based treadle pump are given in Table 1. The tests were performed under the weather condition reported in Table 2.

Table 1: Descriptions of the treadle pump

Parameter	Value (mm)
Length of the pump	1070
Width of the pump	320
Height of the pump	470
Piston diameter	80
Inlet/outlet dia	40/40
Length of pedal	920
Frame length	940
Handle	900
Weight of the system	23.0 kg
Power source	Manual

Table 2: Testing conditions

Weather parameters	Value
Temperature range:	22 - 28 ^{0}C
Wind velocity	1.5 - 2.5 kmph
Relative humidity	80-85 %
Sunshine condition	Bright sunny day

RESULTS AND DISCUSSION

The performance tests of the treadle pump were undertaken with local people selected from both of the genders, the male, and female. Treadle pump's inlet was connected with reflex valve and put in a water tank of depth 5.0 feet and outlet was attached with a tank of capacity 500 liters placed at different heights on an iron angle tower. The weight, the age, blood pressure blood pressure (BP) and general health conditions of the three selected operators were assessed and are reported in Table 3. The age of operators, ranging from 32-45 years. The range of age was selected to assess the performance with age.

Table 3: Testing conditions

Operator	Age (year)	Wight (kg)	Blood Pressure (Hg)	General health
Operator - 1 (male)	32	65	82 - 121	sound
Operator - 2 (male)	44	55	85 - 125	sound
Operator - 3 (female)	45	52	85 - 130	sound

The sets of operations were performed till operator intended to take rest. Each set of operation were lasted for 7-10 minutes depending upon the operator. After each set of operation, a gap of 5-10 minutes was found to be sufficient to resume the operation again. In this way, the operators were operating the pump over a longer period. The average discharge of the treadle pump at the different dynamic heads and with different operators are reported Table 4. The average discharge in litter per minute (LPM) of the pump with different operators was ranged from 80- 32 liters per minute with corresponding total dynamic head, ranged from 10-30 feet. The graphical representation of avg. discharge vs. total dynamic head is shown in Fig.4. Fig. 4 shows that the operator's weight as well as gender type plays important role in performance treadle pump. Both of the genders can operate the pump successfully, having age group of 32-45 years and of weight, ranged between 50-65 kg.

Fig. 3: A diaphragm-based treadle pump

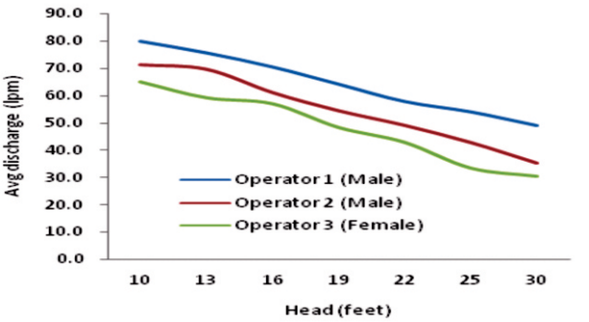

Fig. 4: Head discharge relationship of diaphragm-based treadle pump with different operators

Table 4: Performance of operators and treadle pump

Total dynamic head (Feet of water)	Average Stepping rate (per minute)			Discharge (LPM)		
	Operator-1	Operator-2	Operator-3	Operator-1	Operator-2	Operator-3
10	69	64	57	80.0	71.4	65.2
13	66	61	53	75.8	69.8	59.4
16	63	58	52	70.6	61.2	57.4
19	60	54	51	64.2	54.5	48.4
22	57	52	49	57.9	49.2	42.9
25	56	48	47	54.1	42.9	33.3
30	53	43	42	49.0	35.3	32.3

CONCLUSIONS

The experimental results show that, the males and females of age group 32-45 years with sound health can operate the diaphragm-based treadle easily to extract water from a depth up to 30 feet. This diaphragm based treadle pump can be operated even by an unskilled person with a little technical training. In view of shallow groundwater depth and available human family labours this human powered pump could be useful for marginal farmers in Bihar.

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