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Performance Evaluation of Manually Operated Water Lifting Pumps in Konkan Region of Maharashtra State

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Rain water harvesting in silpaulin-lined farm ponds and augmentation of seasonal stream water in Konkan Vijay bandhras are recommended by the Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli (M.S.). The harvested rain water has to be lifted to irrigate the crops. Manually operated water lifting pumps is considered to be the best choice to avert the problems due to frequent load shedding in this locality. In this context, three manually operated water lifting pumps named as pump A, B and C were tested in respect of their head, discharge, efficiency and heart rate. The pump-A has high discharge ranging from 0.24 to 1.10 lps and efficiency of 34.27 per cent. However, the peddling work was very heavy as the delivery head was absent. The pump-B gives the total head of 16 m, including the delivery head of 12 m. This pump has the discharge ranging from 0.013 to 0.703 lps and the efficiency of up to 40 per cent. The pump, however, can be operated for short period as it gives excessive pains to leg muscles of the operator. The pump-C with total head of 20 m has the discharge ranging from 0.15 to 0.62 lps and the efficiency of up to 55.75 per cent. According to heart rate, the pump A and B comes under very heavy work load conditions and pump C comes under moderate to heavy work load conditions. Considering these factors, pump C is recommended for lifting the harvested rainwater in the Konkan region of Western Maharastra.

(***Key words:*** *Rain water harvesting, Manually operated pumps)*

The irrigated agriculture sector is facing increasing challenges in the face of rapid population growth, decreasing availability of land and competition for scarce water resources. Small scale farmers should be perceived as key players in increasing global agricultural production and achieving food security. In the remote areas of Konkan region, where the rain water harvesting techniques are practiced by farmers needs to be supplemented by proper water lifting technology, so that this harvested water can be used effectively for irrigating short duration crops. Considering the low investment cost, suitability for various field sizes, rapid return on investment and simple inexpensive maintenance, human operated water lifting pumps can play key role for irrigation in small land holdings.

Treadle pumps are convenient for farmers for use in small scale. Shah *et al.*, (1999) studied the socio-economic impact of the treadle pump in eastern India, Nepal and Bangladesh. Keller (2001) studied three different improved irrigation technologies suitable for small holders.

Mangisoni (2006) carried out a case study of impact of treadle pump irrigation technology on small holder's poverty and food security in Malawi, South Africa. According to his report small holder micro-irrigation in the form of treadle pumps offers tremendous opportunities to dramatically increase agriculture production while enriching the livelihoods of many resource poor farmers in Malawi. Thomas (2002) carried out the ergonomic evaluation of treadle pumps at Department of Engineering, University of Warwick Coventry, U.K. He gave the justification for employing a treadle pump rather than a cheaper hand pump because of its higher ergonomic efficiency, its use of leg muscles rather than arm muscles. Here an attempt is made to evaluate the performance of three manually operated water lifting treadle pumps for studying their suitability to be used in Konkan region of Western Maharashtra.

MATERIALS AND METHODS

The testing of the selected pumps A, B and C was carried out in the Experimental Farm of the College of Agricultural Engineering and Technology,

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Dapoli. In case of pump A, (Fig. 1) delivery head was zero, hence testing was carried out by varying the suction heads. This varying suction head was achieved by placing the pump at different heights in the Priyadarshini pond. For the testing of pump B (Fig. 2) and C (Fig. 3), it was necessary to change the suction head as well as delivery head. The delivery head of the pumps was adjusted by passing the pump discharge through vertical PVC pipes of desired length. To maintain the desired delivery head up to 12 m heights, it was necessary to support the pipe of respective length vertically. In order to maintain such a long vertical pipe, the testing was done in the stair case of the building. A storage tank of 200 lit. capacity placed at the ground level was used as a water source for testing of the pumps. The heart rate was measured using Polar Vintage NV computerized heart rate monitor. It is a compact portable instrument to monitor the heart rate. This can be used in field directly where the telemetry system cannot be used.

RESULTS AND DISCUSSIONS

Performance characteristics of pump A

Head, discharge and strokes relationship

The testing of the pump was carried out at different suction lifts (Table 1). It was observed that as the lift of the pump increases from 0 to 6 m, the discharge decreases from 1.1 to 0.24 lps. Also as the number of strokes of the pump increased from 1 to 6 nos/sec, the discharge of the pump increased from 0.24 to 1.1 lps. Also the heart rate increased with increase in the lift of the pump.

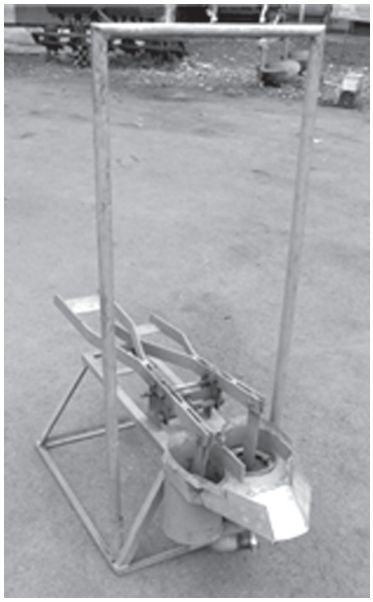

Fig. 1. Pump A

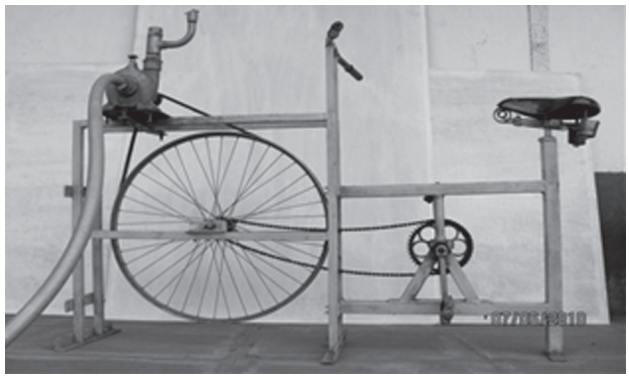

Fig. 2. Pump B

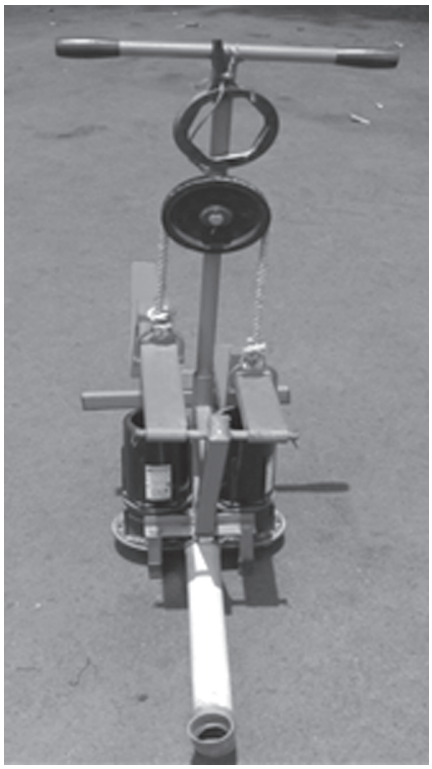

Fig. 3. Pump C

Efficiency-head relationship

Efficiency of the pump was calculated based upon the values of number of strokes, total head, stroke length and discharge (Table 2). It was observed that when the total head of the pump increased from 2 to 4 m, efficiency of pump increased from 33.66 to 34.27 per cent. Further, efficiency of the pump decreased from 34.27 to 22.03 per cent as the total head increased from 4 to 6 m. Hence, at the beginning, efficiency of the pump increased with increase in the total head and then it decreased with further increase in the total head. The efficiency of the pump was found maximum at 4 m total head.

Table 1. *Performance of pump A at various suction lifts*

Sr. No.	Suction lift (m)	Volume collected (litres)	Time (sec)	Discharge (lps)	Strokes/sec	Heart rate, beats/min
1	2	456.39	414	1.10	1.59	153
2	4	200.83	422	0.48	1.35	155
3	6	130.00	540	0.24	1.02	160

Table 2. *Efficiency head relationship of pump A*

Sr. No.	Strokes/min	Total head (m)	Stroke length (m)	Discharge (lpm)	E_{input} (joules/min)	E_{output} (joules/min)	Efficiency (%)
1	42	2	0.16	66.0	3847.44	1294.92	33.66
2	36	4	0.16	28.8	3297.81	1130.11	34.27
3	42	6	0.16	14.4	3847.44	847.58	22.03

Performance characteristics of pump B

Head, discharge and strokes relationship

The testing of the pump was carried out at different suction lifts and delivery heads. The result at the 2 m suction lift and different delivery heads is reported in Table 3a. It was observed that as the lift of the pump increases from 0 to 12 m, the discharge decreases from 0.703 to 0.013 lps. Also as the rpm of the pump increased from 1900 to 2600, the discharge of the pump increased from 0.013 to 0.703 lps. The performance of the pump at 4 m suction lift and different delivery head is reported in Table 3b. It was observed that as the lift of pump increases from 0 to 12 m, discharge decreases from 0.008 to 0.459 lps. Also as the rpm of the pump increased from 2000 to 2500, the discharge of the pump increased from 0.008 to 0.459 lps. The performance of the pump at 6 m suction head is reported in Table 3c. From that, it was observed that as the lift of the pump increased from 0 to 12 m, discharge decreased from 0.281 to 0 lps. Also as the rpm of pump increased from 1900 to 2600, the discharge of pump increased from 0 to 0.281 lps.

From these three tables, it was observed that the discharge of the pump increased with increase in the rpm of the pump, but decreased with increase in the suction lift. Also the heart rate increased with increase in the lift of the pump.

Table 3a. *Performance of pump B at 2 m suction lift*

Sr. No.	Delivery head (m)	Volume collected (litres)	Time (sec)	Discharge (lps)	Pump rpm	Heart rate, beats/min
1	2	87.9	125	0.71	2412	141
2	4	54.17	138	0.39	2310	142
3	6	27.42	133	0.21	2455	151
4	8	15.30	195	0.08	2478	160
5	10	1.64	128	0.01	2412	162

Table 3b. *Performance of pump B at 4 m suction lift*

Sr. No.	Delivery head (m)	Volume collected (litres)	Time (sec)	Discharge (lps)	Pump rpm	Heart rate, beats/min
1	2	85.86	187	0.46	2374	142
2	4	34.89	138	0.25	2415	151
3	6	26.49	215	0.12	2353	162
4	8	10.72	216	0.05	2293	164
5	10	1.55	187	0.008	2164	168

Table 3c. *Performance of pump B at 6 m suction lift*

Sr. No.	Delivery head (m)	Volume collected (litres)	Time (sec)	Discharge (lps)	Pump rpm	Heart rate, beats/min
1	2	43.05	156	0.28	2611	152
2	4	17.91	137	0.13	2712	164
3	6	0.80	131	0.006	2645	161
4	8	0.16	134	0.001	2624	162
5	10	0.00	145	0.00	2572	166

Efficiency-head relationship

Efficiency of the pump was calculated based upon the values of number of strokes, total head, stroke length and discharge (Table 4). It was observed that when the total head of the pump increased from 4 to 6 m, efficiency of pump decreased from 40 to 38 per cent. Further efficiency of the pump decreased abruptly from 38 to 7 per cent as the total head increased from 6 to 12 m.

Performance characteristics of pump C

Head, discharge and strokes relationship

The testing of the pump was carried out at different suction lifts and delivery heads. The result at the 2 m suction lift and different delivery heads is reported in Table 5a. It was observed that as the lift of the pump increases from 0 to 14 m, the discharge decreases from 0.63 to 0.29 lps. Also as the number of stokes of the pump increased from 0.29 to 0.63 no/sec, the discharge of the pump increased from 0.29 to 0.63 lps. The performance of the pump at 4 m suction lift and different delivery head is reported in Table 5b. It was observed that as the lift of pump increases from 0 to 16 m, discharge decreases from 0.62 to 0.21 lps. Also as the number of stokes of the pump increased from 0.24 to 0.98 no/sec, the discharge of the pump increased from 0.21 to 0.62 lps. The performance of the pump at 6 m suction lift and different delivery head is reported in Table 5c. It was observed that as the lift of pump increases from 0 to 16 m, discharge decreases from 0.52 to 0.15 lps. Also as the number of stokes of the pump increased from 0.24 to 1.05 no/sec, the discharge of the pump increased from 0.15 to 0.52 lps.

From these three Tables, it was observed that as the lift of the pump increases, the discharge of the pump decreases and as the number of strokes increases, the discharge of the pump increases. Also the heart rate increases with increase in the lift of the pump.

Efficiency-head relationship

Efficiency of the pump was calculated based upon the values of number of strokes, total head, stroke length and discharge (Table 6). It was observed that when the total head of the pump increased from 2 to 8 m, efficiency of pump decreased from 41.05 to 55.75 per cent. Further efficiency of the pump decreased from 55.75 to 25.75 per cent as the total head increased from 8 to 20 m. Hence, at the beginning efficiency of the pump increases with increase in the total head and then it decreases with further increase in the total head. The efficiency of the pump was found maximum at 8 m total head.

The pump C is recommended for lifting the water from the rain water harvested structures in the Konkan region of Western Maharashtra.

Table 4. *Efficiency head relationship of pump B*

Sr. No.	Discharge (lps)	Total head (m)	Force exerted on pedal (kg)	Radius (m)	Pump rpm	WHP	BHP	Efficiency (%)
1	0.70	4	3.6	0.2	90	0.037	0.090	40.9
2	0.44	6	3.6	0.2	88	0.035	0.088	39.6
3	0.25	8	3.6	0.2	86	0.026	0.086	30.1
4	0.11	10	3.6	0.2	78	0.014	0.078	18.5
5	0.02	12	3.6	0.2	52	0.004	0.052	7.0
6	0.005	14	3.6	0.2	38	0.001	0.038	2.4

Table 5a. *Performance of pump C at 2 m suction lift*

Sr. No.	Delivery head (m)	Volume collected (litres)	Time (sec)	Discharge (lps)	Strokes/ sec	Heart rate, beats/min
1	2	151.08	242	0.63	0.81	110
2	4	148.50	264	0.56	0.72	107
3	6	147.92	276	0.54	0.65	118
4	8	145.10	324	0.45	0.49	128
5	10	145.08	324	0.41	0.47	125
6	12	143.83	396	0.36	0.36	126
7	14	131.00	447	0.29	0.29	135

Table 5b. *Performance of pump C at 4 m suction lift*

Sr. No.	Delivery head (m)	Volume collected (litres)	Time (sec)	Discharge (lps)	Strokes/ sec	Heart rate, beats/min
1	2	150.00	242	0.62	0.98	110
2	4	154.17	274	0.56	0.77	112
3	6	148.67	329	0.45	0.61	118
4	8	144.35	368	0.39	0.52	126
5	10	143.67	410	0.35	0.40	128
6	12	143.67	500	0.28	0.29	135
7	14	115.33	556	0.21	0.24	142

Table 5c. *Performance of pump C at 6 m suction lift*

Sr. No.	Delivery head (m)	Volume collected (litres)	Time (sec)	Discharge (lps)	Strokes/ sec	Heart rate, beats/min
1	2	141.67	272	0.52	1.05	114
2	4	151.33	372	0.41	0.66	119
3	6	136.33	402	0.34	0.55	124
4	8	135.67	493	0.28	0.42	131
5	10	112.67	437	0.26	0.37	137
6	12	109.00	610	0.18	0.28	142
7	14	96.17	631	0.15	0.24	147

Table 6. *Efficiency head relationship of pump C*

Sr. No.	Strokes/min	Total head (m)	Stroke length (m)	Discharge (lpm)	E_{input} (joules/min)	E_{output} (joules/min)	Efficiency (%)
1	35	4	0.18	37.50	3584.57	1471.50	41.05
2	39	6	0.18	35.43	3994.24	2085.41	52.21
3	41	8	0.18	32.40	4561.06	2542.75	55.75
4	50	10	0.18	26.14	5120.82	2564.33	50.08
5	53	12	0.18	22.74	5428.07	2676.95	49.32
6	59	14	0.18	20.62	6042.57	2831.95	46.87
7	64	16	0.18	16.76	6554.65	2630.65	40.13
8	67	18	0.18	11.58	6861.90	2044.80	29.80
9	69	20	0.18	9.12	7099.73	1789.34	25.32

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