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Kapil
Ex Manager Technology, International Development Enterprises India

J Keller
Ex Board Member, International Development Enterprises, and CEO, Keller-Bliesner Engineering, LLC, 35 River Park Dr., Logan, Utah 84321, US

JN Ray
Ex Vice President, International Development Enterprises India

Corresponding Author:
Kapil
Ex Manager Technology, International Development Enterprises India

Research Note

Leveraging renewable small-plot pumping energy with drip irrigation

Kapil, J Keller and JN Ray

Abstract
The authors worked as an International Development Enterprises (IDE) team (the Team) to develop affordable irrigation and auxiliary products for smallholder farmers. Over the past 20 years IDE has been using a social marketing approach to sell manually operated treadle pumps to provide irrigation for smallholder farmers in several states in India in areas where the water table is less than 6 meters from the surface. Treadle pumps are also extensively used in other Asian countries (particularly in Bangladesh), Africa and America where reliable electric power is not available. Assuming an average dynamic pumping head of 6 meters, the average pump discharge is in the neighborhood of 2800 liters/hour. When all household members participate in manual pumping, they typically produce 11,000 to 17,000 liters of irrigation water per day. To reduce the treadle pumping labor IDE (in collaboration with their Indian affiliate, IDEI) has developed water application products that are more efficient than the traditional surface (or flood) irrigation systems used by most smallholder farmers. These systems include two types of low-cost drip irrigation, two types of low-cost low-pressure sprinkle irrigation, and a very low-pressure low-cost piped surface irrigation system. IDE-I sponsored a controlled study on a farmer's field to compare the water use efficiency and productivity of the two types of drip with traditional surface irrigation. One of the drip systems costs about 5.00 USD/100 m^2 and utilizes simple layflat thin-wall polyethylene tubing throughout and hot-punched holes instead of emitters. The other has side passage button emitters that are inserted into the hot-punched holes by hand after the system is installed in the field (which takes 4 to 8 hr/1000 m^2) and costs about 6.00 USD/100 m^2. Sponge gourds were grown on the IDE-I test plot which was located in the Sehore region of Madhya Pradesh. Surface sub-plots were irrigated every six days with application depths based on 100 and 125% of the depth of cup evaporation (CE); the drip sub-plots were irrigated every two days with applications based on 50, 75, and 100% of the CE. The CE for the 77 day growing season was 455 mm and the peak daily CE was 11 mm. The productivity with applications of 100% of CE was 206 Kg/1000 m^2 with button drip versus 75 Kg/1000 m^2 with surface irrigation. Based on treadle pumping 15,000 liters per day, a smallholder could irrigate a 1,500 m^2 plot and it would require 244 hours of household labor to apply 455 mm of irrigation water to it. The sponge gourds sold for 42 Indian Rupees (0.93 USD) per Kg. So even with the late planting resulting in low yields, the gross return from a 1,500 m^2 plot with drip would be 288 USD but only 105 USD with surface irrigation. Thus the 90 USD cost of a 1,500 m^2 drip system would be easily covered by the increased yield during its first crop season.

Keywords: Drip-irrigation, scheduling, water-efficiency, treadle-pump, smallholder

Introduction
The targeted farmers are ones with plots of less than a hectare and with incomes of less than $3/day. Treadle pumps are also extensively used in the river basins of Asian countries where the water table is 6 meters or less from the surface, particularly in Bangladesh where IDE first introduced them (Shah, *et al*., 2000). Smallholder farmers use treadle pumps for lifting and pressurizing water to irrigate small-plots where reliable electric power is not available, which is almost always the case in Africa, the Americas, and in much of SE Asia. The average household sharing for the labour of pumping is about 4 hours per day. (Keller and Keller, 2011) [1]. Thus it was important to find the ways for reducing the pumping labour or increasing the return to pumping labour by increasing irrigation water use efficiency and/ or yields. Over the past several years IDE and their Indian affiliate IDEI have been collaborating in an effort to develop affordable irrigation technologies to increase irrigation water use efficiency. During the past three years this collaborative effort has been done as part of IDE's Rural Poverty Initiative which was funded through a grant from the Bill and Malinda Gates Foundation. During this three year period the Team developed several water application products that are more efficient than the traditional surface (or flood) irrigation systems used by most smallholder farmers.

These systems include two types of low-cost drip irrigation, two types of low-cost low-pressure sprinkle irrigation, and a very low-pressure low-cost piped surface irrigation system. One of the drip systems costs about 5.00 USD/100 m^2 and utilizes simple layflat thin-wall polyethylene tubing throughout and hot-punched holes instead of emitters. The other has side passage button emitters that are inserted into the hot-punched holes by hand after the system is installed in the field (which takes 4 to 8 hr/1000 m^2) and costs about 6.00 USD/100 m^2.There is considerable literature available that compares the water application efficiencies of the various irrigation application methods, for example the chapter: *Irrigation Efficiency* by Howell, 2003. The fact that well maintained standard commercial drip irrigation systems provide the highest efficiencies and vegetable crop yields grown on small plots is well established. But there is no published data available based on controlled field studies using the low-cost SIP drip systems developed by the Team and socially marketed by IDE and IDEI. In view of the above, the Team solicited the support of IDEI to conduct a controlled study on a farmer's field to compare the water use efficiency and yields of the pre-punched and button drip irrigation systems with traditional surface irrigation. The pre-punched drip system utilizes simple to manufacture layflat thin-wall (125 to 250 micron) polyethylene (PE) lateral tubing and a hot needle to punch holes in it to make the drip (water) outlets (figure 1). The button emitter drip system has small (about the size of a carpet tack) side passage emitters that are inserted into the hot-punched holes by hand after the system is installed in the field (figure 2), which takes 4 to 8 hr/1000 m^2.

Fig 1: Pre-Punch Drip

Fig 2: Button Emitter Drip

Location: Sehore is situated at Latitude 23^0 12' North and Longitude 77 ^{0}05' East. It has an average elevation of 502 m. The crop sown was sponge gourd (local variety). The crop was sown on 12th April 2010 and harvested on 27th June 2010. The spacing of the crop was 0.9 m X 0.45 m. The soil of the experimental plot was silt loam. The water table depth was 30 m below the ground surface.

Results

Table 1: Sponge gourd yields for the different irrigation systems and water application levels.

Technology	Water application, %	Crop seasonal irrigation, mm	Yield, kg/1000 m^2	% increase in yield than 100% flood
Flood	100	455	75.2	0
Flood	125	568	105	39.6
Pre-punch	50	227	66.3	-11.8
Pre-punch	75	341	152.2	102.3
Pre-punch	100	455	201.3	167.6
Button Emitter	50	227	83.6	11.1
Button Emitter	75	341	181	140.6
Button Emitter	100	455	206.5	174.6

Conclusions

The study showed that if we to have the same yield there is 51% water saving in drip irrigated plot compared to surface irrigation in sponge gourd crop. Otherwise we may get two and a half times yield under drip irrigated plot in comparison to surface irrigated plot. There was 46.8% energy saving in irrigation in drip irrigated plot. It was found that there is 134 man-hrs labour saving in weeding operation under drip compared to surface irrigated plot. There was considerable labour saving of pumping the treadle pump if we use the drip irrigation system that in turn would lead to more cultivable area. With the intervention of drip irrigation system a small household can cultivate 1500 m^2 area from which the farmer can earn about 288 USD compared to 105 USD while using surface irrigation system. Thus the 90 USD cost of a 1,500 m^2 button drip system would be easily covered by the increased yield during its first crop season.

References

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