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DEVELOPMENT OF WAGON- WHEEL IRRIGATOR

Mukaila Olatunde Lasisi*, S. A. Ogundare and B. O. Fati

Department of Agricultural and Bio- Environmental Engineering, the Federal Polytechnic, Ado- Ekiti, Nigeria.

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***Corresponding Author**
Mukaila Olatunde Lasisi
Department of Agricultural and Bio- Environmental Engineering, the Federal Polytechnic, Ado- Ekiti, Nigeria.

ABSTRACT

The development of wagon- wheel irrigator can make the production and availability of food crops, citrus and vegetables possible throughout the year on small, medium and large scale basis at an affordable cost. In places and periods of water scarcity, the wagon- wheel irrigator can be used for economic growing of vegetables, citrus and food crops all –round the year. The system reduces water loss and conserved water during the period of scarcity. The beauty of this system is that, the controlled moisture available to the plant at low soil tension results in faster growth, higher yields, better quality and more environmentally and health friendly. The slow rate of water application improves the penetration of water into problematic soils and reduces substantially deep percolation and runoff losses. It drips and does not spray, thus sending lot of slow drip(s) where the water is needed. Hence, it saves water, money, time and makes provision for all- season farming. The system was developed using a simple principle of water flow through gravity to drip out water at regulated interval to irrigate a given farm land. The wagon- wheel irrigator was constructed and fabricated locally and tested. The application rate of the emitters is 20.70mm^3/sec and the efficiency of the emitters flow rate is 73.5%. The drum has 267 litres capacity and 42 emitters in all to irrigate 24m^2 portions of vegetable gardens. The total cost of production was estimated to be N33, 360 which is affordable by small and medium scale farmers.

KEYWORD: Development, Wagon, Wheel, Irrigator.

INTRODUCTION

Drip irrigation operates on the principle of delivering water to the root zone of plants through the emitters at a regulated rate. This system is suitable for frequent irrigation and is particularly appropriate for orchards. The beauty of drip irrigation is that, it drips and does not spray, thus sending lot of slow drip(s) where the water is needed. Hence, it saves water, money and time as well. Drip irrigation system has come a long way since some indigenous gardeners have constructed it by laying pipes, punctured them with small holes and turned water on at low pressure (Alam et al, 1999).

According to John Pohly (1999), the idea of irrigation originated in Israel it has impacted positively on water management and conservation, gardening and the growth of plants. In the world today issue of food supply, distribution have occupied a central position. The differences in approach among nations are a function of the different socio- political and economic environments in existence (Oyebanji, 1996). It is indeed assumed that the source of our food supply must not be subjected to or fall outside ambit of our physical control as a nation. It must be appreciated that food is absolutely essential for human survival and it was quest for food that moulded the early communities of mankind. Irrigation as described by Sharma (1990) is a science of survival that has been in existence since time immemorial. Irrigation is known to have been practiced in Egypt as early as 200 B.C. with River Nile as the major source of water. Irrigation is the artificial application of water to the soil for the purpose of supplying the essential moisture for plant growth to eliminate moisture deficiency at various stage of plant growth (Michael, 2000). The development of irrigation system started long time ago and the need arose because of unpredictable nature of rainfall for agricultural production in Nigeria (Anderson, 2002).The problem of not getting the required quantity of water at the right time brought about the use of irrigation system (FAO, 2002). The problem of water availability for agricultural production in Nigeria has led to reduction in agricultural produce which in turn reduce the food production (FAO, 2002). It is regretted that our society has tremendously lost focus on her major occupation which is widely known as farming. The reason is not far from the tediousness involved in the practice, insufficient rainfall, unstable rainfall and its high capital requirement. It is more pronounced that most of our agricultural products are suffering from natural rainfall for growth and development (Hargon, 1967). Irrigation is necessary to provide enough water to fill the deficit arising from the depletion of soil moisture from the combine action two separate phenomena of evaporation and transpiration (Amy Vickers, 2001).

The effectiveness of rainfall, even in high rainfall areas is vitiated by its erratic occurrences and uneven distribution. Drought alternating with floods in one or the other regions causes immense damage to crop production process. The main concern of productive agriculture is the effect and efficient supply of water and growing demand of crop production. On the other hand, when it is limited as compound to available water, the aim would be to maximize production per unit of land without watching water (FAO, 2000). In other place like Egypt or the Arabian Peninsula, it is hardly rain at all, farmer cannot rely justly on the rainfall to water their crops, they have to find some ways of getting water from the river to their fields (Rolland M. 2003).

MATERIALS AND METHOD

The wagon- wheel irrigator was designed and fabricated to apply the correct quantity of water slowly and evenly to the root zone of plants to keep the level of moisture in the soil within the optimum range for healthy growth and minimum stress. The drum was filled with water manually to the brim. The two valves connected to the drum were opened at angle 45^0 and 90^0, the water in the drum flow under gravity through the outlet into the mainline. The mainline received water from the drum and completely moved to the laterals. The water dripped out from the emitters on the laterals moved slowly and evenly to the root zone of plant. Seven beakers were arranged at the nozzle of each emitter and the water collected were measured and the time of collection were recorded to determine the discharge from the emitter. To prevent the emitter from getting blocked, a piece of string threaded through the holes and knotted at each end, pulling the string back and forth on block and holes. The front, back and exploded views of the wagon- wheel irrigator are shown in Figures 1, 2 and 3 respectively. In the design of the machine, the following factors were considered.

i. Cost: The available local materials were used to reduce the cost of production. The galvanized sheet used for fabricating the drum was obtained from abandoned machine.

ii. Strength and rigidity: Because the machine is a field implement, the material used for constructing its drum was a galvanized sheet of 5mm thickness to ensure adequate strength and rigidity.

Components Description

The front and back views of the implement after fabrication are shown in plate 1 and 2. The major components are described as follows.

Drum: The drum was made of galvanized sheet. It has dimension of 0.584 m diameter and 1m long. Two holes of 45 mm diameters were drilled into the drum to serve as the outlets. PVC butterfly valves were fitted into the outlet to regulate the flow of water into the mainline from the drum. The drum was painted with aluminium paint to prevent rusting.

Mainline: The mainline was made of PVC pipes. The pipe was bent using heat to conform to its circular shape. It has 0.620 m diameter and has a six PVC T- joint attached to it, to which the dripper lines were well fitted.

Laterals or Dripper lines: The lateral PVC pipes were 4m long and 50mm diameter. Holes of 4mm diameter were drilled on the pipes. Seven emitters were drilled on each pipe at 50cm intervals. The dripper was connected to the mainline. The end plugs were used to block the pipes to prevent loss of water at the tail end.

Emitters: Water is applied slowly and evenly to the root zone of plants through emitters. Seven emitters were designed for each lateral. Each emitter has 4mm diameter and there were 42 emitters in all from where water drip out to irrigate the vegetable garden.

Description of Wagon Wheel Irrigator

This is a simple and low cost irrigation system similar to drip irrigation system designed for the purpose of dry season vegetable farming. The system has 267 litres volume of water drum at the centre with outlet at the base of the drum with a plastic pipe which goes round the drum. The laterals are linked to the main line on which there are emitters. The water in the drum falls under gravity and applies directly to the root zone of plants.

Wagon- wheel Irrigator Testing

The developed wagon wheel irrigator will irrigate about $24m^2$ of vegetable garden. The water falls under gravity and uses the principle of conservative application of water. The wagon was test run with the drum filled with clean water and then the two valves were opened. Water dripped out from the lateral to the emitters to irrigate the land.

RESULTS AND DISCUSSION

The performance evaluation of the system was done at angle 45^0 and 90^0 valve openings and the records of flow rate at emitters were taken. The results are shown in tables 1 and 2 below.

Table 1: Results showing the emitters delivery at an opening of angle 45^0 of butterfly valve outlet.

Time(s)	Emitter 1 (ml)	Emitter 2 (ml)	Emitter 3 (ml)	Emitter 4 (ml)	Emitter 5 (ml)	Emitter 6 (ml)	Emitter 7 (ml)
10	120	120	120	120	160	160	160
15	250	250	250	270	280	280	280
20	270	270	280	280	310	310	310
25	310	310	310	320	320	320	320
30	470	470	470	480	480	480	480
35	710	710	710	740	740	740	740
40	790	790	700	790	820	820	790

Table 2: Results showing the emitters delivery at an opening of angle 90^0 of butterfly valve outlet.

Time(s)	Emitter 1 (ml)	Emitter 2 (ml)	Emitter 3 (ml)	Emitter 4 (ml)	Emitter 5 (ml)	Emitter 6 (ml)	Emitter 7 (ml)
10	170	170	170	170	220	220	220
15	320	320	320	330	350	350	350
20	350	350	350	370	380	380	380
25	380	380	380	420	420	420	420
30	550	550	550	550	580	580	580
35	820	820	820	840	840	840	840
40	920	920	920	920	950	950	950

Table 1 showed that when the valves were opened at 45^0, the discharges recorded in emitters 1, 2, 3 and 4 were lower than the one recorded in emitters 5, 6 and 7 in the first 25 seconds. Between 30 seconds and 40 seconds, the flow rate reduced drastically.

Table 2 showed that when the valves were opened at 90^0, the discharges recorded in emitters 1, 2, 3 and 4 had a great difference with emitters 5, 6 and 7. As the time increased, the difference reduced and the results showed that as the time increases, it will get to a point where the discharge will be uniform at the emitters i.e. $Q_1=Q_2=Q_3=Q_4=Q_5=Q_6=Q_7$ at emitters 1-7 respectively for the system.

The use of two outlet valves reduced the travel time of water round the mainline by 50% as against when one outlet was used. Tables 1 and 2 had a sharp difference in emitters flow rate due to the opening of valves at 45^0 and 90^0. The pressure head of the water in the drum also affected the results as the volume of water decreased in the drum, there was a drop in pressure thereby reducing the discharge at the emitters.

Functional Efficiency: This was determined by the ratio of the average discharge in emitters in all laterals to the rate of reduction in drum for 25 seconds multiplied by 100.

Average discharge in emitters in all laterals= 3105.3mm3 (output)

Rate of reduction in drum for 25 seconds = 4224.9mm3 (input)

$$Functional\ Efficiency = \frac{Output}{Input}\ x\ 100$$

$$= \frac{3105.3}{4224.5}\ x\ 100$$

$$= 73.5\ \%$$

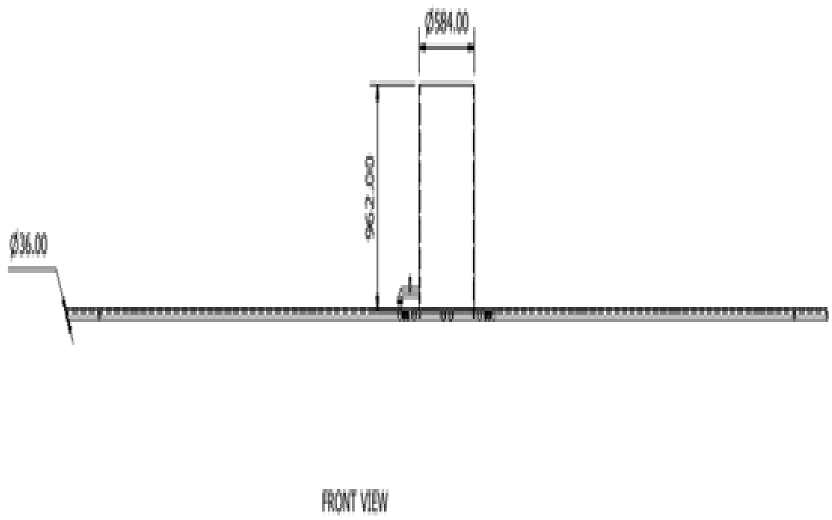


Plate 1.

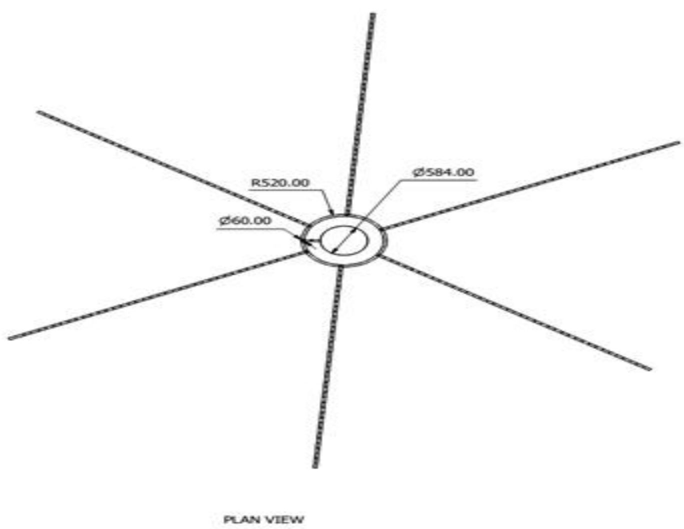
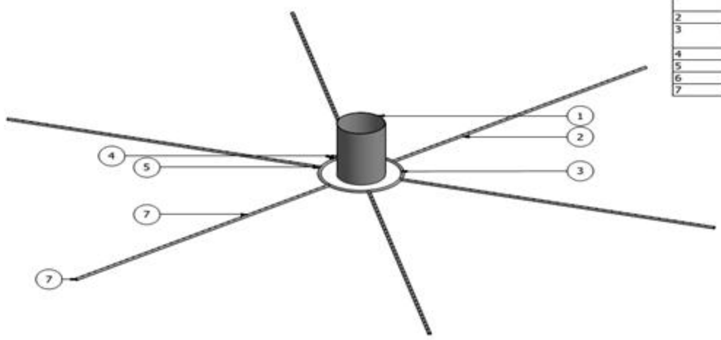


Plate 2.



PARTS LIST

PART NO	DESCRIPTION	SIZE	QTY	MATERIAL
1	DRUM	1000 X 584	1	MILD STEEL
2	DRIPPER LINE	4000 X 40	6	PVC PIPE
3	MAIN LINE	1000 X 40	1	MILD STEEL
4	VALVE	Ø40	2	PLASTIC
5	TEE JOINT	200 X Ø40	6	G. T.
6	END PLUG	Ø4	6	G. T.
7	EMITTERS	Ø4	30	PLASTIC

Plate 3: Isometric View.

CONCLUSION

The wagon wheel irrigator was designed, fabricated and tested. Based on the performance of the implement, the system reduces water loss and conserved water during the period of scarcity. The beauty of this system is that, it drips and does not spray, thus sending lot of slow drip(s) where the water is needed. Hence, it saves water, money, time and makes provision for all- season farming. The system was developed using a simple principle of water flow through gravity to drip out water at regulated interval to irrigate a given farm land. The application rate of the emitters is 20.70mm^3/sec and the efficiency of the emitters flow rate is 73.5%. The drum has 267 litres capacity and 42 emitters in all to irrigate 24m^2 portions of vegetable gardens. The total cost of production was estimated to be N33, 360.

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