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Investigating the Efficiency of saline water irrigation using Solar Evaporation techniques

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Abstract

Water is becoming scarce everywhere in the world and Sri Lanka is no exception. This scarce resource is frequently wasted through our bad practices and improper management. Water conservation in whatever possible manner is an urgent need of the hour in order to meet the increasing needs of all living beings.

Sri Lanka is an agricultural country. Its main goal is to achieve an equitable and sustainable agricultural development through development and dissemination of improved agriculture technology. There are efficient ways of watering cultivations such as drip irrigation to minimize the water consumption. But these methodologies are driven by manually set times for watering irrespective of the need. A better approach would be to water the plant based on the needs of the plants rather than on set frequency. In addition, there is a requirement for exploring the use of saline water for agriculture either by selecting suitable plants or by inexpensive treatment or a combination of both.

This research is about saving of water by introducing novel methodology to water the plant depending on ambient soil and temperature conditions. By this method, in addition to the water conservation, even seawater may be used for watering the plant. Also this novel innovation has many other social, economic and environmental benefits.

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Abbreviations and Acronyms

l	- Liter
m	- Meter
ml	- milliliter
cm	- Centimeter
g	- Gramm
kg	- Kilogram
m^2	- Square meter
0C	- Centigrade
ppt	- Parts per Thousand
mph	- Miles per Hour
RZWS	- Root zone watering system
Centibars (cB)	- Unit of soil moisture measurement. Centibar (cB) is a measurement unit of pressure. This is an hundredth of one bar; a bar is equal to one hundred thousand Newton per square meter or Pascal.

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Project Team

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1.0 Introduction

1.1 Problem Studied

Irrigation is the manual application of water to the land or soil. It is used to assist in the growing of agricultural crops, re vegetation of disturbed soils in dry areas and during periods of inadequate rainfall. Additionally, irrigation also has a few other uses in crop production, which include protecting plants against frost, suppressing weed growing in grain fields and helping in preventing soil consolidation.

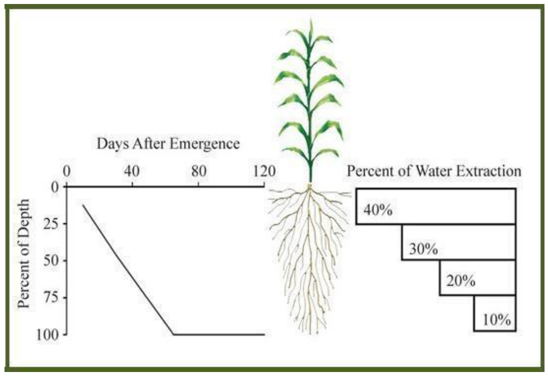


Fig 01: Root zone soil water extraction and plant root development pattern

There are two important points to be considered when promoting sustainable water consumption and agriculture;

- Use of water independent of quality (even high saline water) for irrigation.
- Increasing the soil moisture content to the required level at the root zone of a plant.

However, irrigation methods commonly used today require water in large amounts to achieve the moisture level desired at the root zone. Irrigation systems should consider different depths of rooting and thus different depths of wetting for trees (18-36 in.), shrubs (12-24 in.), herbaceous plants and turf (6 -12 in.) [1]. The proper management of soil moisture is often neglected, but improved soil moisture management is crucial for sustainable improvement of food production and water supply. [2]

From a wider perspective of soil productivity, reduction of soil erosion and runoff will contribute to achieving higher, profitable and sustainable plant production and to improve the regularity of stream flow.

1.2 Hypothesis

- Water Usage for irrigation
- Water Evaporation due to sunlight.
- Mulching process controls weed and evaporation on soil.

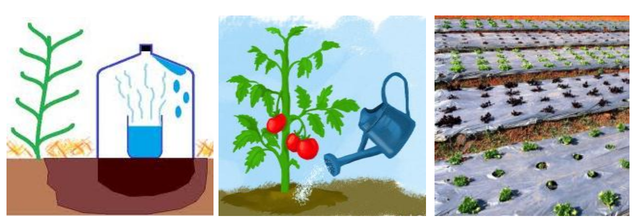


Fig 02: Detailing the Hypothesis

1.3 Objective

The overreaching objective of this research is to introduce a new method to improve the soil moisture content by root irrigation using minimum water amount. The specific objective is to develop a small watering system using waste plastic bottles for root irrigation to improve soil moisture using even high saline water

2.0 Methodology

2.1Location of study

The research was conducted at the backyard of the home of the student.

2.2 Materials used

Watering Unit

- 05 L Plastic bottle : 20 numbers
- 01 L Plastic bottle : 20 numbers

Other materials used

- Temperature scale
- Soil moisture meter
- Measuring equipment : Ruler
- Humidity meter
- Volumetric flask : 500ml
- Nursery Tomato plants
- Water, Fertilizer, Pesticides
- Utensils used for land preparation for paddy cultivation such as mamote,harrower, plough, etc.

2.3 Preparation of the Watering Device

This watering device designed with a methodology (solar evaporation) used to convert saline water into fresh water; to achieve the maximum benefit to plant.

2.4 Operations of Watering Device

Step 01:

5L Water Bottles, 1L Water bottles and 500 ml water bottles were used to prepare the watering device. The 5L Water Bottle was inverted. 1L water bottle was cut half and installed in the mid inner section of the 5L water bottle inverted as a vessel to contain the saline water.500 ml water bottle is cut half and pasted on the top of inverted 5L bottle for the funnel setup to pour water into the device.

Step 02:

The Evaporation part in the system,

The saline water is poured to the inner vessel of the watering device. During the day time the water get evaporated and condensed on the outer layer of the 5L water bottle and then flows to the bottom of the watering device where it will be stored. On the down part was covered in order to prevent the direct sunlight reach inside. (Lower part was painted to reduce the evaporation again of the condensed water). The Lid of the 5L water bottle was installed with a tube where it directs water to the root zone of the plant then it will be released by the tube connected to the lid to the root zone of the plant

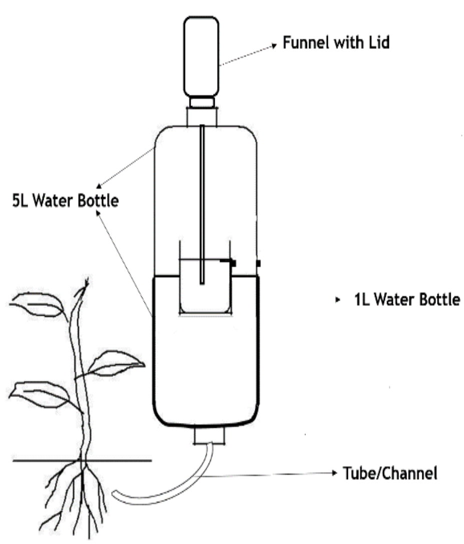
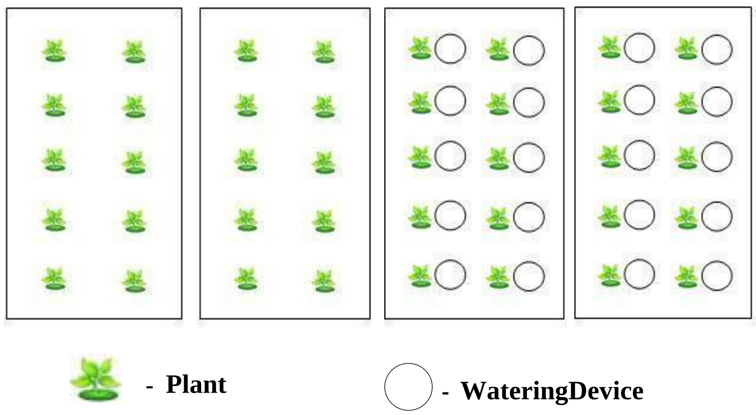


Fig 04: Watering Device

Fig 05: Individual Device

2.5 Experiment Methodology

Four experimental plots were prepared as follow;



Plot A: Plants with watering system using high saline water. (T1)

Plot B: Plants with normal watering system using normal water. (T2)

Plot C: Plants with bottle watering system using high saline water. (T3)

Plot D: Plants with bottle watering system using normal water. (T4)

3.0 Results and Discussion

3.1 General measurements

1. Area of each plot – 3m^2
2. Average level of water fed to each bottle – 400 ml
3. Time duration for one measurement - 24 hours (6 a.m. to 6 a.m. next day)
4. Number of measurement days - 12 (in twelve consecutive weeks)
5. Age of the plant at the time of replanting: 21 days
6. Height of a Plant at the time of replanting (avg): 59 mm
7. Ambient Temperature: 30^{0}C (Average) (varies from 26^{0}C to 34^{0}C)
8. Relative Humidity: 55% (Average) (varies from 45% to 65%)
9. Salinity of normal water: 0% (Constant)
10. Salinity of high saline water: 34% (Constant)
11. PH level of normal water: 7.17
12. PH level of high saline water: 7.48

Fig 06: Preparation of plots

Fig 07: Experiment plots

3.2 Measurement of water usage

Water fed to the bottles and normal watering is measured every day for all 04 plots. Water Evaporated and condensed to the soil is measured by calculating the water volume reduction in the inner bottle.

Table 01: Water evaporated Plot T3 &Plot T4 from 6.00 a.m. to 6.00 p.m.

	Plot C		Plot D
Bottle No	**Water evaporated (ml)**	**Bottle No**	**Water evaporated (ml)**
B_{C1}	41	B_{D1}	42
B_{C2}	40	B_{D2}	42
B_{C3}	40	B_{D3}	41
B_{C4}	42	B_{D4}	43
B_{C5}	42	B_{D5}	42
B_{C6}	43	B_{D6}	44
B_{C7}	45	B_{D7}	43
B_{C8}	42	B_{D8}	43
B_{C9}	42	B_{D9}	42
B_{C10}	43	B_{D10}	41
Total	**420**	**Total**	**423**

3.3 Plant height influenced by different treatments

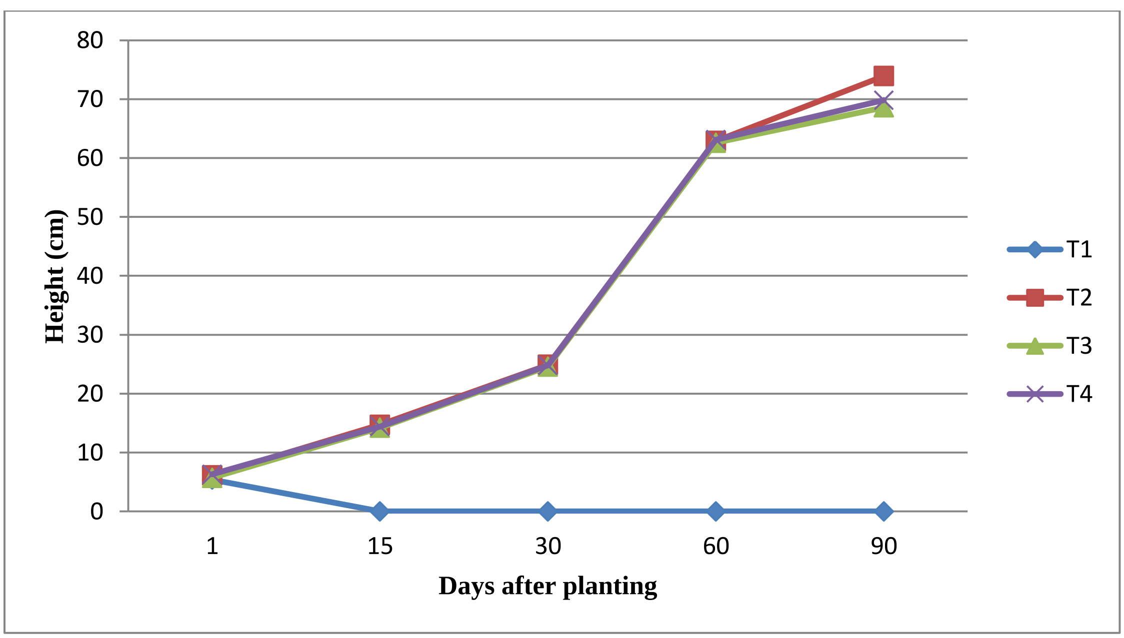


Figure 08: Variation of Plant height

The Fig 08 shows that there is an increasing plant height with the growth period in all the treatments. The maximum height was observed in the plots treated with treatment 2 (i.e plot treated with normal irrigation). Comparatively the saline water irrigated plants showed reduced plant height. However, Duncan's Multiple Range Test (DMRT) analysis showed that there are no any significant differences (p=0.058) in plant height with the different treatments except treatment T1. It is obvious that, irrigation with saline water will affect all plants growth parameters due to the osmotic effects. Salinity is an environmental stress that limits growth and development in plants.

3.4Number of compound leaves per plant influenced by different treatments

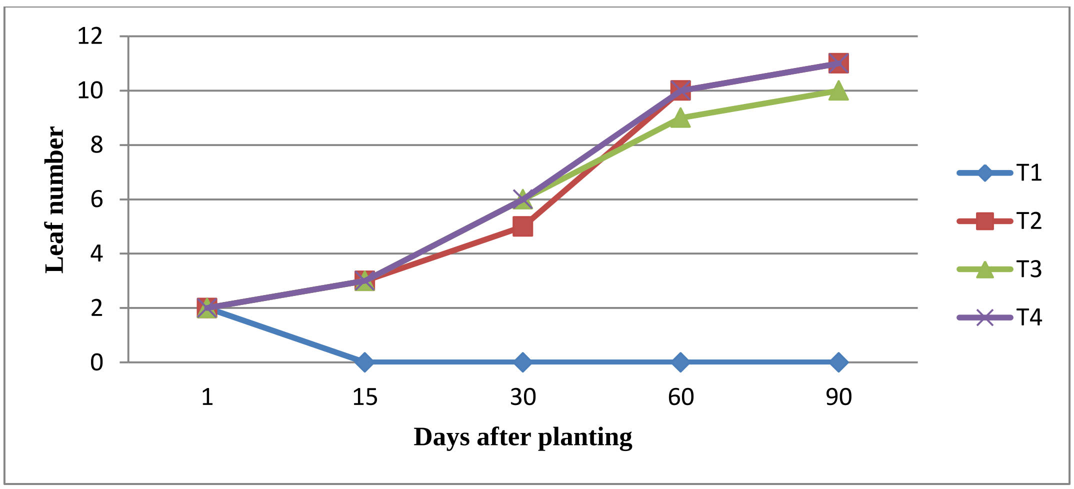


Figure 09: Number of Compound leaves

Similar to the plant height, number of leaves per plant was also counted during the growth period of the tomato. It shows that, the leaves numbers were varied from 7 to 11 at the later part of the growth (Figure 09). Maximum leave numbers were observed in the plots treated with T2 and T4. Negative effect of the saline water and the reduced depth of irrigation may influence on the total leaf number of the tomato plant in this study.

3.5 Yield influenced by different treatment

Treatments	Average Yield(Kg/Plant)			
Days after transplanting	01	30	60	90
T_1: **Saline water irrigation using traditional method.**	----	----	----	00
T_2: **Well water irrigation using traditional method.**	----	----	----	0.556
T_3: **Saline water irrigation using watering device**.	----	----	----	0.424
T_4: **Well water irrigation using watering device**.	----	----	----	0.512

Table 02: Average Yield

Yield was taken at the 90th day after planting. Average yield of 0.556kg, 0.424 kg and 0.512 kg per plant were harvested for the treatments T2, T3 and T4 respectively. Duncan's Multiple Range Test analysis showed there were no any significant differences (p=0.801)in yield with different treatments. However, soil moisture levels in the root zone of the tomato may be the reasons for the variation in yield among the treatments.

4.0 Discussion

As the human population grows, notably in the tropics and subtropics (where many rural people live in poverty), the difficulties of increasing food production also increases. In these areas, average crop yields are in gradual decline. In spite of improved plant breeding, the rates of rise in potential yield are slowing down. Problems caused by erosion and lowland flooding are more frequent, providing evidence of ecological instability in upland areas. Water tables are falling as a result not only from drought, but also from overuse.

Soil moisture is often neglected, but improved soil moisture management is crucial for sustainable improvement of food production and water supply. A wider perception of soil productivity and the reasons for soil erosion and runoff will contribute to achieving higher, profitable and sustainable plant production and to improve the regularity of stream flow

Scientific Endeavour should continue to increase our knowledge of the components of these problems and offer partial solutions. However, unraveling details of problems will not automatically result in workable means of solving them. Conventional approaches to crop production with minimum water quantity for watering offer limited scope for future progress. There is a need to think laterally, to see if there are other ways of looking at old assumptions to identify new ways forward.

This research, intended for farmers, aims to provide a solid basis for sound, sustainable soil moisture management with minimum water quantity at the time it required.

Heat from the sun causes water at the surface of oceans, lakes and rivers to change into water vapor in a process called evaporation. Using this simple theory, in a green house, the study produce water to evaporate and condense to the root level of the plant to make the soil moisture level high. This condenses water, once it gets mixed with the soil, does not get evaporated again to the environment.

Transpiration in plants is a similar process, in which water is absorbed from the soil by plant roots and transported up the stem to the leaves, from where it is released (transpired) as water vapor into the atmosphere. This phenomenon created lower water concentration in the plant, which stimulates plant roots to absorb water from the moisture contaminated in the soil. Transpiration from leaves highly affected with wind and relative humidity. Lower the humidity, higher the transpiration and hence, plant absorb more water from the soil. Hence, soil moisture level get lower and required regular feeding to increase the moisture level. Watering device, maintains the soil moisture level at the day time by the evaporation of water in water container. For the efficient water usage we can’t use high saline water to the plant this is confirmed in the T1 treatment. Plant growth and Yield affected by the different salinity level saline water irrigation to the plant. [3]

Figure 08 shows T2 plant is taller than other plant because it receives more water by the traditional irrigation method. Comparison of T3 and T4, T4 is little bit taller than the T3 because evaporation rate high in Watering Devices in Plot D (T4), One of the most important water quality parameter that affect the evaporation rate is the salinity concentration. Salinity affects the physical water characteristics such as surface temperature and density; moreover it reduce the vapour pressure on the water surface as well as it increase the amount of energy required to convert the water molecules from liquid on vapour state.[4] Therefore T4 treatment plants received more water than the T3 treatment plants. Table 02 shows the average yield variation of the T2, T3 and T4 treatments. According to this yield data T2 produced high yield than T4 followed by T3. However, the water usage is 30 times more than in T2 while comparing T3 and T4.

5.0 Conclusions

As there were no significant variations were observed in Duncan's Multiple Range Test analysis of plant height, leaf and yield of tomato among the treatments T2, T3 and T4, sea water irrigation with solar evaporation techniques can also be used in modern agriculture especially to low water required crops. At the same time, farmers will be able to conserve water and reduce the operational cost of cultivation.

Application of bottle system device to a farming plot to increase the moisture level of the root zone could successfully prevent the water waste by feeding water to the topsoil layer. By supplying the required amount of water at the roots with this controlling device, significant amount of water can be saved during the period.

This efficient and novel device could achieve following environmental and social benefits;

- Improvement of productivity of farmers due to less usage of water.
- Prevention of Soil erosion
- Increase of yield due to prevention of flushing off the fertilizer from plots.

6.0 Suggestion for further research

- Due to the pandemic this research has not been tested on a field to experience the real life conditions so that it is recommended to the field study.
- Try the research for different plant varieties.
- Experiment for using coconut fiber for removing Na ions in sea water.
- Technology adaptations for efficiency and effectiveness.

7.0 Reference

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