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Effect of Zai Pit Technology on the Infiltration Capacity of the Soil

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Increase in population and depletion of ground water resources are the major problems for food security and stability. Irrigated lands now produce only 4% of the food supply which doesn't meet the required demand. Zai pit technology provides a window of opportunity for farmers to improve crop performance in harsh & changing climate by trapping rain water and retains moisture by allowing water long enough to infiltrate. The present study was carried out at the College of Agricultural Engineering, Madakasira, which was located in Anantapuram district, Andhra Pradesh. The methodology follows estimation of infiltration rate for both Zai pit technology and furrow irrigation method. The Zai pit consists of dug holes excavated in grids, with a diameter of 15-20 cm,70 to 80 cm spacing, and a depth of 10-15 cm or more, filled with manure. The spacing of pits within a row, as well as the space between rows of pits, varies between 60 and 100 cm. Pits were prepared and organic manure was placed at the beginning of rainy season. In Zai pit technology,

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infiltration rate of the soil increased from 1.45 to 2.25 cm/hr whereas in furrow irrigation, it was decreased from2.24 to 1.1 cm/hr. In Zai pit technology, the organic manure was decomposed properly and the micro-organisms present in the soil make way to reach the organic manure and thus the micro pores in the soil increased whereas in furrow irrigation the soil was compacted which decreases the infiltration rate. This may be the reason behind the increasing of infiltration in the Zai pit technology. Thus, Zai pit technology reactivates biological activities in the soil and eventually leads to an improvement in soil structure and converts barren lands to cultivated lands.

Keywords: Zai pit technology; furrow irrigation; infiltration rate.

1. INTRODUCTION

The population of India is expected to stabilize around 1640 million by the year 2050. Moreover, every year the population will increase but the cultivated lands will not increase, to meet the required food supply [1,2]. So, it is necessary to convert the barren lands into cultivable lands with better land and water management to provide required food supply. Gross per capita water availability will decline from 1820 cu. m/ year in 2001 to as low 1140 cu.m/year in 2050. Increase in population and depletion of ground water resources is the major problem for food security and stability. Irrigated lands now produce only 4% of the food supply which doesn't meet the required demand. Therefore, it is necessary to choose a suitable irrigation method, to convert the uncultivated land into cultivated land for getting an optimum yield which meet the necessary requirement with available water by applying best irrigation management practices. Furthermore, good management and timely application of water may result in preventing of land degradation [3-5].

Infiltration is the process by which water on the ground surface enters the soil. Infiltration rate is a measure of the rate at which soil is able to absorb rainfall or irrigation. It is measured in inches per hour or millimeters per hour. If the soils have low infiltration rate, then the runoff will be more and also the water holding capacity of soil will be low [6,7]. The precipitation rate exceeds the infiltration rate, runoff will usually occur unless there is some physical barrier. To overcome the above problem, infiltration rate can be increased by reactivating the biological activities in the soil and thus improving the soil properties. This can be achieved by a new sustainable land and water management technique which is called Zai pit method.

1.1 Zai Pit Method

Zai pit is traditional land rehabilitation technology. Zai pit technology provides a window of opportunity for farmers to improve crop performance in harsh & changing climate. This method increases the amount of water stored in the soil profile by trapping rain water. It retains moisture and holds water long enough to allow it to infiltrate. It promotes the efficient use of limited quantities of organic matter and ensures the concentration of water & soil fertility [8,9].

Zai technology also reactivates biological activities in the soil and eventually leads to an improvement in soil structure. This eventually leads to less desertification [10-12]. The poorly available organic matter is placed at the bottom of the pit and not broadcast over the whole field. The organic material used attracts termites, which play a crucial role as they dig channels in the soil and by doing so improve its "architecture". The termites also digest the organic material, making nutrients more easily available to the crops planted or sown in the pits.

2. MATERIALS AND METHODS

The present study was conducted at College of Agricultural Engineering, Madakasira, which was located in Anantapuram district of Andhra Pradesh, it is located in arid ecological zone, and mainly it is designated as rain shadow region. The area is located between 13°56'56.89" N latitude and 77°18'42" Longitude. The annual rainfall of Madakasira is 532 mm and it is found to be drought prone area. The maximum air temperature is 40.3ºC and the minimum air temperature is 15.5 ºC and the average air temperature is 28.42 ºC.

2.1 Planning of Experiment

The experimental field with total area of 196m^2 was selected for experimentation. The total area was divided into 2 plots i.e., one plot for Zai pit technology and another plot for furrow irrigation method. One plot for Zai pit technology having 98m^2(7 m×14m) area was selected for

experimentation. Another plot for furrow irrigation having 98m^2(7 m× 14m) area was selected for experimentation. The spacing for tomato crop was selected about 80×80cmfor experimentation.

2.2 Field Preparation

FYM (Farm Yard Manure) was applied to the furrow irrigation site and the field was ploughed well to bring to optimum tilth. The ploughing provides opening of soil, crushing of clods, destroy the weeds and utilize the micro nutrients for crop growth. The Zai pit consists of dug holes excavated in grids, with a diameter of 15-20 cm and a depth of 10-15 cm or more, filled with manure (Fig. 1). They are spaced 70 to 80 cm apart. The spacing of pits within a row, as well as the space between rows of pits, varies between 60 and 100 cm. At the beginning of the rains, 200- 600 g of dung or compost are added to the pits.

2.3 Transplanting

The seedlings were transplanted into the field on 8th February, 2018. Light irrigation was done immediately after transplanting. Gap filling was done on fourth day of transplanting.

2.4 Harvesting

Harvesting of tomatoes was done manually at 60, 75 and 95 days after transplanting.

Harvested fruits were weighed and collected in trays and marketed in Madakasira Town.

2.5 Infiltration Characteristics

The infiltration rate was measured using the double ring infiltrometer as described by Michael (1978) in each experiment field. The standard double ring infiltrometer set consists of pair concentric rings (Fig. 2). The diameter of inner ring is 30 cm and outer ring is 60cm having depth 30 cm. The double ring infiltrometer made of 14mm gauge rust resistant galvanized steel sheet. The purpose of outer ring is to have the infiltrating water acts as a buffer zone against infiltrating water straining away sideways from the inner ring. The inner ring is used for measuring infiltration rate of water. One side (Bottom side) of two rings is sharpened for easy insertion of rings into soil. The other side is made hard and small elbow projections are provided diagonally opposite to each other at six places. These projections are useful for easy carrying of rings and also used as guides while inserting infiltrometer into the ground. The rings were driven at about 10cm deep into soil by using falling weight type hammer striking on a wooden plank placed on top of ring uniformly without or undue disturbance to soil surface.

2.6 Installation of Infiltrometer

For accurate installation of infiltrometer, the land was neatly cleaned by removing small obstacles such as stones or twigs etc. The rings are driven into the ground by falling weight type hammer striking on top of the rings or by light blows with an ordinary hammer and using a short wooden plank to prevent damage to the edges of the metal rings. To avoid the disturbance of the soil, the vibrations are avoided by standing one or two persons standing on the ring. After installing inner ring, place the outer ring with the cutting edge facing down and exact concentric with inner cylinder. With the help of driving plate and impact absorbing hammer slowly insert the outer ring. The both cylinders are installed about 10cm deep in the soil. Care is taken to keep the installation depth of the rings the same in all experiments. This is accomplished by marking the outside of the rings at the 15cm level and driving the rings up to the mark.

2.7 Measurement of Infiltration Rate from Double Ring Infiltrometer

Infiltration was measured in three stages i.e., before planting, before harvesting and after harvesting. For measuring the infiltration rate of the soil, fill the outer ring with water, then immediately in the inner ring to approximately 10cm. To avoid the seepage of water from inner ring to outer and vice-versa, the water levels in both the cylinders are kept approximately the same. After filling water, immediately determine the water level in inner ring with the help of point gauge. Water level in the inner ring as indicated on the point gauge is measured starting from small time intervals (5 min). The time interval is gradually increased as 10 min, 20 min, 30 min, 40 min, 1 h. The water is refilled into both rings when the water level is reaches near to 5 cm mark. Care is taken to fill the container completely each time before adding water to the rings. This process is continued the infiltration reaches a constant infiltration rate. The

readings have been taken in three trails at each experimental setup. The infiltration rate is calculated bythe following formula

$$\text{Infiltration rate (cm/h)} = \frac{\text{Initial water depth} - \text{final water depth}}{\text{Time required, h}}$$

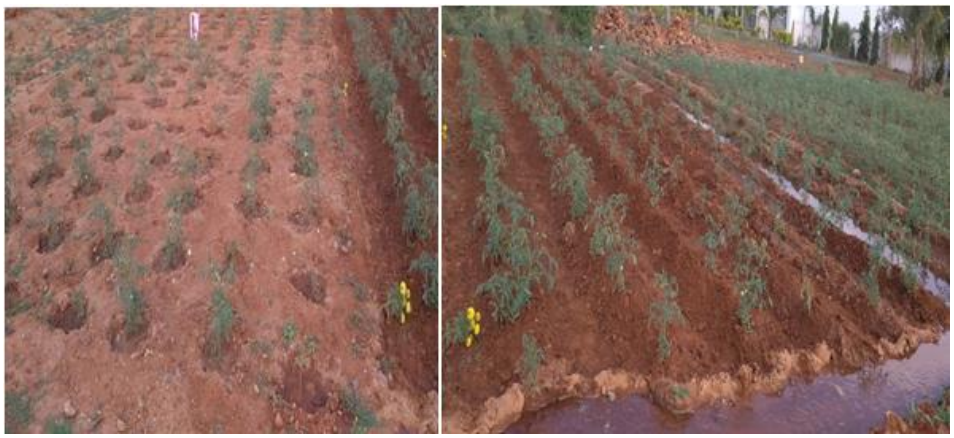

Fig. 1. Zai pit and furrow methods

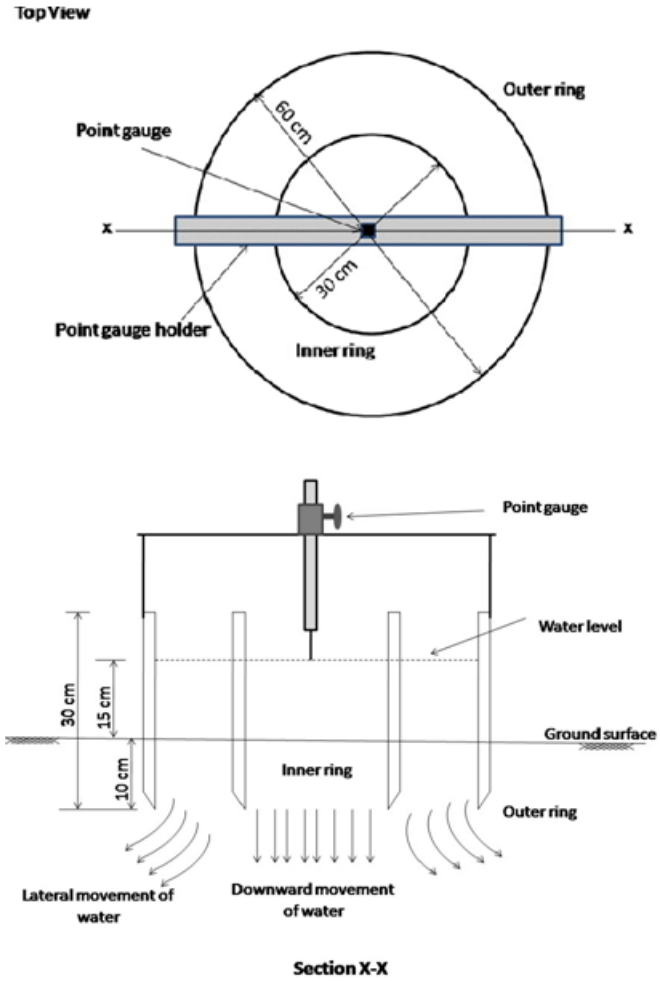

Fig. 2. Double Ring Infiltrometer

3. RESULTS AND DISCUSSION

3.1 Measurement of Infiltration Rate in Furrow Irrigation Method

Infiltration was measured in three stages i.e. before planting, before harvesting and after harvesting. The obtained values were shown in Fig. 3. From the Fig. 3, it was observed that the infiltration rate in furrow irrigation method is in decreasing trend *i.e* 2.24, 1.275 and 1.1 cm/hr during the three stages of crop. This was due to compactness of soil surface by the application of irrigation water in the form of flood irrigation in furrows.

3.2 Measurement of Infiltration rate in Zai Pit Method

Infiltration was measured in three stages i.e., before planting, before harvesting and after harvesting. The obtained values were shown in Fig. 4. From the Fig. 4, it was observed that the infiltration rate in Zai Pit technology is in increasing trend i.e.1.45, 1.675 and 2.2 cm/hr during the three stages. This is may be due to organic matter which is present in the pits attracts the micro-organisms, so that they travel towards the organic manure, which increases micro pores and pore space in the soil.

3.3 Comparison of Yield of Tomato Crop between Zai Pit Technology and Furrow Irrigation

- Tomato crop was harvested manually in the both methods and the yield was calculated and presented in Table 1.
- The yield of tomato crop increased twice in Zai pit technology (4081.63 Kg/ha) when compared to furrow irrigation method (2040.81Kg/ha).

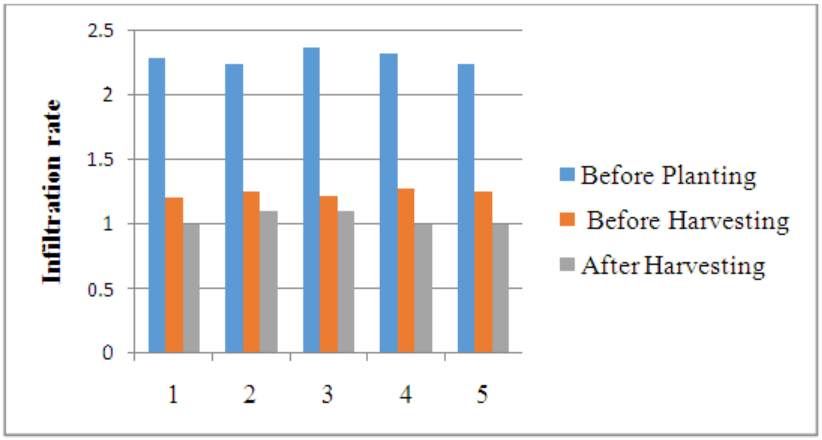

Fig. 3. Infiltration rate in furrow irrigation method

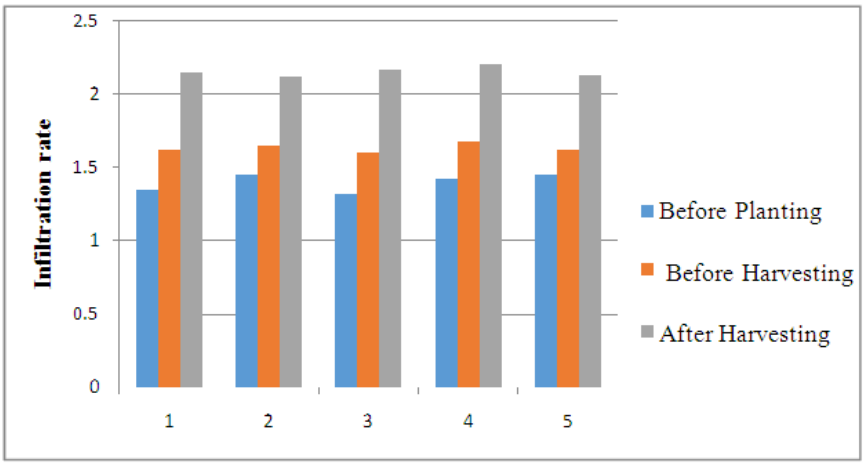

Fig. 4. Infiltration rate in Zai Pit method

Table 1. Comparison of yield of tomato crop between zai pit technology and furrowirrigation method

S. No.	Crop	Type of irrigation method	Yield(kg/ha)
1		Zaipit technology	4081.63
2	Tomato	Furrow irrigation method	2040.81

4. CONCLUSION

The Zai concept captures rainfall and runoffs, promotes the efficient use of limited quantities of organic matter and ensures the concentration of water and soil fertility at the beginning of the rainy season. The use of the Zai pit method increases the amount of water stored in the soil profile by trapping rain water. It retains moisture in-situ and holds water long enough to allow it to infiltrate. Zai pit improves soil fertility in completely barren soils where nothing could grow before. Continuous cultivation with Zai pit technology for 3 years, barren land can be converted into cultivated land. Zai technology also reactivates biological activities in the soil and eventually leads to an improvement in soil structure. The infiltration rate was increased from 1.45 to 2.25 cm/hr in Zai pit technology and the infiltration rate was decreased from 2.24 to 1.1 cm/hr in furrow irrigation. The yield of tomato crop increased twice in zai pit technology (4081.63 Kg/ha) when compared to furrow irrigation method (2040.81Kg/ha).

Thus, Zai pit technology provides a window of opportunity for farmers to improve crop performance in harsh & changing climate by trapping rain water and retains moisture by allowing water long enough to infiltrate and increases crop productivity.

HIGHLIGHTS

- Infiltration is the process by which water on the ground surface enters the soil. Infiltration rate is a measure of the rate at which soil is able to absorb rainfall or irrigation.
- The use of the Zai pit method increases the amount of water stored in the soil profile by trapping rain water. The infiltration rate was increased from 1.45 to 2.25 cm/hr in Zai pit technology and the infiltration rate was decreased from 2.24 to 1.1 cm/hr in furrowirrigation.
- The yield of tomato crop increased twice in zai pit technology (4081.63 Kg/ha) when compared to furrow irrigation method (2040.81Kg/ha).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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