PITCHER POT IRRIGATION AND TILLAGE PRACTICES ON SALINITY MANAGEMENT FOR VEGETABLE PRODUCTION UNDER COASTAL SOIL OF WEST BENGAL

A Thesis
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in partial fulfillment of the requirement
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In

Agriculture (Soil and Water Conservation)

By

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Dedicated to my Teacher, beloved Parents, Sister and my Grand Mother

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APPROVAL OF EXAMINERS FOR THE AWARD OF THE DEGREE OF DOCTOR OF PHILOSOPHY IN AGRICULTURE (SOIL AND WATER CONSERVATION)

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This is to certify that the work recorded in the thesis entitled ***"Pitcher pot irrigation and tillage practices on salinity management for vegetable production under coastal soil of West Bengal"*** *submitted by* ***Rahul Adhikary*** *in partial fulfillment of the requirement for the Award of the Degree of* ***Doctor of Philosophy*** *in Agriculture (Soil and Water Conservation) of the faculty of Agriculture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal is a faithful and bonafide research worker. The work was carried out under my personal supervision and guidance.*

The result of the investigation reported in this thesis has not so far been submitted for any other Degree or Diploma. The assistance and help receive from various sources during the course of investigation have been duly acknowledge.

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Title of the thesis	**Pitcher pot irrigation and tillage practices on salinity management for vegetable production under coastal soil of West Bengal.**
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Abstract

Coastal saline soil of West Bengal suffers from the multi-dimensional production constraints, of which non-availability of good quality irrigation water is the prime one. Some of the available options for saline water use include the appropriate irrigation methods and their scheduling, blending of saline and fresh water, selection of crop varieties resistant to salinity etc. Localized irrigation system becomes one of the most effective innovations for reducing moisture stress and mitigating soil salinity. Thus developing traditional, low-cost, water saving technology for sustainable crop production, particularly in saline soil area remains a major change in science and engineering, one that has been ignored by most international development programs. A notable example of such a neglected traditional method is pitcher irrigationIn order to assess the effectiveness of various application of blending of saline and sweet water in pitcher pot for pitcher irrigation with different type of tillage which improved soil quality and enhancement of crop productivity, the present study has been undertaken.The experiment was conducted with eight treatments combinations viz. T_1 = Sweet water (100%) + Conventional tillage, T_2 = Sweet water (100%) + Mulch Tillage, T_3= Sweet water (25%) + saline water (75%) + Conventional tillage, T4= Sweet water (25%) + saline water (75%) + Mulch tillage, T_5 = Sweet water (50%) + saline water (50%) + Conventional tillage, T_6 = Sweet water (50%) + saline water (50%) + Mulch tillage, T_7 = Sweet water (75%) + saline water (25%) + Conventional tillage and T_8 = Sweet water (75%) + saline water (25%) + Mulch tillage. All the treatments were combination of saline and sweet water with pitcher (10lit capacity), placed between four plants. Crops taken in experiment vegetable crops viz, tomato in rabi and chilli in summer season. The plots were maintained in split plot design in rabi and summer crops having 15 sq. m plot size with 4 replication.The selected sites of the experiments were at the farmer's field

at the Simabandh village, Kakdwip, South 24 Parganas, West Bengal under Coastal saline Zone, taking tomato-chilli vegetable for 2012 and 2013.The results reveals that (T_8), (T_7), (T_2), (T_1), (T_6), (T_5) and (T_4) treatmentsshow much better performance than control plot (T_3) in respect of yields,yield attributes, growth parameters, and water use efficiencies for each of the crops. Application of blending of saline and sweet water in pitcher pot with different type of tillage improves the physical and chemical environments in soil thus favoring better soil conditions and nutrient availabilities towards better growth and yield of crops. Among the various application of blending of saline and sweet water in pitcher pot with different type of tillage, the 25% saline water + 75% sweet water with mulch tillage proves much superior for growth, yield and yield attributes of various crops as well as water use efficiencies and various soil properties. Statistical correlations between various soil properties and yield and other growth parameters were also worked out.Step down regression analysis were also made to identify the best fitted equation between yield and other soil properties.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS USED IN THE TEXT

SL. NO.	ABBREVIATIONS	FULL FORM
1.	%	Percent
2.	@	At the rate of
3.	^{0}C	Degree centigrade
4.	BD	Bulk density
5.	cc	Cubic centimeter
6.	cm	Centimeter
7.	DAS	Days after sowing
8.	*et al.*	*et aliorum*
9.	Fig.	Figure
10.	gm	Gram
11.	GMD	Geometric mean diameter
12.	ha	Hectare
13.	hr	Hour
14.	i.e.	That is
15.	irri	Irrigation
16.	K	Potassium
17.	kg	kilogram
18.	Km	Kilometer
19.	L.	Linnaeus
20.	M	Meter
21.	m	Million
22.	Mm	Milimeter
23.	MWD	Mean weight diameter
24.	N	Nitrogen
25.	no.	Number
26.	NS	Not significant
27.	OC	Organic carbon
28.	P	Phosphorus
29..	pH	Pondus hydrogen
30.	q	Quintal
31.	S.coefficient	Structural coefficient
32.	SE (m)	Standard error of mean
33.	Sig.	Significant
34.	Std.	Standard
35.	t	Tonn
36.	WSA	Water stable aggregates
37.	Y	Yield

Chapter 1

Introduction

Water is the primary input for crop production and increasingly become scarce due to its high demand in agricultural sector. Quality of water is assuming great importance with the increasing demand in industries, agriculture and rise in standard of living. Agriculture is the major user (89%) of the India's water resources. However, dwindling of fresh water resources and deterioration of irrigation water quality due to its overuse to meet up the high demands in agriculture sector becomes the serious concern in sustainable crop production .Driven by this twin pressures, poor quality of irrigation water even saline water are being increasingly diverted to irrigation purpose in fresh water scarce regions. Thus developing traditional, low-cost, water saving technology for sustainable crop production, particularly in saline soil area remains a major change in science and engineering, one that has been ignored by most international development programs (Brinbridge 2001). A notable example of such a neglected traditional method is pitcher irrigation.

Pitcher irrigation is an ancient irrigation method thought to have originated in Northern Africa and Iran (Stein, 1998). Pitcher irrigation has been mentioned in a book written some 2000 years ago in China (Sheng, 1974). The method reportedly has been used to irrigated watermelons in India and Pakistan (Mondal. 1974); horticultural crops in Brazil, Germany and Indonesia (Stein, 1997) and corn, tomato and okra in Zimbabwe (Batchelor *et al.,* 1996).

Pitcher irrigation, a traditional system of irrigation alternative to drip method is the latest advancement and effective innovation of localized methods of irrigation and found suitable where water scarcity becomes a major stress for crop production. Pitcher irrigation is a self-regulative, low cost and eco-friendly technique of irrigation having high potential of energy saving, water saving and very much efficient in orchard planting (Gupta 1999). In this method, unglazed backed earthen pitchers buried up to neck into the soil, filled with water which slowly seeps out through their pores wall into the root zone by the action of static and soil suction pressure. The seepage rate is directly proportional to the pitchers conductance and potential evapotranspiration of crops and is controlled by the moisture content in the soil matrix or its environments, namely the soil, climate and plants and the pitcher (Mondal, 1978; Stein, 1998).

Indiscriminate use of saline irrigation water in absence of proper management of water –crop- soil poses a grave risk of endangering to the development of salt effected soils accompanying with serious crop damage. Several studies indicate that saline water is to be irrigated in such amount and quality that meets the evapotranspiration demands of the crop, minimize root zone salinity and selection of suitable crop and varieties tolerant to water and salinity stress (Katerji *et al.*, 2003).

Some of the available options for saline water use include the appropriate irrigation methods and their scheduling, blending of saline and fresh water, selection of crop varieties resistance to salinity etc. Localized irrigation system becomes one of the most effective innovations for reducing moisture stress and mitigating soil salinity. High energy pressurized system for irrigation like sprinkler and drip although found suitable, but have limitations of high mechanizations and involves with huge initial investment beyond the reach to the poor farmers. The present investigation is thus, proposed for using saline water blended with fresh water in various concentrations for irrigation purposes through pitcher method and its efficiencies towards minimization of salt related constraints to enhance crop productivity in fresh water deficit region.

Coastal saline soil of West Bengal suffers from the multi-dimensional production constraints, of which non-availability of good quality irrigation water is the prime one. The high EC content of soil detrimental for plant growth in these regions emphasizes the need for growing salt tolerant crops like rice, chilli, sunflower, sugar beet etc. of which Tomato (*Solanum lycopersicum* L) and Chilli (*Capsicum annuum* L.) are considered as most promising for the area.

Tomato, (*Solanum lycopersicum* L) is one of the most consumed vegetables in the world and global production is estimated at around 136 Billion ton per year. Tomato is the 3rd most economically important vegetable crop after potato and onion. Major production countries in descending order include China, USA, India, Turkey and Egypt respectively. Europe contributes 22% of the world's tomato production. Tomato is worldwide the most important greenhouse vegetable crop with a production of 720 MT and a total value of $170 Million per year (FAOSTAT, 2008).

In India it is grown about 0.46 M ha area with 7.28 M mt production with 15.9 mt/ha productivity. The major tomato producing states of the country are Bihar, Karnataka, Uttar Pradesh, Orissa, Andhra Pradesh, Maharashtra, Madhya Pradesh and West Bengal. In West Bengal, tomato is grown over an area of 43,600 ha with the production 0.59 M mt with productivity of 13.6 mt/ha.

Tomato is a dietary source of vitamins especially A and C, minerals and fiber, which are important for human nutrition and health. Also, tomatoes are the richest source of lycopene, a phytochemical that protects cells from oxidants that have been linked to human cancer (Giovannucci, 1999). Other antioxidant compounds in tomato fruit include flavonoids and phenolic acids. Flavonoids and phenols are regarded as potentially health benefitting compounds since they are implicated in the prevention of human inflammatory and, cardiovascular diseases as well as cancer (Mutanen et al., 2011). Chlorogenic acid (CGA) is the major soluble phenolic in Solanaceous species. In some tomato cultivars CGA represents 75% of the total phenolic contents in green and 35% in ripe fruit (Wardale, 1973). The beneficial health properties, based on its antioxidant properties, include the prevention of cancer (Martin et al. 2004) and atherosclerosis. In addition CGA also shows hepatoprotective, hypoglycemic and antiviral activities (Tamagnone *et al.,* 1998; Park *et al.*, 2010).

Fresh fruits of tomatoes are used in salads, various culinary preparations, juices, or processed in the form of purees, concentrates, condiments and sauces Varieties for fresh consumption are cultivated in greenhouses and in the open air, while varieties for processing are only cultivated in the open air. Today, nearly all the tomato cultivars for the fresh market, as well as an increasing number of cultivars for processing, are hybrids (Díez & Nuez, 2008; Razdan & Mattoo, 2007).

Chilli is one of the most important vegetable in all over the world. Chillies are native of Peru and Mexico and Portuguese were the first to introduce chillies in India during 15th century. Its cultivation became popular in the 17th century. Though chilli is an introduced crop in India, due to its suitable growing climate, India stands first in chilli cultivation in the world covering 45 per cent of the total hectarage (Reddy and Sadashiva, 2001).

Chilli (*Capsicum annuum* L.) belongs to the family Solanaceae, grown for its fruit. It is one of the most important spice cum vegetable crops of the world and is widely cultivated throughout the warm, temperate, tropical and subtropical countries. It is an indispensable spice essentially used in every Indian cuisine due to its pungency, spice, taste, appealing odour and flavour. Chilli fruits are rich source of Vitamin C, A and E.

Chilli is raised over an area of 1832 thousand hectares in the World, with a production of 2959 thousand tons in the year 2009 (Tiwari, 2010). India is the world leader in chilli production followed by China and Pakistan. This shows that the bulk share of chilli production is in Asian countries, though it is produced throughout the world. The top 10 chilli producing countries, India, China, Ethiopia, Myanmar, Mexico, Vietnam, Peru, Pakistan, Ghana and Bangladesh. Accounted for more than 85% of the world production in 2009, the lion's share is taken by India with 36% share in global production, followed by China (11%), Bangladesh (8%), Peru (8%) and Pakistan (6%) (Tiwari, 2010).

In India, chilli is grown on an area of 7.67 lakh ha with annual production of 12.02 lakh tonnes and productivity of 1.6 tonnes per ha (Anon, 2010), which is considerably lower as compared to world's productivity. The production of Chilli in India is dominated by Andhra Pradesh which contributes nearly 57% to the total production. Karnataka is the second largest producer contributing 12% to the total production followed by Orissa (5%), West Bengal (5%), Maharashtra (4%), Madhya Pradesh (3%)and others about 14% during 2006-07 (Tiwari, 2010). About 95 per cent of total annual production of the country is consumed within the country and five per cent is exported to other countries such as USA, Srilanka, Bangladesh, Nepal and Mexico. The other commercially chilli growing states are Punjab and Bihar. The highest productivity is in Jammu and Kashmir followed by Tamil Nadu, Delhi, West Bengal, Punjab and Bihar.

Particular vegetable crop suffer by lack of good quality irrigation facilities and management practices during winter and summer seasons. On this background pitcher pot irrigation with different type of tillage have the opportunity to act as high water use efficiency as well as reducing soil salinity and enhancing crop productivity in the coastal saline zones of West Bengal.

The proposed programmed, thus envisaged to assess the effectiveness of tomato and chilli crop production by pitcher pot irrigation with tillage in different season and conserving water towards increasing of crop productivity in this region.

Keeping above views the present study therefore, aims to investigate with the following objectives —

- To access the stability of pitcher irrigation method for using blending of saline and sweet water with different tillage on vegetable crop production.
- To compare the water use efficiency for application of blended saline and sweet water in various combinations towards growth and yield of vegetable crops.
- To study the use of pitcher irrigation and tillage on improvement of physical and chemical properties in soil.

Chapter 2

Review of Literature

Some of the available options for saline water use include the appropriate irrigation methods and their scheduling, blending of saline and fresh water, selection of crop varieties resistance to salinity etc. Thus developing traditional, low-cost, water saving technology for sustainable crop production, particularly in saline soil area remains a major change in science and engineering, one that has been ignored by most international development programs (Brinbridge 2001). A notable example of such a neglected traditional method is pitcher irrigation. Pitcher irrigation, a traditional system of irrigation alternative to drip method is the latest advancement and effective innovation of localized methods of irrigation and found suitable where water scarcity becomes a major stress for crop production.

Effect of pitcher irrigation:

The pitcher pot or pitcher method is one of the most efficient systems of irrigation known and is ideal for many small farmers. (Mondal, 1974; Reddy and Rao, 1980; Bainbridge, 1988; Bainbridge *et al.*, , 1998). Da silva *et al.*, ., (1981) stated that pitcher pots can either be filled by hand if labor is inexpensive or connected to a pipe network or reservoir. Clay pots can be glued together to make porous capsules, or porous capsules can be manufactured.

Stein (1997) reported that the water seeps out through the clay wall of the pitcher pot at a rate that is influenced by the plant's water use. This auto regulation leads to very high efficiency, considerably better than most drip irrigation systems, and up to 10 times more efficient than conventional surface irrigation. Pitcher pots are better than high technology drip systems in several respects. First, they are not as sensitive to clogging as drip emitters, although they may clog over time (three to four seasons) and require renewal by reheating the pots. Second, pitcher pots can be used without pressurized or filtered water systems. Third, pitcher pots can be made with locally available materials and skills. Fourth, pitcher pots are less likely to be damaged by animals or clogged by insects than drip systems. And finally, while even a brief interruption of water supply to a drip irrigation system due to a pump or filter failure can lead to serious problems and costly damage to crops, the pitcher pot systems may require water only once a week.

The drawbacks of pitcher pots include the cost of the clay pots, the energy required to fire them, the time to install them, and less flexibility once they are installed. However, Mondal (1978) found that 800 pitcher pots costing US$ 280/ha (1978 dollars) provided a potential profit of US$ 400 to 1030/ha, for a net profit of US$ 120 to 750/ha after paying for the clay pots. Amortizing the clay pots over several year would make the conversion even more profitable. Where water costs are high (due to labor or pumping cost) or where supplies are limited the returns would be even better.

Okalebo *et al.,* (1995) reported that the effectiveness of pitcher irrigation in curbing the effects of salinization was determined in Juja, Kenya, using 4 salinity treatments on a red loam soil. The 4 salinity treatments were 0.02, 2.00, 4.00, 8.00 mmhos/cm. The test crop grown was French beans (Phaseolus vulgaris) which is highly sensitive to the concentration of soluble salts in irrigation water. Results demonstrated that normal and above normal yields were obtained using this new technique of irrigation. A decrease of 0.24 cm and 0.31 grams for every 1 mmhos/cm increment of salinity level was observed for the average length and weight of the pod, respectively. While using this technique a potential yield of 61.45% was realized using irrigation water of 8.00 mmhos/cm. currently, the potential yield of French beans is 0% with irrigation water of below 4.2 mmhos/cm salinity level applied using other irrigation methods. The results encourage the use of pitcher irrigation in Kenya and especially in arid and semi-arid lands where salinization is a major hindrance to crop productivity.

Sheng Han (1974) describes the use of pitcher pot irrigation in China more than 2000 years ago. It is likely that, pitcher pot irrigation had been used for many years before this description was published, and current practices remain much the same. "Make 530 pits per hectare, each pit 70 cm across and 12 cm deep. To each pit add 18 kg of manure. Mix the manure well with an equal amount of earth. Bury an earthen jar of 6 1 capacity in the center of the pit. Let its mouth be level with the ground. Fill the jar with water. Plant four melon seeds around the jar. Cover the jar with a tile. Always fill the jar to the brink if the water level falls."

Rai (1982) reported that the water use efficiency of irrigation systems depends on many factors including soil type, crop type and management, weed competition, and microclimate. Few controlled experiments have been conducted on pitcher pots, but the results from these tests suggest pitcher pots may use as little as 10% of the water used in conventional surface irrigation.

Ajit *et al.,* (2007) studied hydraulic conductivity using modified falling head method and a constant head method of eight pitchers selected from local producers in Udaipur. The two methods of measuring Ks was found accurate. However, procedure for falling head method was faster and simpler. Ks varied from 360.5 to 484.0 mm/day considering falling head method and from 398.6 to 574.4 mm/day in case of constant head method.

Effect of Pitcher irrigation on vegetables and fruits

Batchelor (1997) carried out Irrigation trials and experiments in south-east Zimbabwe and northern Sri Lanka during 1985 to 1995 to compare and quantify the benefits of using simple micro irrigation techniques on traditional vegetable gardens. Micro irrigation techniques that were evaluated included low-head drip irrigation, pitcher irrigation and subsurface irrigation using clay pipes. Of these methods, subsurface irrigation using clay pipes was particularly effective in improving yields, crop quality and water use efficiency as well as being cheap, simple and easy to use. The comparative advantages of subsurface irrigation were maintained for a range of crops grown under different climatic conditions.

Comparing the field experiment conducted by Mondal(1974) and scheuring(1983), it was stated that yield of pitcher pot irrigated melon in India was 25 t/ha using only 2 cm water/ ha (Mondal, 1974), where the yields of melon was 33 t/ha using 26 cm of water with flood irrigation (Scheuring, 1983).

Mondal *et al.,* (1992) described that baked earthen pitchers were buried up to the neck in soil. Six-week-old brinjal [aubergine] and 4-week-old cauliflower seedlings were planted around the pitchers retaining 3 and 4 plants/pitcher, respectively on establishment. The pitchers were filled with saline water of electrical conductivity 4, 8, 12 or 15 dS/m. Tube well water (EC 0.4 dS/m) was used as a control. Brinjal yield showed a 20% decrease at 12 dS/m compared with the control but was not adversely affected below this level of salinity. Curd yield of cauliflower was not adversely affected by irrigation with saline water. The highest curd yield (6.2 kg/pitcher) was obtained with 12 dS/m irrigation water. Pitcher irrigation is considered more efficient than surface, drip and sprinkler irrigation and produces yields even when saline water is used. However, this method is labour intensive.

Balakumaran *et al.,* (1982) conducted a detailed study of cucumber production which showed that irrigation of 1.9 mm/ha with pitcher pots provided yields comparable to 7.3 mm/ha by hand irrigation. he grew Hopi corn *(Zea mays)* using pitcher pots with a water use on a full field basis of only 7.5 cm/ha, one tenth the conventional water use for corn in California. The above ground plant yield per cubic meter of water was 6.3 kg, total plant yield was 12.6 kg/m^3.

Gobin *et al.,* (1998) described that in Enugu State, southeast Nigeria, present day population densities of up to 400 persons per square kilometre and the limited availability of land for agriculture have encouraged intensified land-use practices such as dry season gardening. Parastatal controlled formal irrigation schemes, concentrating mainly on rice production, currently operate at only 20% of their capacity. Given the present economic crisis, government funding to rehabilitate these schemes is unlikely. Informal vegetable irrigation by smallholder farmers, however, is on the increase with many men cultivating these traditionally women's crops. The paper focuses on the response of farmers to the problems of water and labour scarcity, and potential low-cost improvements that can be made to current water management practices. Effective and efficient means of using water are suggested: pitcher irrigation; subsurface pipe irrigation; and low-head drip systems.

Maiti *et al.,* (2002) reported that in the first experiment, four popular hybrids viz., bhendi-101, chilli-101, tomato-402 and bhendi-7001 were evaluated for their saline tolerance. Brinjal-101, chilli-101 and tomato-402 were more vigorous. Brinjal-101 had a higher mean emergence (23.75) at 0.05 M NaCl. The lowest mean emergence was observed in bhendi-7001 (15.0). Though bhendi-7001 had the lowest mean emergence (15.0) at 0.05M NaCl, its mean emergence was on par with that of 0.1 M NaCl and was the one with the highest mean emergence of 14.0 at 0.1 M NaCl, compared to other vegetable hybrids. Tomato-402 recorded the lowest mean emergence among these four vegetable hybrids. In the second experiment, 21 different vegetable seeds were evaluated for salinity tolerance at 0.1 and 0.15 M NaCl. Among the 21 different vegetables, bitter gourd-1201, brinjal-003, chilli-9002, chilli-101, tomato-401, tomato-402 and bhendi-777 were more vigorous than other vegetables. The mean percent emergence at 0.1 M NaCl was highest in green gram (84.0) followed by cowpea-444 (68.80) among the grams. However, among the vegetables, brinjal-103 (81.33) and brinjal-102 (76.0) had the highest mean percent of emergence at 0.1 M NaCl. None of the vegetable seeds tested, except brinjal-103 and brinjal-102 could withstand a higher concentration of 0.15 M NaCl. Bhendi-867 (8.67), chilli-9002 (6.0) and chilli-101 (8.0) were susceptible to saline at 0.1 M NaCl and have recorded the lowest mean percent of emergence. For osmotic stress, 13 different vegetable varieties have been evaluated to different levels of osmotic stress. Among the different vegetables, tomato-angel, tomato-403, tomato-402, SCH-902, SCH-9002, brinjal-003, bhendi-777 and bhendi-7001 were more vigorous than others. Brinjal sharma and Brinjal royal-101 were highly tolerant at higher levels of moisture stress/more negative water potentials (-8 Mpa). At moderate level of moisture stress (-5 Mpa), 100% germination was observed in chilli-SCH-902 and brinjal-003. Angel hybrid of tomato had 93.3% germination at -5 Mpa. Bottle gourd was highly susceptible to be moisture stress.

Saha *et al.,* (2005) conducted an experiment with pumpkin (C. moschata) during the early summer of 2001/02 and 2002/03 in Canning, West Bengal, India, and involving 3 methods of irrigation (drip irrigation by direct pitcher, drip irrigation by pipe from pitcher and basin system of irrigation). The direct pitcher method recorded significantly higher values for vine length, number of nodes per vine, stem girth and significantly lower values for internode length compared to the other 2 methods of irrigation in both years at all stages of plant growth. The basin method exhibited the lowest values for vine length, number of nodes per vine, stem girth and the highest values for internode length. The values for number of branches per plant, number of fruits per plant as well as polar length, diameter, weight and yield of fruits were highest under the direct pitcher method followed by the pipe from pitcher method; the basin method recorded the lowest values for these characters. The direct pitcher method was found to be the best method to obtain higher crop yield of pumpkin.

Chakraborty,-P-B *et al.,* (2004) stated that a series of studies was conducted during the dry seasons of 1992/93, 1993/94 and 1994-95 in West Bengal, India, to determine and compare the water requirements of both boro-paddy and different non-boro winter crops (wheat, Indian mustard, groundnut, sesame, sunflower, lentil, gram, potato, sweet potato, chilli, tomato and brinjal [aubergine]). Seasonal water requirement varied widely with the type of crops. Boro-paddy utilized the highest amount of water (1470 mm), while the lowest water use (121 mm) was observed in sunflower. The rest of the crops required water between 155 and 333 mm. The rate of water use of the crops also varied to a great extent. The water consumption rate of boro-paddy was 8.56 mm/day, whereas for the other crops it ranged from 1.42 to 5.27 mm/day. Water use efficiency was maximum in tomato (79 kg ha-1 mm-1) and minimum in boro-paddy (4 kg ha-1 mm-1). The water use index was also highest in tomato (Rs. 393.33 ha-1 mm-1) and lowest in boro-paddy (Rs. 18.86 ha-1 mm-1). Crop yield was highest in tomato (23.17 t/ha) and lowest in sunflower (0.81 t/ha).

Narvane *et al.,* (1989) reported that nine-month-old grafted plants of the cultivar Kesar were planted and the following irrigation treatments were applied: (1) surface irrigation, (2) surface irrigation + black polyethylene mulch, (3) surface irrigation + sugarcane trash mulch, (4) irrigation via a 3.5-litre pitcher buried 10 cm from the plant at planting, with the mouth above ground level, and (5) sub-soil irrigation via a pitcher buried 10 cm from the plant, 1 foot below ground level, covered by a plastic plate and fed through a 3-cm diameter pipe. The quantity of water applied/plant per day was 3.0, 2.0, 2.0, 1.5 and 1.25 litres, respectively. The best result, with regard to plant height, stem girth, leaf production, leaf area, plant DW, and root number were obtained with treatment (5).

According to the report of Bainbridge (1988) & Bainbridge et al., . (1998) pitcher pot irrigation is excellent for propagating cuttings in the nursery or in the field. The bottom of the outside pot is filled with gravel and the area between the two pots is filled with the mix best suited for the cuttings involved, typically three parts sand, two parts leaf mold (or granulated peat), and one part medium loam. The root or stem cuttings are then placed in the moist soil. The inside pitcher pot is then kept filled with water just as it is in the field. I have also used pitcher pot irrigation to start plants in the nursery from seeds.

Fan Sheng-chih Shu (1974) describes intercropping with pitcher pots. This ancient text recommends planting 10 scallions around the pitcher pot with four melon seeds. The scallions should be harvested at the fifth month as the melons begin to ripen. Lesser beans can also be planted in with the melons and scallions with bean leaves sold as greens. Many other intercrops, including the traditional corn, bean, squash intercrop should work well with pitcher pots. Pitcher pots should make it easier to grow vegetables under trees with active root systems near the soil surface like Eucalyptus.

Pachpute (2010) stated that a package of water management practices including pitcher irrigation method and water conserving techniques of manure application and mulching is experimented for sustainable growth and improved production of cucumber crop in Makanya village in North Eastern Tanzania. The increase in total yield due to package of water management practices is 203 per cent and water use efficiency obtained is 12.06 kg m-3. The seasonal water requirement of cucumber crop under package of water management practices ranges from 146.30 to 198.10 mm, which is on an average 4.19 times less as compared to control treatment of can irrigation. The irrigation interval in package of water management practices is 4.9 times higher than the can irrigation method. The water and labour uses are reduced by 75.9 and 73 per cent, respectively in package of water management practices. The results showed that the self-regulative nature of pitchers and moisture retention by water conserving techniques is helpful in mitigating water stress in crop root zone. The moisture retention period in soil is increased assisting reduction of labour hours required in irrigation. In local context, the water management practices included in the package are easy to understand, adopt, operate and maintain.

Effect of Pitcher irrigation with saline water

Clay pot irrigation will prove most useful in helping farmers grow crops successfully in areas with salinity problems (about 50% of the World's irrigated land). The stable soil moisture maintained by pitcher pot irrigation enables crops to be grown in very basic or saline soil or with saline water under conditions in which conventional irrigation would fail (Alemi, 1980; Mondal, 1974, 1983,1984; Rai, 1982). High tomato yields, 27 t/ha, were obtained in India using saline irrigation water, EC 10.2 mmhos/cm, while typical yields in this area with fresh water, EC 0.4, ranged from 15-25 t (Mondal, 1983). In Kenya 61% of normal crop yield was achieved with irrigation water of EC 8, when typical irrigation fails at EC 4 (Okalebo et al., ., 1995).Alemi in 1980 stated that Pitcher pot irrigation moved salt out of the plant root zone better than drip irrigation. Very low-fired pots may break up in very saline soil as a result of chemical reactions with the salts.

Mondal *et al.*, ., (1992) experimented pitchers when water for irrigation is saline. They buried baked earthern pitchers up to the neck in soil. Six week old brinjal and 4 week old cauliflower seedlings were planted around the pitchers retaining 3 and 4 plants/pitcher, respectively. The pitchers were filled with saline water of electrical tomato yields, 27 t/ha, were obtained in India using saline irrigation water, EC 10.2 mmhos/cm, while typical yields in this area with fresh water, EC 0.4, ranged from 15-25 t (Mondal, 1983). In Kenya 61% of normal crop yield was achieved with irrigation water of EC 8, when typical irrigation fails at EC 4 (Okalebo et al., ., 1995).Alemi in 1980 stated that Pitcher pot irrigation moved salt out of the plant root zone better than drip irrigation. Very low-fired pots may break up in very saline soil as a result of chemical reactions with the salts.

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The hydraulics of pitcher irrigation in saline water condition was studied by Naik *et al.*, (2008) in laboratory conditions in terms of flow behaviour of pitcher, soil moisture distribution, wetting front advance and distribution of salt concentration in the soil using different pitcher making materials. The Pitcher Type 1 (PT1) made up of local soil and sand yielded the lowest mean hourly depletion ranging from 0.42 to 0.62% depending on salinity of the water used. It was followed by PT2 made up of local soil, sand and resinous material with a mean hourly depletion of 0.51-0.69% and PT3 with local soil, saw dust and sand with a mean hourly depletion of 0.91-1.02%. In all cases, with the increase in salinity level of the water used (ranging from 5 to 20 dS/m), the depletion rate and moisture content in the soil profile were found to decrease. Similarly, it was found that PT1 yielded the lowest wetting front advance and salt movement followed by PT2 and PT3. It was observed that the wetting front advance in the soil decreased with increasing salinity level of the water. The salt concentration in the soil was minimum near the pitcher and maximum at the soil surface and periphery of the wetted zone. In case of PT1, the maximum salt concentration in the soil profile ranged between 1.09 and 3.88 dS/m using water with a salinity ranging from 5 to 20 dS/m, respectively. Similarly, for PT2 the maximum salt concentration in the soil profile also ranged from 1.09 to 3.88 dS/m and for PT3 from 2.30 to 6.07 dS/m. A paired t-test revealed that the moisture as well as the salt distribution of PT3 differed significantly from PT1 and PT2 at alpha =0.05. Even, if the salt concentration remained the same and the moisture content remained within field capacity for PT1 and PT2, PT1 is preferred in comparison to PT2 and PT3 as the pitcher material of PT1 is locally economically available.

Dubey *et al.,* (1990) conducted experiment on ridge-gourd (*Luffa acutangula*) cv. Pusa Nasdar during 1987. Eight seeds were sown around the pitchers at 25 cm from the centre of the pitcher. N was applied by adding 5 g urea to the irrigation water in the 3rd and 6th week afer sowing. Treatments consisted of irrigation waters with electrical conductivities of 0.4, 4, 8, 12 or 15 dS/m and 3 irrigation schedules (filling the earthenware irrigation pitchers daily, or on alternate days or every 3rd day). Increasing salinity resulted in increasing delay in germination; 100% germination occurred after 13, 23, 25, 29 and 31 days for the 5 irrigation waters, respectively. Highest yield (4.45 kg/pitcher) was obtained with 0.4 dS/m irrigation water and filling the pitchers every 3rd day. Yield decreased with increasing salinity. The average daily water requirement increased with increasing salinity and decreased with increased interval between two consecutive pitcher fillings. An irrigation rate of 2.4 litres/day was required with 15 dS/m irrigation water and daily refilling, compared with 1.1 litres/day with 0.4 dS/m irrigation water and refilling every 3rd day. When mean yield and irrigation water salinity were applied to a piecewise linear salt tolerance model, a threshold value of 3.15 dS/m was obtained; irrigation waters up to this salinity would produce no reduction in yield.

Gupta (1999) describes four technologies for saving irrigation water in India: (i) storage of rainwater in rice fields as a component of the three tier technology of rain, water harvesting and reuse (which can store 80-90% of runoff from agricultural lands); (ii) division of long sloping borders into compartments (to improve uniformity of ponding in the rice crop and to save 24-32% of the water applied during the first irrigation); (iii) a pitcher irrigation technique (an indigenous alternative to drip irrigation that helps conserve fresh water and allows use of relatively more saline water); (iv) recycling drainage effluent. The paper also highlights many secondary benefits that accrue with the adoption of these technologies.

Effect of saline water on physical and chemical properties of soil

Bhingardeve *et al.,* (2006) studied the influence of saline, canal water and n-fertilizer level through drip irrigation on pH, ECe of soil and plant height at different growth stages of brinjal. A field experiment was conducted at the PGI farm of M.P.K.V., Rahuri (Maharashtra, India) during summer season of 2000 to find out influence of saline, canal water and urea N-fertilizer through drip irrigation on pH and ECe of soil at different growth stages of brinjal [aubergine]. It was observed that pH and ECe of soil increased in both depths of soil (0-15 and 15-30 cm) at harvest stage of plant for saline and canal water treatments. Regarding fertility levels, 100% recommended dose of urea (150 kg urea ha-1) level recorded the highest values of pH and ECe of soil, the values were more than those recorded in 75 and 50% recommended dose of urea through drip irrigation. At harvest plant height was maximum (78.94 cm) due to canal water than saline water treatment. It further showed that subsequent irrigations of saline water added salts to soil in surface and subsurface layer of soil. Hence, pH and ECe of soil increased, that means ECe is directly proportional to the pH of soil and plant height was decreased due to the saline water treatments. The interaction effects were non-significant.

Kadam *et al.,* (2007) experimented the nutrient concentration, plant height and dry matter yield of brinjal as influenced by saline water and urea-N-fertilizer through drip irrigation. A field experiment was conducted in Rahuri, Maharashtra, India during 1998-99 to evaluate the effect of saline water irrigation and N urea fertilizer applied through drip irrigation on the nutrient content, plant height and dry matter accumulation in brinjal cv. Krishna. Saline water (S1) or canal water (S0) was supplied. N urea fertilizer rates were: 100, 75 and 50% of the recommended (150 kg/ha), corresponding to F1, F2 and F3, respectively. The concentration of N was highest in canal water treatment (1.60%) under SW0 + F1 treatment than saline water treatment (1.2%) under SW1 + F1 at harvest in the plant, and 2.81 and 2.08% in fruits. The plant height was highest (71.3 cm) in canal water treatment (SW0 + F1) at 90 days after transplanting and lowest height (54.7 cm) was observed in saline water treatment (SW1+F1) at 90 days after transplanting. The highest dry matter accumulation (112.6 g/plant) was under canal water treatment and the lowest was observed (86.3 g/plant) in saline water treatment (SW1 + F3). The highest dry matter accumulation in fruit was recorded in SW1 + F1 (87.4 g/plant) and lowest (66.9 g/plant) was obtained in SW1 + F3 treatment.

Kadam *et al.,* (2007) also studied the effect of saline water and fertigation on the availability of nutrients in soil, uptake of nutrient and yield of brinjal. A field study was conducted in Rahuri, Maharashtra, India, during 1998-99 to evaluate the effect of saline water and fertigation on the availability of soil nutrients, nutrient uptake and yield of brinjal cv. Krishna. The fertilizer treatments were: F1, F2 and F3, corresponding to 100, 75 and 50% of the recommended N (urea) fertilizer rate (150 kg/ha), respectively. Saline water was applied at 0.21 dS/m, and canal water was used in the control. The available N decreased from 30 days to harvest at 0-15 and 15-30 cm soil depth. In saline water treatment, available N was 171.2, 163.5, 153.17 and 149.6 kg/ha at 30, 60, 90 DAP at harvest respectively. At 60 days after transplanting there was decrease in available from 19.3 to 14.6 kg/ha as compared to 30 days (21.8 kg/ha) after transplanting. The highest available R was observed in SW0 (control) + Fl treatment at 30 days while lowest available P (14.8 kg/ha) was observed in treatment SW1 (saline water) + F3 treatment compared to other treatments. At 30 days after transplanting, SW0 + Fl treatment showed the highest available K of 465.2 kg/ha compared to other treatments. In saline water treatment, available K was low i.e. 455.7, 421.0 and 416.6 kg/ha for 30, 60, 90 days and at harvest, respectively, compared to canal water treatment. The application of 100% urea-N fertilizer through drip irrigation recorded the highest yield of 51.9 t/ha followed by 75% N-fertilizer (48.9 t/ha). Under saline water treatment, N-uptake was 52.6 and 70.2 kg/ha in plant and fruit, respectively. The P uptake was 12.9 and 11.3 kg/ha in plant and fruit, respectively, and K uptake was 94.5 and 105.16 kg/ha in plant and fruit, respectively.

Kumari *et al.,* (2009) described a survey was conducted in chilli growing areas of Guntur district on soil properties, nutrient status and microbial populations besides collection of rhizosphere samples for isolation of Azospirillum inoculants. The survey indicated that out of 50 rhizosphere soils surveyed, 40 samples were heavy black or mixed black, the rest of 10 were sandy or red sandy loams. All the soils were neutral to alkaline in reaction, non saline and high in potassium status. Only 12 and 18 per cent of the surveyed samples were medium in organic carbon and available nitrogen, respectively. Rest were low in both the parameters. Only 8 per cent of samples recorded medium in available P2O5 and the rest were high. Population of Azospirillum ranged from 3.53 to 5.82 log10 CFU. High population of Azospirillum (>5 log10 CFU) was noticed in rhizosphere of chilli grown in heavy black soils.

Comparatively, higher populations of other bacteria, fungi and actinomycetes were noticed where the crop was grown on heavy black soils under high level of input utilization. A non-significant negative correlation was observed between the soil pH and EC and microbial population. Significant positive correlation was noticed between organic carbon and population of Azospirillum, other bacteria and fungi. Similar significant positive correlation was noticed between soil N and Azospirillum, other bacteria and fungi.

Gupta *et al.,* (1999) worked on some technologies to conserve irrigation water. This paper describes four technologies for saving irrigation water in India: (i) storage of rainwater in rice fields as a component of the three tier technology of rain, water harvesting and reuse (which can store 80-90% of runoff from agricultural lands); (ii) division of long sloping borders into compartments (to improve uniformity of ponding in the rice crop and to save 24-32% of the water applied during the first irrigation); (iii) a pitcher irrigation technique (an indigenous alternative to drip irrigation that helps conserve fresh water and allows use of relatively more saline water); (iv) recycling drainage effluent. The paper also highlights many secondary benefits that accrue with the adoption of these technologies.

Duguma (1988) stated that Pitcher pot irrigation is very effective for establishing live cuttings in the field. The stable soil moisture provides excellent conditions for rooting plants that establish readily from cuttings. Pitcher pot irrigation may also make it possible to establish plants that do not root readily. Angling the shoot can increase the range of soil moisture conditions, making it more likely to meet plant demands for good rooting. Angling the cuttings can also concentrate the growth hormones that stimulate rooting. The stable moisture and air should also be favorable for root cuttings. Air layered *Prosopis juliflora* was planted out with 100% survival using pitcher pot irrigation in India. Pitcher pot irrigation facilitated rapid establishment and faster growth of the plants.

Saleh *et al.,* (2010) conducted numerical and experimental studies to investigate the water flow in the soil surrounding a pitcher and to figure out the availability of soil moisture for crops. The Darcy and Richards' equations of water flow in a cylindrical coordinate system was applied and was solved using Finite Element Method to describe soil moisture profiles. Two soil textures was used, one was silty clay and the other was sand. The hydraulic conductivity of the pitcher was in order 10-6 cm/s which was 100 times smaller than that of the two soils. The pitcher was buried in the center axis of a soil box and water was given from Mariotte tube to maintain a constant water level inside the pitcher. The results showed the infiltration rates decreased linearly rather than exponentially even though the soil was initially dry. The advancement of wetting front was very slow and somewhat limited to a radius and depth of no more than 30 cm and 40 cm, respectively for both tested soils. The surrounding soil moisture was in a range available for plant growth. Different depths of pitcher placement in the soil produced different reaching distances of the wetting front but showed insignificant differences in water availability. Accurate placement of pitcher depth in soil is important to provide effective soil wetness in the root zone and reduce evaporation rate. The right placement of pitcher must be determined based on the hydraulic characteristics of the pitcher and the soil. In this study, 5 cm placement depth of the pitcher's shoulder is an appropriate reference for the application of pitcher irrigation.

Niu *et al.,* (2010) conducted an experiment of salt tolerance of five cultivars of Capsicum annuum L. Early Jalapeno, Golden Treasure, NuMex Sweet, NuMex Joe E. Parker, and Santa Fe Grande, two cultivars of C. chinense Jacq. Habanero and Pimienta De Chiera, and one accession of C. annuum, NMCA 10652, were evaluated in a field study. Seedlings were transplanted in late May to field raised beds containing loamy sand soils in a semi-arid environment. Plants were well irrigated throughout the experiment. Three saline solution treatments, prepared by adding NaCl, MgSO4, and CaCl2 to tap water at different amounts to create three salinity levels of 0.82 dS m-1 (control, tap water), 2.5 dS m-1, and 4.1 dS m-1 electrical conductivity (EC), were initiated on 15th June and ended in late August. Among the eight varieties, NMCA 10652 had the highest survival percentage at 100% in the 4.1 dS m-1 treatment, followed by 'Early Jalapeno', 'NuMex Sweet', 'Pimienta De Chiera', 'Santa Fe Grande', 'Golden Treasure', and 'NuMex Joe E. Parker'. 'Habanero' had the lowest survival at 28%. Compared to control, final shoot dry weight of the plants irrigated with saline solution at 4.1 dS m-1 was reduced by 92% in 'Habanero', followed by 'Golden Treasure' at 80%. For fruit fresh weight in 4.1 dS m-1 vs. control, 'Habanero' had the highest reduction at 86%, followed by 'Golden Treasure' at 74%, while NMCA 10652 and 'Santa Fe Grande' had the least at 26% and 19%, respectively. NMCA 10652, the most tolerant to salinity, had the lowest leaf Na+

accumulation, while 'Habanero', the most sensitive to salinity, had the highest Na+ in the leaves. For leaf Cl-, 'Early Jalapeno' had the highest, while 'Habanero' had the lowest Cl- accumulation in the leaves. Generally, sensitive varieties accumulated more Na+ and/or Cl- in leaves, except for 'Early Jalapeno', which was relatively tolerant to salinity but had high Na+ and Cl- accumulation in leaves.

The new technique was developed an infiltration model and evaluated it for pitcher irrigation system. Infiltration models were based on quantitative relationships among variables that were developed analytically, or from a spectrum of infiltration data that could be fitted into the equation. An attempt was made to begin the development of a mathematical (infiltration)m model using the assumptions of Hillel and Gardner (1969; 1970), incorporating the assumptions of Philip (1957a; 1957c). The model developed in this study used Pitcher (pot) and soil properties, as well as the time of infiltration as inputs. The model proved to be capable of predicting infiltration better than the pitcher infiltration equation advanced by Clifthill (1983), which did not consider the properties of the soil beneath the pitcher. The developed pitcher model gave a better prediction of infiltration, especially with pitchers fired at low temperatures (<650 degrees C) and, which invariably had higher seepage rates than in pitchers fired at high temperatures (>850 degrees C).

Srinivas *et al.,* (1991) conducted a field study with the chilli [Capsicum sp.] cv. Byadagi compared 5 irrigation treatments during the kharif season in 1987 and 1988. Treatments consisted of (1) non-saline canal water only, (2) 2 applications of non-saline water alternating with one of saline water, (3) alternations of non-saline and saline water, (4) one application of non-saline alternating with 2 of saline water, and (5) saline (well) water only. In the 1st year the crop was irrigated 7 times and in the 2nd year (when rainfall as greater) 4 irrigations were applied; in both years water was applied to a depth of 6 cm. The EC of the non-saline water was 0.25 ds/m and that of the saline water was 0.76-1.0 ds/m. Soil and water analyses are tabulated. The highest dry chilli yields (8.12 and 20.78 q/ha in 1987 and 1988, respectively) were obtained with treatment (1), followed by (2) with 7.30 and 20.38 q/ha respectively. Plants in treatment (5) yielded 3.99 and 11.72 q/ha respectively, which represented yield reductions of 50.8 and 43.6%, compared with (1). The most promising treatment for using saline water to supplement the limited supply of canal water appeared to be (2).

Niu *et al.,* (2012) described about Salt tolerance of five cultivars of Capsicum annuum L. Early Jalapeno, Golden Treasure, NuMex Sweet, NuMex Joe E. Parker, and Santa Fe Grande, two cultivars of C. chinense Jacq. Habanero and Pimienta De Chiera, and one accession of C. annuum, NMCA 10652, were evaluated in a field study. Seedlings were transplanted in late May to field raised beds containing loamy sand soils in a semi-arid environment. Plants were well irrigated throughout the experiment. Three saline solution treatments, prepared by adding NaCl, MgSO4, and CaCl2 to tap water at different amounts to create three salinity levels of 0.82 dS m-1 (control, tap water), 2.5 dS m-1, and 4.1 dS m-1 electrical conductivity (EC), were initiated on 15th June and ended in late August. Among the eight varieties, NMCA 10652 had the highest survival percentage at 100% in the 4.1 dS m-1 treatment, followed by 'Early Jalapeno', 'NuMex Sweet', 'Pimienta De Chiera', 'Santa Fe Grande', 'Golden Treasure', and 'NuMex Joe E. Parker'. 'Habanero' had the lowest survival at 28%. Compared to control, final shoot dry weight of the plants irrigated with saline solution at 4.1 dS m-1 was reduced by 92% in 'Habanero', followed by 'Golden Treasure' at 80%. For fruit fresh weight in 4.1 dS m-1 vs. control, 'Habanero' had the highest reduction at 86%, followed by 'Golden Treasure' at 74%, while NMCA 10652 and 'Santa Fe Grande' had the least at 26% and 19%, respectively. NMCA 10652, the most tolerant to salinity, had the lowest leaf Na+ accumulation, while 'Habanero', the most sensitive to salinity, had the highest Na+ in the leaves. For leaf Cl-, 'Early Jalapeno' had the highest, while 'Habanero' had the lowest Cl- accumulation in the leaves. Generally, sensitive varieties accumulated more Na+ and/or Cl- in leaves, except for 'Early Jalapeno', which was relatively tolerant to salinity but had high Na+ and Cl- accumulation in leaves.

Effect of pitcher irrigation on chilli :

Vikram *et al.,* (1999) conducted a trial in Jobner (Rajasthan) in 1989 using the chilli [Capsicum] cultivar Pusa Jwala irrigated by the pitcher method (which has relatively low evaporation and leaching losses compared with other methods, and also uses less water). The lateral and vertical movement of moisture and soluble salts in the soil profile was monitored and the method was concluded to be very effective for chillies. It was also recommended that when using saline water, salt-resistant and shallow rooted crop such as chillies could be grown near the pitcher for effective utilization of saline and high residual sodium carbonate (RSC) water in sandy loam soil of arid and semiarid regions.

Chakraborty, P.B (2000) conducted an experiment during 1993-94 and 1994-95 in West Bengal, India, to study the influence of paddy straw mulch on yield and water use efficiency of chilli (*Capsicum annuum*) growing in a saline ecosystem. Mulch was applied in the inter-row spaces at 2, 4 and 6 t/ha; a no-mulch treatment was the control. Results showed that application of mulch at 4 and 6 t/ha was the most effective in keeping the soil non-saline throughout the growth period of the crop. Yield was increased by 37.10 and 40.59% over the control in 1993-94 and 1994-95, respectively, with mulch applied at 6 t/ha. Mulching showed a significant positive correlation (r = 0.72) with yield. Higher moisture conservation efficiency (91.1%) with mulching enhanced water use efficiency. Profit was maximized when the crop was mulched at 6 t/ha with paddy straw

Jagadev, P *et al.,* (1990) conducted an experiment during 1987-88, 8 genotypes of Capsicum annuum were evaluated for 8 yield components and disease incidence. Cv. Sindhur gave the highest fresh and dry pod weights (3.74 and 0.79 t/ha, respectively) followed by Pusajwala (2.73 and 0.58 t/ha, respectively) and BC21-2 (2.20 and 0.54 t/ha, respectively).

Effect of pitcher irrigation on Tomato

The highest total and marketable fruit yields were obtained from clay pot irrigation combined with application of nitrogen fertilizer with irrigation water irrespective of difference in plant population. The clay pot irrigation had seasonal water use of up to 143.71 mm, which resulted in significantly higher water use efficiency (33.62 kg m-3) as compared to the furrow irrigation. This experiment carried out by (Tesfaye *et al.,* 2011)

Malash *et al.,* (2005) described that the effect of two water management strategies were investigated in the Nile Delta, Egypt, on tomato (cv. Floradade) yield, growth and salt concentration in the root-zone. The strategies comprised:- alternating and mixed supply of fresh [canal water (0.55 EC)] and saline [drainage water (4.2-4.8EC)] water in 6 ratios applied through drip and furrow method. Drip irrigation enhanced tomato growth earlier in the growing season than furrow irrigation. However at later stages, there was little difference in plant growth between the two irrigation systems. Drip irrigation gave higher yields. Regardless of irrigation method, mixed water management practice gave higher growth and yield than the alternating one. The highest yield obtained (3.2 kg/plant) resulted from the combination between drip system, mixed management practice and using a ratio of 60 % fresh water with 40 % saline water. Tomato yield was found to reduce with seasonal average of soil solution EC.

Gawad *et al.,* (2003) was conducted an experiment where drip irrigation was found to have higher water use efficiency than traditional methods. Also salt tolerant varieties of tomato developed through DNA marker technology had higher yields than local varieties. The sugar content of tomato fruits grown using saline irrigation water was higher than that irrigated with non-saline waterDrip irrigation of tomato was found to produce higher yields than traditional surface irrigation, and to reduce water consumption. The yield produced under saline irrigation (with 15% leaching fraction for 8 dS/m EC water) is about 50% of that grown under non-saline irrigation.

Kadam *et al.,* (2005) experimented the nutrient concentration, plant height and dry matter yield of tomatoes influenced by saline water and urea-N-fertilizer through drip irrigation. Krishna. Saline water (S1) or canal water (S0) was supplied. N urea fertilizer rates were: 100, 75 and 50% of the recommended (150 kg/ha), corresponding to F1, F2 and F3, respectively. The concentration of N was highest in canal water treatment (1.60%) under SW0 + F1 treatment than saline water treatment (1.2%) under SW1 + F1 at harvest in the plant, and 2.81 and 2.08% in fruits. The plant height was highest (71.3 cm) in canal water treatment (SW0 + F1) at 90 days after transplanting and lowest height (54.7 cm) was observed in saline water treatment (SW1+F1) at 90 days after transplanting. The highest dry matter accumulation (112.6 g/plant) was under canal water treatment and the lowest was observed (86.3 g/plant) in saline water treatment (SW1 + F3). The highest dry matter accumulation in fruit was recorded in SW1 + F1 (87.4 g/plant) and lowest (66.9 g/plant) was obtained in SW1 + F3 treatment.

Malash,*et al.,* (2008) described that the effects of irrigation with saline drainage water (seasonal average of 4.5 dS/m) and non-saline water (0.55 dS/m) applied by two different water management strategies (cyclic or blended saline water with non-saline water in different ratios) and two different irrigation methods (drip or furrow) were studied on growth and productivity of tomato (*Lycopersicon esculentum* Mill cv Floradade), salinity distribution in root zone and water use efficiency. The results indicated that salinity (at 3 dS/m and above) significantly reduced leaf area, height and dry weight of plant as well as fruit weight and number and hence total yield, but increased fruit T.S.S. content. Water use efficiency (WUE) was increased by using water with low and moderate salinity levels (2 and 3 dS/m) as compared to those obtained with non-saline water (0.55 dS/m) or the highest salinity level (4.5 dS/m). Salinity increased Na, Cl and Mg contents as well as dry matter percentage, but decreased N, P, K and Ca contents in leaves of plants. Drip irrigation enhanced tomato growth, yield and WUE under both saline and non-saline conditions, but showed more advantages under saline conditions as compared with furrow irrigation.

Chapter 3

Materials and Methods

Crop yield and its productivity are mostly unstable under coastal saline Zones of West Bengal. This area has been found to be low and unstable due to unfavorable soil condition, mono cropping practices. Saline region occupying a vast area of three districts in the state of West Bengal. Hence, a good understanding with pitcher irrigation and tillage for improving vegetable crop production is required for the development of a suitable crop strategy in these areas. With this in view, some effort have been undertaken in the present programmed to investigate the different type of tillage with pitcher irrigation management practices on growth and productivity of vegetables crops as well as its effect on changes in soil properties of coastal saline soils under the said Zones.

3.1. Location of the experimental site:

The present study was carried out at the farmer's field at the Simabandh village, Kakdwip, South 24 Pargona,. West Bengal under Coastal saline Zone. West Bengal situated at 21^0 58' N latitude, 88^0 11' E longitude, with an altitude at 1.2 m above the mean sea levelIt is bounded by the districts of North 24 Pargonas in the north, Purba Medinipur in the west and Bay of Bengal in the South and east.

The area flat coastal topography and the general elevation ranges from 1.1 to 1.2 m above mean sea level with a general slopes of 0.1 to 0.3% from north to south,relief is subnormal with slight to medium runoff. Topographically the land was classified as medium class. The external and internal drainage of the most soils in the higher situation are excessive but drainage congestions are problem in the lands of medium and lower situations.

3.2. Climatic condition of the experimental site:

The selected area falls under sub humid tropic climate and is situated under moderate rain area. The mean annual rainfall of this zone is 1500 mm received in 90 rainy days, of which the highest rainfalls generally occur in the month of August-September.Pre monsoon rain is common in the month at April and May. Monsoon occurs June to September and ceases during October and cool season set in November.Monsoon in this area usually break in the first week of June and continues up to September. The mean rainfall during winter and summer months are measure with 109 mm and 89 mm about 8 and 9 rainy days receptivity.

Temperature start rising rapidly in this district from the beginning of March. The maximum temperature rises to about 30^0 C in the month of May with the onset of south-west monsoon by about first week of June, the day temperature drops appreciably. December is the coldest month in the district with a mean daily minimum temperature of 15^0 C - 25^0 C. The relative humidity becomes very high in the month of July, August and September with the average of 84.0, 85.2 and 84.2% respectively. Sky is clouded in June to September during the south west monsoon seasons. Cloudiness decreases in October and sky is clear or lightly clouded during the rest of the year. The weekly distribution of the metrological parameter for the selected area during crop growing season is presented in Table-1.

Table 1:Distribution of weekly rainfall, average air temperature, evaporation and wind speed during study period (2012-13 to July 2013-14).

Standard week	Rainfall (mm)	Temperature (^{0} C)		Relative humidity (%)		Evaporation (mm)	Wind speed (Km/hr)
		Max.	Min.	Max.	Min.		
48	11.9	28.4	16.9	93.42	33.85	3.72	0.54
49	00.0	29.8	17.1	91.85	41.45	3.7	0.80
50	7.8	30.1	16.8	97.14	54.85	4.84	2.9
51	00.0	32.5	17.8	94.64	52.35	4.95	4.32
52	14.9	33.7	18.2	97.42	40.42	4.77	2.04
1	21.8	33.9	19.4	97.14	56.14	6.48	3.94
2	00.0	34.5	19.2	83.71	51.42	6.08	5.7
3	00.0	35.1	20.5	80.57	56.57	4.78	6.7
4	00.0	35.2	21.2	86.00	59.85	3.55	1.00
5	0.00	35.8	22.4	91.28	72.71	4.60	3.45
6	00.0	36.4	23.9	87.14	59.28	3.95	1.42
7	00.0	36.9	23.4	88.57	70.00	3.18	0.31
8	15.9	35.4	24.8	94.71	72.85	4.21	5.72

Continued...

2nd year

Standard week	Rainfall (mm)	Temperature (^{0} C)		Relative humidity (%)		Evaporation (mm)	Wind speed (Km/hr)
		Max.	Min.	Max.	Min.		
9	00.0	32.5	17.8	94.64	52.35	4.95	4.32
10	14.9	33.7	18.2	97.42	40.42	4.77	2.04
11	21.8	33.9	19.4	97.14	56.14	6.48	3.94
12	00.0	34.5	19.2	83.71	51.42	6.08	5.7
13	00.0	35.1	20.5	80.57	56.57	4.78	6.7
14	00.0	35.2	21.2	86.00	59.85	3.55	1.00
15	35.5	35.8	22.4	91.28	72.71	4.60	3.45
16	00.0	36.4	23.9	87.14	59.28	3.95	1.42
17	00.0	36.9	23.4	88.57	70.00	3.18	0.31
18	15.9	35.4	24.8	94.71	72.85	4.21	5.72
19	00.0	35.9	25.9	85.28	77.57	3.18	6.62
20	35.8	34.8	26.2	97.85	78.51	2.92	4.11
21	42.8	33.4	26.3	90.57	56.57	4.18	5.31
22	14.5	32.2	26.5	86.00	59.85	4.21	5.72
23	00.0	32.5	26.9	81.28	72.71	5.18	6.62
24	00.0	33.4	26.8	77.14	59.28	4.92	4.11

Source: *Regional Research Station Bidhan Chandra Krishi Viswavidyalaya, Kakdwip. 24-parganas (south), West Bengal.*

3.3 Soil of the experimental site:

The selected area represents coastal saline soil with high portion of saline in the field. These soils have high electrical conductivity due to salt content. The soils have developed in alluvium on deltaic plain of the river Ganga having 1-2% slope. The soils are deep imperfectly drain and have whitish, sandy clay loam. A horizon dane gray mild alkaline silty clay distinctly mottled B horizon. CEC ranges from 21.9 to 26.1 meg per 100 g of soil. EC is 1:2.5 water extract ranges between 2.0to 24.0ds/m. The crop yield suffers due to moisture& salinity. All the relevant physicochemical properties of the selected site are given in table-2.

Table 2: Initial soil parameter of the experimental plot.

Sl. No.	Particulars		Values
A)	**Physical properties**		
1	Bulk density (mg/m^3)		1.32
2	Porosity (%)		52.50
3	Particle size distribution (%)		
	• Sand		44.2
	• Silt		16.2
	• Clay		39.6
	Textural class		Sandy clay loam
4.	Water holding capacity (%)		42.51
5	Soil aggregates		
a)	Mean weight diameter (mm)		0.706
b)	Structural coefficient		0.514
c)	GMD (mm)		0.426
d)	WAS> 0.25%		58.74
e)	WAS < 0.25%		41.26
B)	**Chemical Properties**		
1.	Soil pH (1 : 2.5 soil suspension)		6.32
2.	EC (mmhos/cm)	Winter seasons	2.43
		Summer season	4.52
3.	Organic carbon (%)		0.58
4.	Available nitrogen (kg/ha)		20.80
5.	Available phosphorus (kg/ha)		25.63
6.	Available potassium (kg/ha)		168.33

3.4 Experimental Details:

The experiment was conducted with growing of tomato (*Lycopersicom esculentum*) variety, Pusa Ruby during winter seasons and chilli (*Capsicum annum*) variety local Pirek during summer seasons.

T_1 = Sweet water + Conventional tillage

T_2= Sweet water + Mulch Tillage

T_3= Sweet water (25%) + saline water (75%) + Conventional tillage

T_4= Sweet water (25%) + saline water (75%) + Mulch tillage

T_5= Sweet water (50%) + saline water (50%) + Conventional tillage

T_6= Sweet water (50%) + saline water (50%) + Mulch tillage

T_7= Sweet water (75%) + saline water (25%) + Conventional tillage

T_8= Sweet water (75%) + saline water (25%) + Mulch tillage

One pitcher placed between four plants. Two different tillage viz, conventional tillage and mulch tillage and four type of blending of saline and sweet water filled for refilling in the pitcher pot, applied in this experiment. The experiment was continued for second year (i.e. 2012-13 and 2013-14).

Plot size: 5 x 3 square meters

Design: Split plot

Replication: 4

Lay out experimental of plot

T_7	**T_1**	**T_3**	**T_5**	**R_1**
T_2	**T_6**	**T_4**	**T_8**	
T_8	**T_2**	**T_6**	**T_4**	**R_2**
T_3	**T_5**	**T_1**	**T_7**	
T_1	**T_7**	**T_5**	**T_3**	**R_3**
T_4	**T_8**	**T_2**	**T_6**	
T_6	**T_4**	**T_8**	**T_2**	**R_4**
T_5	**T_3**	**T_7**	**T_1**	

Rabi and *Kharif* Season

3.5. Details of cultural operation:

3.5.1. Land preparation:

Land was prepared with one deep ploughing by tractor followed by two ploughing by power tiller in order to make the soil well pulverized. The soil was ultimately brought to lose friable and crumb condition. Clods were broken down, stubbles, weeds grasses etc were removed from soil by hand and then leveling was done properly with the help of ladder. One pitcher having capacity of 10 liters is installed between four vegetables crops covering one square meter area.

3.5.2 Fertilizer application:

The recommended doses of fertilizer were applied as basal at the time of final land preparation and @10 ton organic matter mixed with soil.

for Tomato @ NPK=80:60:40

for Chilli @ NPK=40:40:40

Nitrogen, Phosphorus and potassium were applied in the form of urea, single super phosphate and Muriate of potash respectively for each of the vegetables crops.

3.5.3 Selection of seed / seedlings:

Disease free and healthy seeds are selected for sowing and same technique also followed for transplanting with seedlings.

3.5.4 Seed treatment:

Seed treatment was done by with Diathem M-45 (3 gm/kg) for tomato and chilli.

3.5.5 Number of Seedling, spacing and sowing time:

Crop	No. of seedling	spacing	sowing time
Tomato	@ 17800/ha	75cm X75cm	last week of November
Chilli	@ 17800/ha	75cm X75cm	2nd week of March

3.5.6 Weeding:

Weeding was done at 25 and 45 days after sowing for all crops.

3.5.7. Earthing up:

Immediately after weeding, earthing up operation was started with the help of small spade.

3.5.8. Plant protection measure:

As the disease and pests attack were below the economic threshold levels, therefore no plant protection measures were imposed during experimentation.

3.6. Method of recording on observation:

3.6.1. Biometrical observation:

3.6.1.1. Height of the plant:

Ten numbers of plants were tagged different vegetables with different seasons were selected and their heights from the ground level up to the tip of fully expanded topmost leaf were recorded before harvesting from every treatment and every replication.

3.6.1.2. Number of branch:

Ten numbers of plants were tagged were selected for ten plant and number of branch were recorded before harvesting from every treatment and every replication.

3.6.1.3. Dry matter accumulation:

Ten numbers of tagged were selected for ten plant of each plot were up rooted from soil before harvesting. The samples were then dried in electrical oven at 60 - 70^0C till a constant weight was obtained for measuring of dry matter accumulation in g m^{-2} of the plot.

3.6.1.4. Crop growth rate:

Crop growth is the ratio of dry matter production or accumulation and growing period (number of days).

3.6.2. Yield parameter:

3.6.2.1. Number of fruits per plants:

Ten numbers of tagged were selected for ten plant of each plot and recorded total number of fruits each plant and calculated the average number to record average number of fruit /plant.

3.6.2.2. Weight of fruits:

Ten numbers of tagged were selected for ten plant of each plot and recorded weight of fruits each plant and calculated the average weight to record average weight of fruit.

3.6.2.3. Length of fruits:

Ten numbers of tagged were selected for ten plant of each plot and recorded length of fruit.

3.6.2.4. Diameter of fruits:

Ten numbers of tagged were selected for ten plant of each plot and recorded diameter of fruits each plant and calculated the average diameter to record average diameter of fruit .

3.7. Methods of soil analysis:

3.7.1. Soil sampling

Composite soil samples from 0-15 cm soil depth from each plot of the experiment were collected after 1st and 2nd year (after three crops),of experiments, the collected soils were mixed thoroughly and bulk of which were brought to the laboratory, a portion of which were air-dried grinded, sieved and kept for laboratory analysis. The soils were passed through 2 mm sieve and were stored for determination of various physical and chemical properties. Other parts of collected samples broken with hands only avoid any destruction of soil structure of the manual aggregates and then allowed for air drying. Different physical-chemical properties of each soil layers namely, bulk density, porosity, water holding capacity, particle size distribution, aggregate analysis, pH, organic carbon, available nitrogen, available phosphorus and available potassium.

3.7.2 Physical properties:

3.7.2.1 Soil texture:

Particle size distribution of the soils was determined by following the hydrometer method as suggested by Piper (1966).

3.7.2.2 Bulk density:

Bulk density of soil was determined by collecting the soil using core sampler followed by measuring the volume and weight of the sample. It is calculated by following relationship by Piper (1966).

$$\text{Bulk density} = \frac{\text{Oven dry weight of the soil (mg)}}{\text{Volume of the soil core (M}^3\text{)}} (\text{mg/M}^3)$$

3.7.2.3. Water holding capacity:

The water holding capacity (WHC) of the soil is measured with the help of Keen Rackzoskii's box as described by Piper (1966).

$$\text{Water holding capacity (\%)} = \frac{\text{Weight of wet soil} - \text{weight of oven dry soil (gm)}}{\text{Weight of oven dry soil (gm)}} \text{X100}$$

3.7.2.4. Porosity:

Porosity of the soil is measurement by the relationship of Bulk density and particle density.

Porosity= (1- bulk density/particle density) x 100

3.7.2.5. Soil aggregates:

The distribution of various sizes of aggregates was determined by the process of aggregate analysis through wet sieving technique as described by Black (1965). In this methods soil sample having aggregate size below 8 mm in diameter is slowly wetted by capillarity for 30 minutes and is them passed through sieves (sizes: 5.0 mm, 2.0 mm, 1.0 mm, 0.5 mm, 0.25 mm and 0.1 mm), immersed in water. The sieves ate slowly raised and lowered through water at a rate of oscillation 30 per minute for 30 minutes by an electronic motor. The different size groups of aggregates retained on each sieves are then weighed, dried and the proportionate distributions of the aggregate sizes were calculated. The results of aggregate size distributions are expressed as follows-

3.7.2.5.1 Mean weight diameter (MWD):

From the weight of the soil particles (aggregates + sand) in each size group, its proportion to total weight was calculated. The mean weight diameter of stable aggregate, as an index of aggregation was then determined by the introduced by Van Bavel (1950) expressed as below:

$$MWD = {}^{1/N} \sum_{i=1}^{n} Xi\ Wi$$

Where,

Xi = mean diameter of each size fraction (mm).

Wi = proportion of the total sample weight occurring on each sieve.

n = number of size fraction.

3.7.2.5.2. Water stable aggregates (WAS):

The water stable aggregates are represented by the percentages of aggregates greater than 0.25 mm in diameter.

3.7.2.5.3. Geometric Mean Diameter (GMD):

Bavel (1950) suggested that geometric mean diameter (GMD) be used as an index of the aggregate size distribution. The geometric mean diameter is calculated approximately by equation.

$$GMD = \exp\left(\frac{\sum_{i=1}^{n} Wi \log Xi}{\sum_{i=1}^{n} Wi} \right)$$

Where,

Wi is the weight of aggregates in a size class with a average diameter X and

$\sum_{i=1}^{n}$ Wi is the total weight of the sample.

3.7.2.5.4. Structural coefficient:

The structural coefficient was calculated from the relationship.

Structural coefficient = (D-S)/D

Where,

'D' is the percentage of primary particles less than 0.25 mm in diameter

'S' is the percentage of the soil aggregates (primary + secondary particles) less than 0.25 mm in diameter.

3.7.3. Chemical properties:

3.7.3.1. Organic carbon:

Organic carbon of the soils was estimated following the back titration method as proposed by Walkley and Black (Jackson 1973).

3.7.3.2. pH:

pH of the soil was determined by soil and water suspension ratio 1:2.5 using conductivity pH meter (Jackson, 1973) and a glass electrode pH meter.

3.7.3.2. EC:

EC of the soil was determined by soil and water suspension ratio 1:2.5 using conductivity meter (Jackson, 1973).

3.7.3.3 Available Nitrogen:

Available nitrogen contents of the soil samples were estimated by the modified Kjeldhal's method described by Jackson (1973).

3.7.3.4 Available phosphorus:

Available phosphorus contains was estimated by usual procedure of extracting the soils with Olsen's reagent [0.5 (M) $NaHCO_3$] solution with the help of spectrometer (Jackson, 1973).

3.7.3.5. Available Potassium:

Available potassium content of the soil samples was estimated by extracting the soil with 1 N normal ammonium acetate (adjusted to pH 7.0) and available potassium content was determined with the help pf Flam Photometer as described by Jackson (1973).

3.8. Measurement of soil moisture:

Soil sample were collected from 0-15 cm depth of each treatment with replication at every 7 days interval during crop growth period immediately after collection of soil sample kept at 105^0 C for 24 hours and moisture content of sample were determined. (Piper, 1966).

3.8.1. Soil moisture in weight basis:

$$\text{Soil moisture \%} = \frac{\text{Moisture present in soil}}{\text{Weight of oven dry soil}} \times 100$$

3.8.2. Soil moisture in volume basis:

Volume /volume water was determined by following methods;

$$\text{Soil moisture content in 15cm soil depth} = \frac{\text{Soil moisture \% X BD X 150}}{100} \text{mm}$$

3.8.3. Total water use:

Total water use = Effective rainfall + soil profile contribution (soil moisture in volume basis) + irrigation

3.9. Water use efficiency:

Water use efficiency which is defined at the ratio between total yield and total water use during the growing period of crop

WUE = Crop yield / Total water use by the crop.

3.10 Statistical calculations:

Necessary statistical analysis was worked out to interpret the effects of treatments of various observations by the methods as suggested by Gomez and Gomez (1984). The effects of treatments on various biometric observations including crop yields and other properties were compared by the values of critical differences. The 'F' values for various comparisons at 5% level of significance were collected from the table down by Fisher (1990).

Chapter 4

Results and Discussion

Crop yield and its productivity in coastal soil mostly occur under saline zone of West Bengal have been found to be low and unstable due to high salt concentration. Experimental evidence from research, however, shows the soils are capable of producing more food with appropriate soil-and water- management systems.Particular vegetable crop suffer by lack of quality irrigation facilities and management practices during winter and summer seasons. On this backgroundthe present section aims to test the effectiveness pitcher pot irrigation with different type of tillage operation have the opportunity to act as high water use efficiency and enhancing crop productivity in thecoastal saline zones of West Bengal.*i.e.*growing of tomato during rabi seasons and chilliduring Summer season.

4.1. Effect of different blending of saline and sweet water in pitcher pot and tillage on yield, yield components and benefit cost ratio of tomato.

4.1.1. Yield and yield attributes of tomato:

The results (Table 3) of pooled data onyield of tomato grown in 2012 and 2013 during rabi seasons showed variation with the application of blending of saline and sweet water in pitcher pot for pitcher irrigation with different type of tillage. The fruit yields of tomato were recorded as 27.86t/ha, 26.82 t/ha, 25.01t/ha, 23.90 t/ha 20.78t/ha 19.95 t/ha 17.66t/ha and 16.83t/ha respectively in the plots of saline water(25%)+sweet water (75%)+ mulchtillage (T_8),saline water(25%)+sweet water(75%)+ conventional tillage (T_7), pitcher (Sweet water) + mulch tillage (T_2), pitcher (Sweet water)+ conventional tillage (T_1),saline water(50%)+Sweet water(50%) + mulch tillage (T_6), saline water(50%)+ sweet water(50%) + conventional tillage (T_5), saline water(75%)+sweet water(25%)+ mulchtillage (T_4)and saline water(75%)+sweet water(25%)+ conventional tillage (T_3).The effect of pooled data for 2012 and 2013 also resembles with findings (fig.1). Significantly highest fruit yield was recorded in plots received in saline water (25%)+ sweet water (75%) + mulch tillage (T_8). Response of tomato yield over saline water(75%)+ sweet water(25%) + conventional tillage (T_3) due to eachother treatments were 11.03 t/ha (65.53%), 9.99 t/ha (59.35%), 8.18 t/ha (48.60%) and 7.07t/ha (42.00%) , 3.95 t/ha (23.46%), 3.12 t/ha (18.53%), 0.83 t/ha (4.93%) respectively in saline water(25%)+sweet water (75%)+ mulchtillage (T_8), saline water (25%)+sweet water(75%) + conventional tillage (T_7), pitcher (Sweet water) + mulch tillage (T_2), pitcher (Sweet water)+ conventional tillage (T_1),saline water(50%)+Sweet water(50%) + mulch tillage (T_6), saline water(50%) + sweet water(50%) + conventional tillage (T_5) and saline water(75%) + sweet water(25%) + mulch tillage (T_4). The yield of tomato significantly increased ($P<0.05$) with the application of each of the different types of treatments over pitcher pot Saline water (75%)+Sweet water (25%)+ Conventional tillage (T_3).

The data also reveals that tomato yield due to application of treatment for each of the year, however, the performances of yields were much better in the second year for each of the treatments. The variations of tomato yield in different year were significant at each of the treatments. Result further reveals that yield is positively and significantly correlated with height of plant ($r = 0.918$), number of branch ($r = 0.902$), number of fruit / plant ($r = 0.854$), weight of fruit ($r = 0.898$), length of fruit ($r = 0.524$), diameter of fruit ($r = 0.934$), total water use ($r = 0.844$), moisture use efficacy ($r = 0.933$), dry matter production ($r = 0.930$), crop growth rate ($r = 0.568$) at 1% level of significant (Table 8).

Table 3. Effect of different blending of saline and sweet water in pitcher pot and tillage on yield, yield components and benefit cost ratio of tomato.

Treatment		No of fruit / plant			Fruit Weight (gm.)			Yield (ton/ha)			Benefit Cost Ratio (B:Cratio)		
		1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled
T_1 = Pitcher (Sweet water)+ Conventional tillage		43.43	40.05	41.74	55.25	58.78	57.01	24.14	23.64	23.90	3.2:1	3.2:1	3.2:1
T_2 = Pitcher (Sweet water) + Mulch tillage		45.56	41.22	43.39	56.25	59.36	57.79	25.56	24.46	25.01	3.1:1	3.1:1	3.1:1
T_3 = Saline water(75%)+Sweet water(25%)+ Conventional tillage		35.64	32.34	33.99	48.51	50.20	49.36	16.91	16.75	16.83	3:1	3:1	3:1
T_4 = Saline water(75%)+Sweet water(25%)+ Mulch tillage		36.41	33.32	34.87	49.30	50.86	50.09	17.86	17.46	17.66	3.1:1	3.1:1	3.1:1
T_5 = Saline water(50%)+Sweet water(50%)+ Conventional tillage		36.69	36.19	36.44	53.25	56.25	54.75	19.54	20.36	19.95	3.2:1	3.2:1	3.2:1
T_6 = Saline water(50%)+Sweet water(50%) + Mulch tillage		37.55	37.20	37.38	53.50	58.00	55.75	20.11	21.45	20.78	3.1:1	3.1:1	3.1:1
T_7 = Saline water(25%)+Sweet water(75%)+ Conventional tillage		51.66	43.47	47.56	57.75	62.75	60.25	26.60	27.03	26.82	3.4:1	3.4:1	3.4:1
T_8 = Saline water(25%)+Sweet water(75%) + Mulch tillage		55.33	44.26	49.79	59.25	64.30	61.77	27.30	28.42	27.86	3.3:1	3.3:1	3.3:1
Irrigation	SE(m)	0.573	0.131	0.573	0.076	0.195	0.210	0.107	0.123	0.141	0.00	0.00	0.00
	CD(0.05)	1.701	0.390	1.630	0.225	0.578	0.598	0.317	0.365	0.403	0.00	0.00	0.00
Tillage	SE(m)	0.257	0.141	0.117	0.056	0.092	0.065	0.055	0.093	0.043	0.00	0.00	0.00
	CD(0.05)	1.158	0.634	0.527	0.252	0.412	0.293	0.249	0.416	0.192	0.00	0.00	0.00
Irrigation * Tillage	SE(m)			0.810			0.297			0.200			0.00
	CD(0.05)			2.306			0.846			0.569			0.00

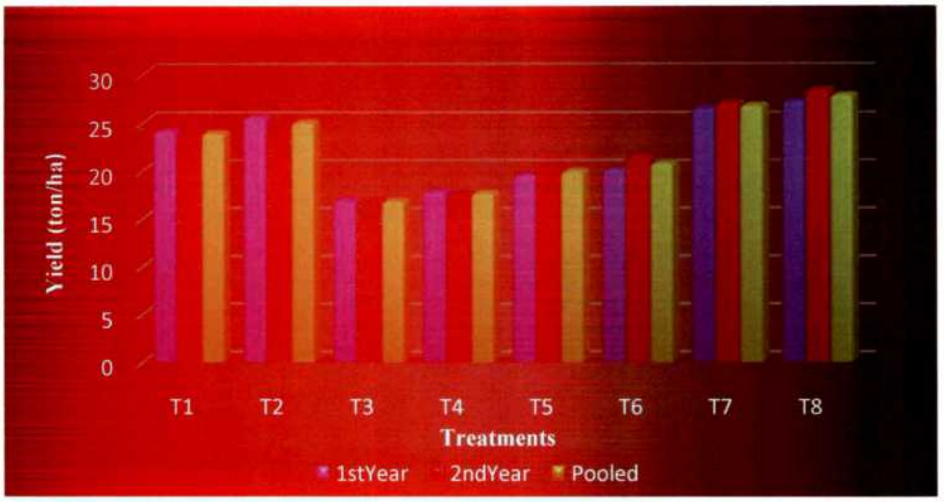

Fig. 1: Effect of various blending of saline and sweet water in pitcher pot with different type of tillage on yield of tomato.

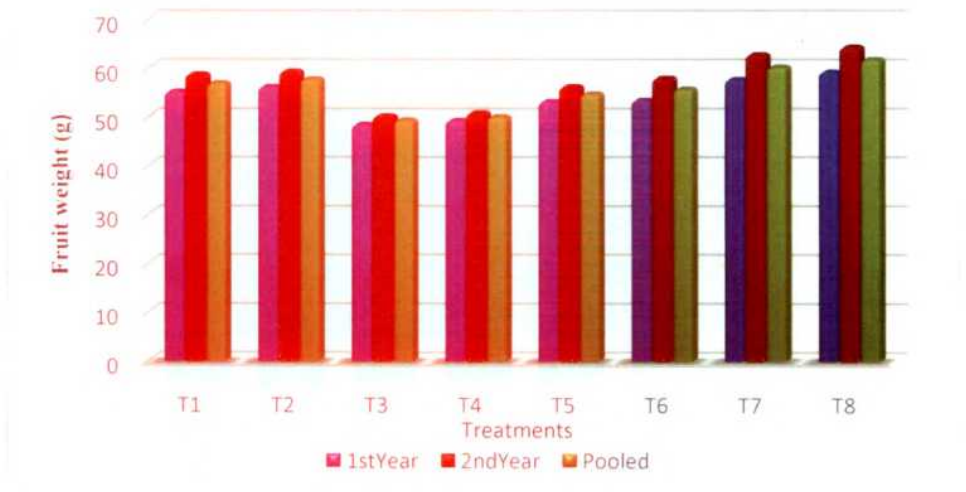

Fig. 2: Effect of various blending of saline and sweet water in pitcher pot with different type of tillage on Fruit weight of tomato.

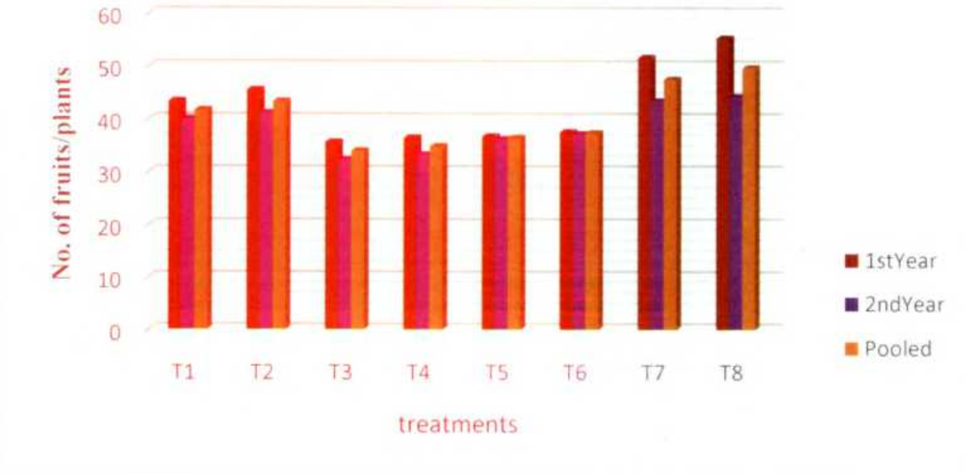

Fig. 3: Effect of various blending of saline and sweet water in pitcher pot with different type of tillage on no. of fruit/plant of tomato.

The number of fruit / plant of tomato pooled data also show that41.74, 43.39, 33.99, 34.87, 36.44, 37.38, 47.56 and 49.79 (Table 3) respectively in the plots of (T_1), (T_2), (T_3), (T_4), (T_5), (T_6), (T_7) and (T_8). Significantly highest ($P<0.05$) number of fruit / plant was recorded saline water (25%) + sweet water (75%) + mulch tillage (T_8). The effect of pooled data for 2012 and 2013 also resembles with findings (fig.3). The results reveals that response of number of fruit / plant over saline water(75%)+ sweet water (25%) + conventional tillage (T_3) due to each treatment were 7.75 (22.80%), 9.4 (27.65%), 0.88 (2.58%) 02.45(7.20%), 13.57 (39.92%), and15.8 (46.48%) respectively in the plots (T_1), (T_2), (T_4), (T_5), (T_6), (T_7) and (T_8). The number of fruit / plant of tomato significantly increased ($P<0.05$) with the application of each of the different types of treatments over saline water (75%) + sweet water (25%) + conventional tillage (T_3).

The data also shows that variation of number of fruit / plant of tomato crop due to application treatment for each of the year, however, the performances of yields were better in the second year for each of the treatments. The variations of number of fruit / plant of tomato crop in different year were significant at each of the treatments. Result further reveals that number of fruit / plant is positively and significantly correlated with number of plant height (r = 0..780), number of branch (r = 0..835), fruit weight (r = 0.680), diameter of fruit (r = 0.809), yield (r = 0..854) total water use (r = .662), moisture use efficacy (r = 0.845), dry matter production (r = 0.733), at 1% level of significance (Table 8).

The results of fruit weight also showed similar trend of results as observed for the earlier results number of fruit / plant. Highest values (61.77 gm) are observed for the treatments of saline water (25%) + sweet water (75%) + mulch tillage (T_8). followed by the treatments of T_7(60.25 g),T_2(57.79g), T_1 (57.01g),T_6 (55.75g),T_5(54.75g) T_4 (50.09g) and T_3(49.36). The effect of pooled data for 2012 and 2013 also resembles with findings (Table 3& figure). The response of fruit weight over pitcher saline water(75%) + sweet water(25%)+ conventional(T_3) due to each treatment were 12.41 (25.14%), 10.89 (22.06%), 8.43(17.07%) ,7.65(15.49%), 6.39(12.94%), 5.39(10.91%) and 0.73(1.47%)respectively in the plots received the treatments(T_8), (T_7), (T_2), (T_1), (T_6), (T_5) and (T_4). Significantly highest ($P<0.05$) fruit yield was recorded in plots received in pitcher saline water (25%) + sweet water (75%) + mulch tillage (T_8). Result further reveals that fruit weight is positively and significantly correlated with plant height (r = 0.856), number of branch (r = 0.799), number of fruit / plant (r = 0.608), length of fruit (r = 0.813), diameter of fruit (r = 0.880), yield (r = 0.898), total water use (r = 0.843), moisture use efficacy (r = 0.779), dry matter production (r = 0.904) and crop growth rate (r = 0.536) at 1% level of significance (Table 8).

The results of the effect of pitcher pot irrigation with various tillage on the length of fruit of tomato crop are presented in Table 3. The results of length of fruit of tomato were observed as 6.04, 5.74, 5.62, 5.55, 5.61,5.60, 4.97 and 4.89 respectively in (T_8), (T_7), (T_2), (T_1), (T_6), (T_5), (T_4) and (T_3) treatments of which higher values are obtained in the plots received the treatment of saline water (25%) + sweet water (75%) + mulch tillage (T_8). The pool data of the two year analysis (Fig 3) follow the similar trend of result. The results also found that response length of fruit of tomato over pitcher saline water(75%) + sweet water(25%)+ conventional tillage (T_3)due to each treatment were 11.15(23.51%), 0.85(17.38%), 0.73(14.92%), 0.66(13.49%), 0.72(14.72%), 0.71(14.02%) and 0.08(1.63%) respectively in (T_8), (T_7), (T_2), (T_1), (T_6), (T_5), (T_4) treatments.

The length of fruit of tomato also showed positive and significant correlation with plant height (r = 0.565), number of branch (r = 0.452), fruit weight (r = 0.813), diameter of fruit (r = 0.548), yield (r = 0.524), total water use (r = 0.535), moisture use efficacy (r = 0.419),and dry matter production (r = 0.608) at 1% level of significance (Table 8). The minimum length of fruit of tomato is also found under the saline water (75%) + sweet water(25%)+ conventional tillage(T_3) plot in the each of year. The variations of number of fruit / plant of tomato crop in different year were significant at each of the treatments.

The result of the diameter of fruit of the tomato crop as influence by various applied treatments is shows in table 3. The significantly highest diameter of fruit of tomato crop was observed in pitcher saline water (25%) + sweet water (75%) + mulch tillage (T_8) both the year. Diameter of fruit varies with the variation of treatments and values are obtained as 3.54, 3.50, 3.24, 3.20, 3.15, 3.10, 2.90 and 2.87cm in respectively of in (T_8), (T_7), (T_2), (T_1), (T_6), (T_5), (T_4) and (T_3) treatments. The effect of pooled data for 2012 and 2013 also resembles with findings (fig 6.).

The data further showed diameter of fruit is positive and significant correlation with plant height (r = 0.831), number of branch (r = 0.847), number of fruit / plant (r = 0.809), fruit weight (r = 0.880), length of fruit (r = 0.548), yield (r = 0.934), total water use (r = 0.821), moisture use efficacy (r = 0.844), dry matter production (r = 0.904) and crop growth rate (r = 0.653) at 1% level of significance (Table 8).

Cost benefit ratio which is define at the ratio between total economic return and total cost of cultivation were also influence by pitcher irrigation with various type of tillage (Table 4). Cost benefit ratio (1:3.3) is highest in saline water (25%) + sweet water (75%) + conventional tillage (T_7) treatment and lowest (1:3) in saline water (75%) + sweet water (25%) + conventional tillage (T_3) treatment.

Application of blending of saline and sweet water in pitcher pot for pitcher irrigation with different type of tillage caused to increase tomato yield along with yield attributes than saline water (75%) + sweet water (25%) + mulch tillage (T_3). Pitcher pot of saline water (25%) + sweet water (75%) + mulch tillage (T_8) found to be most effective in increasing number of fruit/plant, length of fruit, diameter of fruit, weight of fruit and tomato yield as well as benefit cost ratio than the other treatments. Variations in results of yields and yield attributes of tomato due to application various blending of saline and sweet water with different tillage may be attributes to the variations of favourable soil condition mainly decreased soil salinity more precisely by the increasing availability of nutrients in soils.

The above results find support by Tesfaye*et al* (2011). A field experiment was conducted to determine irrigation water and fertilizer use efficiency, growth and yield of tomato under clay pot irrigation at the experimental site of Sekota Dryland Agricultural Research Center, Lalibela, Ethiopia in 2009/10. The experiment comprised of five treatments including furrow irrigated control and clay pot irrigation with different plant population and fertilization methods. The highest total and marketable fruit yields were obtained from clay pot irrigation combined with application of nitrogen fertilizer with irrigation water irrespective of difference in plant population. Thus, clay pot irrigation with 33,333 plants ha-1 and nitrogen fertilizer application with irrigation water in clay pots was the best method for increasing the yield of tomato while economizing the use of water and nitrogen fertilizer in a semiarid environment.

According to Setiawan,-B-I *et al* (1998) conducted to determine an appropriate technology option for irrigation in water-short areas in Indonesia is presented. The pitcher irrigation system utilizes a bottle-like emitter made of baked clay, sand and ash. Water level is maintained constant inside the pitcher and permeates the pitcher wall to supply crops in the surrounding soil. The system has been applied successfully to horticultural products such as chillies, tomatoes, grapes and mangos, in greenhouse as well as in the field.

4.1.2. Physiological parameter of tomato:

The result of physical parameters inducing growth of tomato crop presented in (Table 4) by application of blending of saline and sweet water in pitcher pot for pitcher irrigation with various tillage. The results of the effect of pitcher pot irrigation with various tillage on the plant height of tomato crop are summarized (fig.4)The significantly highest ($P<0.05$) plant height of tomato crop were observed in pitcher pot pitcher pot of saline water (25%) + sweet water (75%) + mulch tillage (T_8) both the year. The results found that plant height were recorded as 113.94, 106.93, 106.60, 108.27, 101.59, 99.86, 95.57 and 94.17 cm respectively in(T_8), (T_7), (T_2), (T_1), (T_6), (T_5), (T_4) and (T_3) treatments. The results also found that response plant height of tomato over pitcher saline water (75%) + sweet water (25%) + conventional tillage (T_3) treatment due to each treatment were 19.77(20.99%), 12.72 (13.54%), 15.46 (16.41%) , 14.1 (14.97%), 7.42(7.87%), 5.69(6.04%) and 1.4(1.48%) respectively in (T_8), (T_7), (T_2), (T_1), (T_6), (T_5), (T_4) treatments.

Table 4. Effect of different blending of saline and sweet water in pitcher pot and tillage on Physiological parameter and yield component of tomato.

Treatment		Plant height(cm)			No of Branch			Length of fruit (cm)			Diameter of fruit (cm)		
		1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled
T_1 = Pitcher (Sweet water)+ Conventional tillage		106.95	109.59	108.27	7.26	7.28	7.25	5.08	6.05	5.55	3.2	3.2	3.20
T_2 = Pitcher (Sweet water) + Mulch tillage		109.08	110.13	109.60	7.33	7.35	7.34	5.09	6.15	5.62	3.2	3.27	3.24
T_3 = Saline water(75%)+Sweet water(25%)+ Conventional tillage		94.25	95.58	94.17	5.53	5.53	5.53	4.51	5.25	4.89	2.9	2.82	2.87
T_4 = Saline water(75%)+Sweet water(25%)+ Mulch tillage		98.08	96.06	95.57	5.63	5.55	5.59	4.54	5.40	4.97	2.9	2.90	2.90
T_5 = Saline water(50%)+Sweet water(50%)+ Conventional tillage		98.18	101.63	99.86	6.20	6.18	6.19	4.95	6.02	5.60	3.1	3.10	3.10
T_6 = Saline water(50%)+Sweet water(50%) + Mulch tillage		100.75	102.43	101.59	6.50	6.53	6.51	5.02	6.10	5.61	3.1	3.20	3.15
T_7 = Saline water(25%)+Sweet water(75%)+ Conventional tillage		106.85	107.00	106.93	7.28	6.75	7.01	5.24	6.25	5.74	3.5	3.50	3.50
T_8 = Saline water(25%)+Sweet water(75%) + Mulch tillage		114.38	113.50	113.94	8.60	8.37	8.45	5.52	6.56	6.04	3.5	3.57	3.54
Irrigation	SE(m)	0.647	0.555	0.427	0.075	0.047	0.049	0.019	0.032	0.030	0.001	0.025	0.014
	CD(0.05)	1.924	1.650	1.217	0.223	0.141	0.139	0.058	0.094	0.084	0.001	0.074	0.039
Tillage	SE(m)	0.602	0.444	0.497	0.036	0.029	0.016	0.008	0.019	0.011	0.000	0.014	0.006
	CD(0.05)	2.708	2.000	2.236	0.163	0.128	0.071	0.036	0.087	0.050	0.000	0.062	0.025
Irrigation * Tillage	SE(m)			0.604			0.069			0.042			0.019
	CD(0.05)			1.720			0.196			0.119			0.055

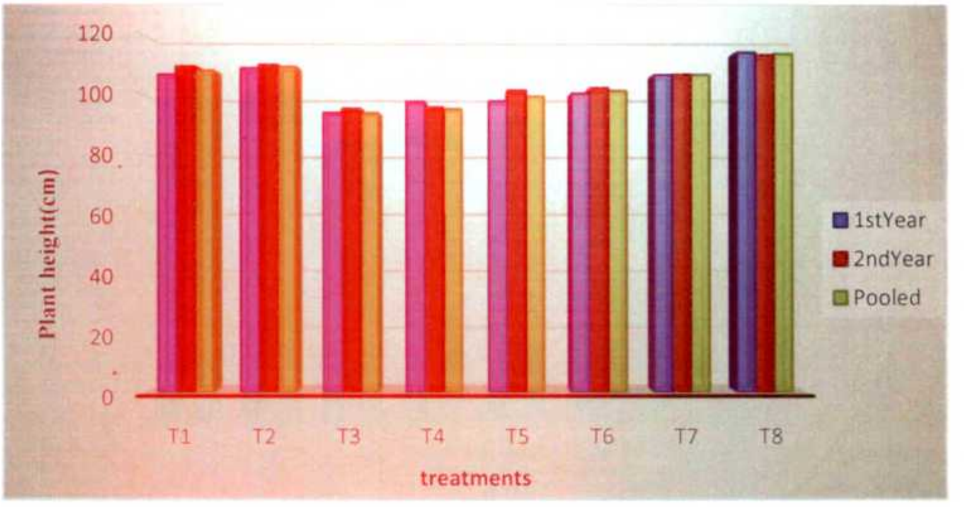

Fig. 4: Effect of various blending of saline and sweet water in pitcher pot with different type of tillage on plant height (cm) of tomato.

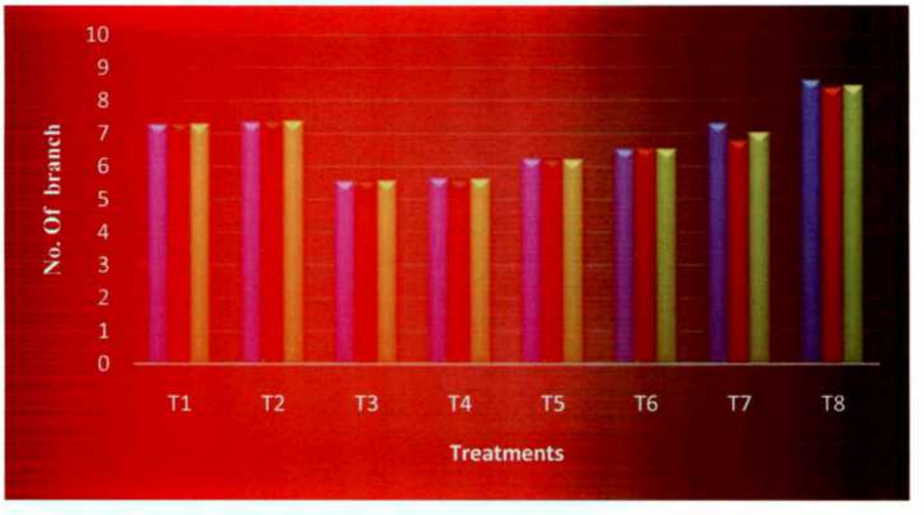

Fig. 5: Effect of various blending of saline and sweet water in pitcher pot with different type of tillage on no. of branch of tomato.

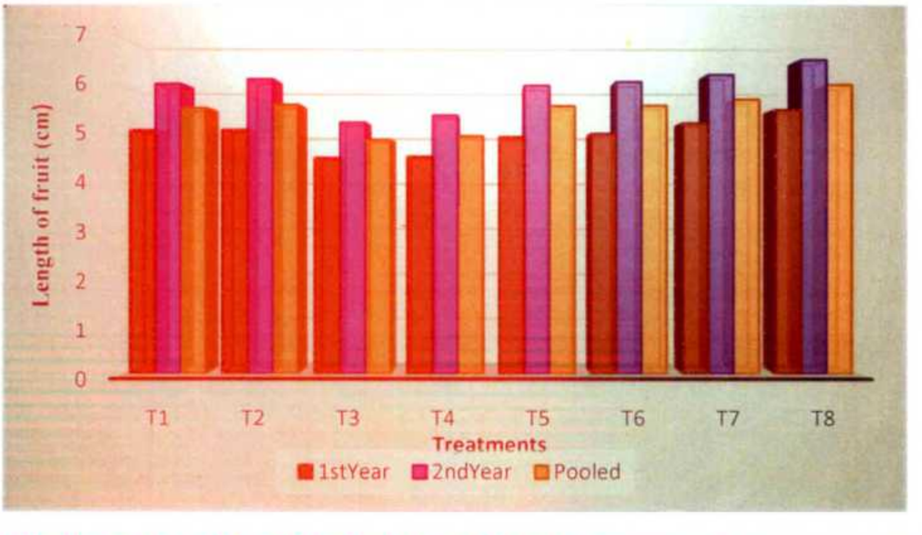

Fig. 6: Effect of various blending of saline and sweet water in pitcher pot with different type of tillageon length of fruits of tomato.

Result further shows that plant height is positively and significantly correlated with number of branch (r = 0.945), number of fruit / plant (r = 0.780), fruit weight (r = 0.856), length of fruit (r = 0.565), diameter of fruit (r = 0.831), yield (r = 0.918), total water use (r = 0.822), moisture use efficacy (r = 0.830) dry matter production (r = 0.901)and crop growth rate (r = 0.580) at 1% level of significance (Table).The plant height of tomato showed significant variation ($P<0.05$) for application of each types of treatments over pitcher saline water (75%) + sweet water (25%) + conventional tillage (T_3) and there were 1% level of significance at each of the treatments variations in different year.

Similarly the number of branch of tomato crop effect of various tillage with different pitcher irrigation combinations are summarized Table 4. The results found that numbers of branch initiation pool data were recorded as 8.45, 7.01, 7.34, 7.25, 6.51, 6.19, 5.59 and 5.53 cm respectively in treatments (T_8), (T_7), (T_2), (T_1), (T_6), (T_5), (T_4) and (T_3).

Result further shows that no. of branches are positively and significantly correlated with plant height (r = 0.945), number of fruit / plant (r = 0.835), fruit weight (r = 0.799), diameter of fruit (r = 0.847), yield (r = 0.902), total water use (r = 0.801), moisture use efficacy (r = 0.816) dry matter production (r = 0.861)and crop growth rate (r = 0.551) at 1% level of significance (Table 8).The plant height of tomato showed significant variation ($P<0.05$) for application of each types of treatments over pitcher saline water (75%) + sweet water (25%) + conventional tillage (T_3) and there were 1% level of significance at each of the treatments variations in different year.

Table 5 Effect of different blending of saline and sweet water in pitcher pot and tillage on crop growth rate and moisture use efficiency of tomato.

Treatment		Dry matter production at harvesting (g/m^2)			Crop growth rate (g/day/m^2)			Total water use(mm)			MUE (kg/ha/mm)		
		1stYear	2ndYear	Pooled	1stYear	2ndYear	Pooled	1stYear	2ndYear	Pooled	1stYear	2ndYear	Pooled
T_1 = Pitcher (Sweet water)+ Conventional tillage		375.63	379.40	377.51	3.39	3.46	3.42	533.10	541.29	537.19	45.28	43.59	44.44
T_2 = Pitcher (Sweet water) + Mulch tillage		378.62	382.02	380.37	3.42	3.49	3.45	534.41	542.11	538.26	47.33	44.85	46.34
T_3 = Saline water(75%)+Sweet water(25%)+ Conventional tillage		345.21	347.49	346.39	3.01	3.10	3.05	445.33	439.75	442.54	37.98	38.95	38.46
T_4 = Saline water(75%)+Sweet water(25%)+ Mulch tillage		349.66	352.59	350.98	3.04	3.12	3.08	447.13	440.55	443.84	40.13	39.75	39.94
T_5 = Saline water(50%)+Sweet water(50%)+ Conventional tillage		364.07	367.59	365.83	3.18	3.36	3.26	526.14	521.63	523.89	37.14	39.03	38.09
T_6 = Saline water(50%)+Sweet water(50%) + Mulch tillage		367.57	370.92	369.24	3.26	3.41	3.33	528.25	522.01	525.13	38.07	40.75	39.40
T_7 = Saline water(25%)+Sweet water(75%)+ Conventional tillage		381.49	384.80	383.15	3.47	3.56	3.52	540.65	543.45	542.05	49.20	49.79	49.50
T_8 = Saline water(25%)+Sweet water(75%) + Mulch tillage		382.52	386.63	384.57	3.51	3.61	3.56	542.50	545.81	544.16	50.32	51.27	50.79
Irrigation	SE(m)	0.069	0.198	0.119	0.000	0.071	0.037	0.287	0.150	0.882	0.231	0.340	0.321
	CD (0.05)	0.205	0.588	0.338	0.000	0.210	0.106	0.853	0.446	2.510	0.687	1.009	0.917
Tillage	SE(m)	0.044	0.105	0.067	0.001	0.044	0.022	0.165	0.123	0.139	0.122	0.261	0.113
	CD (0.05)	0.198	0.473	0.301	0.004	0.198	0.097	0.745	0.552	0.624	0.548	1.174	0.509
Irrigation * Tillage	SE(m)			0.168			0.052			1.247			0.454
	CD (0.05)			0.478			0.149			3.549			1.292

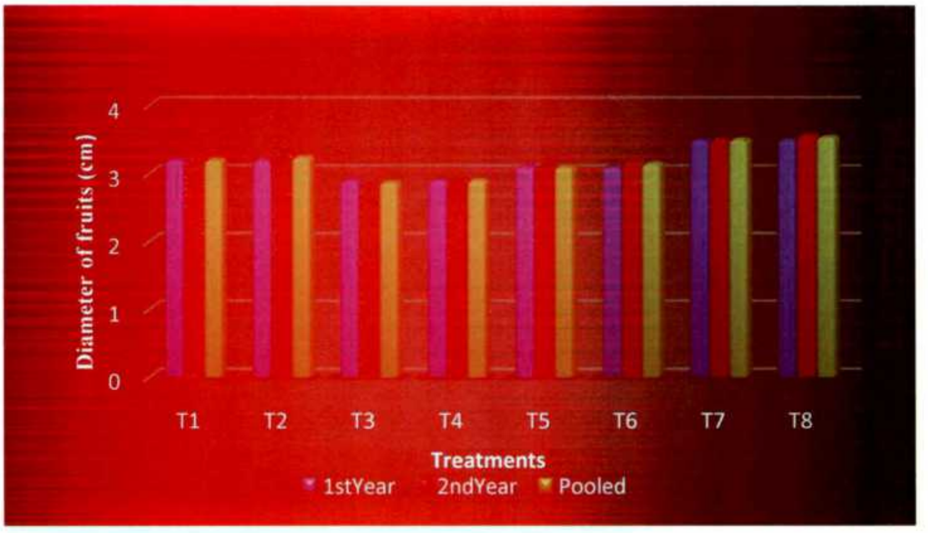

Fig. 7: Effect of various blending of saline and sweet water in pitcher pot with different type of tillageon diameter of fruit of tomato.

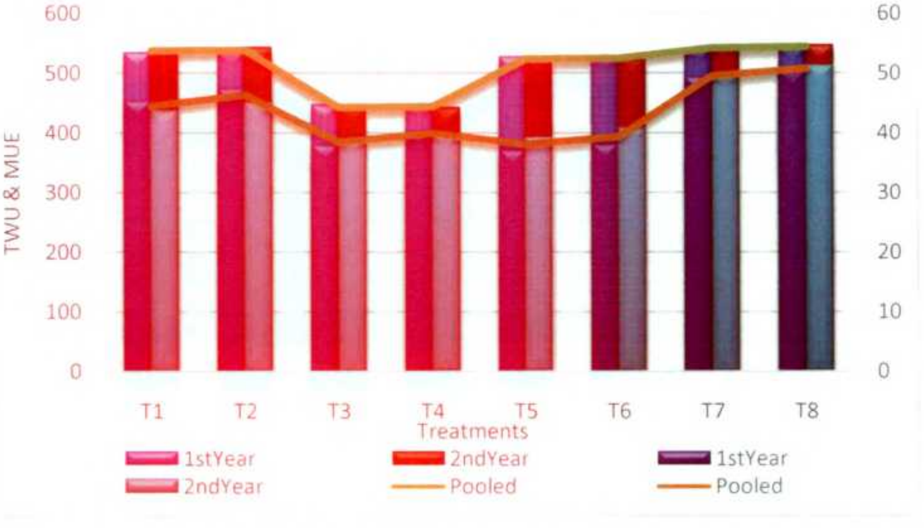

Fig. 8: Effect of various blending of saline and sweet water in pitcher pot with different type of tillageon Total water use and moisture use efficiency of tomato.

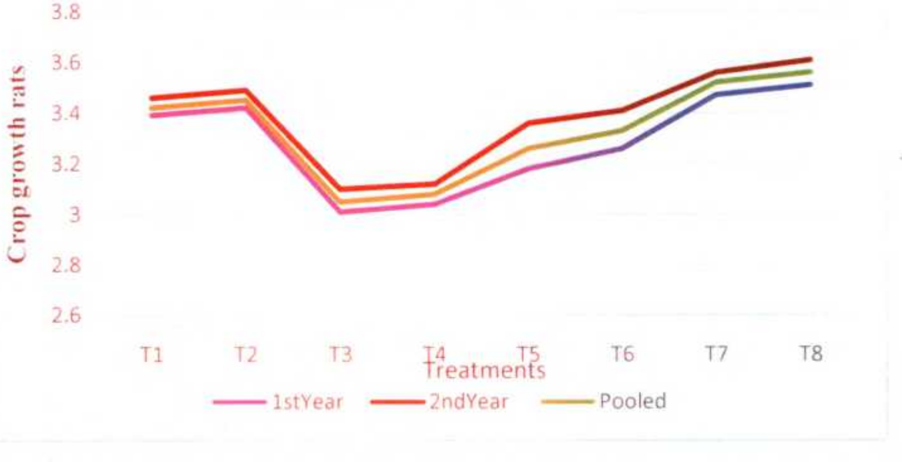

Fig. 9: Effect of various blending of saline and sweet water in pitcher pot with different type of tillageon crop growth rateof tomato.

4.1.3. Growth and crop growth rate of tomato:

The result in the table 5 shows that the dry matter accumulation of the crop progressively increase with increasing period after sowing at each of the treatment in each year. The dry matter production found highest in saline water (25%) + sweet water (75%) + mulch tillage (T_8) in both years. The results reveal that total dry matter weight were 384.57, 383.15, 380.37, 377.51, 369.24, 365.83, 350.98 and 346.39gm/m^2 respectively (T_8), (T_7), (T_2), (T_1), (T_6), (T_5), (T_4) and (T_3) treatments. Response of dry matter production over pitcher saline water (75%) + sweet water (25%) + conventional tillage (T3)due to each treatment were 38.18(11.02%), 36.36(10.61%), 33.98(9.80%) 31.12(8.98%), 22.85(6.59%), 19.44(5.61%), 4.59(1.32%)and respectively in (T_8), (T_7), (T_2), (T_1), (T_6), (T_5) and (T_4) on the total dry matter weight of the tomato crop. Result further reveals that crop growth rate is positively and significantly correlated with plant height ($r = 0.901$), number of branch ($r = 0.861$), number of fruit / plant ($r = 0.733$), fruit weight ($r = 0.904$), length of fruit ($r = 0.608$), diameter of fruit ($r = 0.904$), yield ($r = 0.930$), total water use ($r = 0.705$), moisture use efficacy ($r = 0.789$) and crop growth rate ($r = 0.705$) at 1% level of significance (Table 8).The variations of dry matter accumulation dry matter accumulation of tomato in different year were not significant at each of the treatments.

Similarly result of crop growth rates of the tomato as influenced by various applied treatments are showed in the Table 5.Crop growth rate was found 3.56, 3.52, 3.45, 3.42, 3.33, 3.26, 3.08 and3.04g/day/m^2 and increased over saline water (75%) + sweet water (25%) + conventional tillage (T_3)by0.51(16.72%), 0.47(15.40%), 0.40(13.11%), 0.37(12.13%), 0.28(9.18%), 0.21(6.88%) and 0.03(1.98%)in respectively(T_8), (T_7), (T_2), (T_1), (T_6), (T_5) and (T_4) treatments. The effect of pooled data for 2012 and 2013 also resembles with findings (figure 8).The significantly highest crop growth rates of tomato crop were observed in saline water (25%) + sweet water (75%) + mulch tillage (T8) both the year.

The minimum crop growth rates of tomato are also found under saline water (75%) + sweet water (25%) + conventional tillage (T_3) plot in the both years. The effect of pooled data for 2011 and 2012 also resembles with findings (figure). Result further shows that crop growth rate is positively and significantly correlated with plant height ($r = 0.580$), number of branch ($r = 0.551$), number of fruit / plant ($r =$

0.454), fruit weight (r = 0.536), diameter of fruit (r = 0.653), yield (r = 0.568), total water use (r = 0.573), moisture use efficacy (r = 0.466) and dry matter production (r = 0.705)at 1% level of significance (Table 8).The variations of dry matter production of tomato in different year were significant different at each of the treatments.

Effect of drip irrigation levels and mulches on growth, yield and water use efficiency of tomato study by Kumar *et al.*, (2012). Experiment conducted on tomato (cv. ArkaVikas) the during winter (rabi) season of 2011-12 on a sandy clay loam soil in Hyderabad, Andhra Pradesh, India. There were 3 drip irrigation treatments: at 0.6, 0.8 and 1.0 E pan and 4 mulch treatments.

Table 6.Changes of soil moisture % from 0-15 cm soil depth during growing period of tomato.

1st Year

Treatment	Standard Meteorological Week													
	47	48	49	50	51	52	1	2	3	4	5	6	7	8
	Rainfall (mm)													
	0.0	0.0	0.0	24.4	0.0	0.9	8.0	0.0	0.0	0.0	0.0	0.0	5.8	0.0
T_1 = Pitcher (Sweet water)+ Conventional tillage	29.73	26.92	24.57	35.83	26.39	29.94	32.41	3073	28.52	27.17	25.69	24.26	32.84	30.59
T_2 = Pitcher (Sweet water) + Mulch tillage	28.16	26.78	27.43	27.39	26.27	28.88	31.86	32.94	32.38	33.89	32.57	30.91	32.33	30.27
T_3 = Saline water(75%)+Sweet water(25%)+ Conventional tillage	20.96	20.83	23.74	23.65	24.91	25.17	27.56	29.74	29.43	31.12	30.64	29.48	30.17	28.16
T_4 = Saline water(75%)+Sweet water(25%)+ Mulch tillage	21.28	21.15	24.38	23.93	25.07	25.41	27.60	29.85	29.56	31.22	30.17	29.79	30.19	28.20
T_5 = Saline water(50%)+Sweet water(50%)+ Conventional tillage	23.28	23.15	26.38	26.23	25.37	27.91	31.55	32.29	31.24	33.22	31.47	30.29	31.19	29.75
T_6 = Saline water(50%)+Sweet water(50%) + Mulch tillage	23.75	23.98	26.85	28.60	27.15	28.54	31.96	33.22	32.16	33.95	31.65	31.02	31.64	30.22
T_7 = Saline water(25%)+Sweet water(75%)+ Conventional tillage	28.16	26.78	27.43	27.39	26.27	28.88	31.86	32.94	32.38	33.89	32.57	30.91	32.33	30.27
T_8 = Saline water(25%)+Sweet water(75%) + Mulch tillage	29.73	26.92	24.57	35.83	26.39	29.94	32.41	3073	28.52	27.17	25.69	24.26	32.84	30.59

Contd.......

2^{st} Year

Treatment	Standard Meteorological Week													
	9	10	11	12	13	14	15	16	17	18	19	20	21	22
	Rainfall (mm)													
	0.0	0.0	0.0	0.0	0.0	0.0	4.5	0.0	53.0	0.0	0.0	0.0	0.0	0.0
T_1 = Pitcher (Sweet water)+ Conventional tillage	26.24	25.92	25.77	27.15	28.18	26.63	26.37	26.24	27.11	27.29	26.27	26.11	26.94	26.67
T_2 = Pitcher (Sweet water) + Mulch tillage	26.66	26.23	25.74	27.38	28.69	27.22	26.73	26.38	27.47	27.21	26.59	26.34	27.17	27.29
T_3 = Saline water(75%)+Sweet water(25%)+ Conventional tillage	23.35	22.97	22.58	23.9	24.36	24.15	23.77	23.49	23.83	23.78	23.29	23.2	23.14	23.87
T_4 = Saline water(75%)+Sweet water(25%)+ Mulch tillage	25.7	25.34	25.18	26.56	27.48	26.41	26.28	25.87	26.75	26.93	25.84	25.47	26.29	25.75
T_5 = Saline water(50%)+Sweet water(50%)+ Conventional tillage	26.11	25.26	24.92	25.32	25.05	25.85	28.47	26.44	26.12	25.91	25.54	24.87	24.35	24.16
T_6 = Saline water(50%)+Sweet water(50%) + Mulch tillage	26.24	25.92	25.77	27.15	28.18	26.63	29.37	26.24	27.11	27.29	26.27	26.11	26.94	26.67
T_7 = Saline water(25%)+Sweet water(75%)+ Conventional tillage	26.66	26.23	25.74	27.38	28.69	27.22	29.73	26.38	27.47	27.21	26.59	26.34	27.17	27.29
T_8 = Saline water(25%)+Sweet water(75%) + Mulch tillage	26.92	26.37	26.96	27.55	29.14	27.73	31.38	26.84	27.96	27.43	26.9	26.38	27.62	27.39

Table 7. Total water use (mm) from 0-15 cm soil depth during growing period of tomato.

1st Year

Treatment	Standard Meteorological Week													
	48	49	50	51	52	1	2	3	4	5	6	7	8	Total water use
T_1 = Pitcher (Sweet water)+ Conventional tillage	34.27	36.46	42.38	49.46	42.54	45.56	44.86	41.56	39.54	41.37	42.56	39.3	33.24	533.10
T_2 = Pitcher (Sweet water) + Mulch tillage	34.59	37.78	42.45	50.32	42.68	47.86	45.69	42.67	40.65	40.42	38.43	37.42	33.45	534.41
T_3 = Saline water(75%)+Sweet water(25%)+ Conventional tillage	29.05	30.43	35.22	39.19	38.52	34.36	34.02	33.82	39.08	35.35	33.46	35.68	27.15	445.33
T_4 = Saline water(75%)+Sweet water(25%)+ Mulch tillage	29.05	30.43	35.22	40.19	38.52	34.36	34.02	33.82	39.08	35.25	33.46	36.68	27.15	447.13
T_5 = Saline water(50%)+Sweet water(50%)+ Conventional tillage	33.24	38.46	42.03	49.46	42.75	43.56	44.87	41.56	39.54	39.17	38.96	39.3	33.24	526.14
T_6 = Saline water(50%)+Sweet water(50%) + Mulch tillage	34.65	38.46	42.03	49.46	42.76	43.56	44.94	41.56	39.54	39.17	38.96	39.41	33.75	528.25
T_7 = Saline water(25%)+Sweet water(75%)+ Conventional tillage	34.82	38.78	43.52	50.15	43.46	47.46	45.77	42.46	41.65	40.42	39.29	39.42	33.45	540.65
T_8 = Saline water(25%)+Sweet water(75%) + Mulch tillage	34.9	38.86	43.56	50.75	43.46	47.56	45.85	42.62	41.81	40.6	39.45	39.53	33.55	542.50

Contd…….

2^{st} Year

Treatment	Standard Meteorological Week												
	9	10	11	12	13	14	15	16	17	18	19	20	21	Total water use
T_1 = Pitcher (Sweet water)+ Conventional tillage	34.27	36.46	42.38	49.46	42.54	45.56	44.86	41.56	39.54	41.37	42.56	39.3	33.24	541.29
T_2 = Pitcher (Sweet water) + Mulch tillage	34.59	37.78	42.45	50.32	42.68	47.86	45.69	42.67	40.65	40.42	38.43	37.42	33.45	542.11
T_3 = Saline water(75%)+Sweet water(25%)+ Conventional tillage	29.05	30.43	35.22	39.19	38.52	34.36	34.02	33.82	39.08	35.35	33.46	35.68	27.15	439.75
T_4 = Saline water(75%)+Sweet water(25%)+ Mulch tillage	29.05	30.43	35.22	40.19	38.52	34.36	34.02	33.82	39.08	35.25	33.46	36.68	27.15	440.55
T_5 = Saline water(50%)+Sweet water(50%)+ Conventional tillage	33.24	38.46	42.03	49.46	42.75	43.56	44.87	41.56	39.54	39.17	38.96	39.3	33.24	521.63
T_6 = Saline water(50%)+Sweet water(50%) + Mulch tillage	34.65	38.46	42.03	49.46	42.76	43.56	44.94	41.56	39.54	39.17	38.96	39.41	33.75	522.01
T_7 = Saline water(25%)+Sweet water(75%)+ Conventional tillage	34.82	38.78	43.52	50.15	43.46	47.46	45.77	42.46	41.65	40.42	39.29	39.42	33.45	543.45
T_8 = Saline water(25%)+Sweet water(75%) + Mulch tillage	34.9	38.86	43.56	50.75	43.46	47.56	45.85	42.62	41.81	40.6	39.45	39.53	33.55	545.81

Table 8.Correlation metrics involving yield and yield attributes characters of tomato.

	Plant height	No of branch	No of fruit / plant	Fruit Weight (gm.)	Length of fruit (cm)	Diameter of fruit (cm)	Yield (ton/ha)	Total water use(mm)	Water use efficiency(kg/ha/mm)	Dry matter production at harvesting (g/m2)	Crop growth rate (g/day/m2)
Plant height	1.000										
No of branch	.945**	1.000									
No of fruit / plant	.780**	.835**	1.000								
Fruit Weight (gm.)	.856**	.799**	.608**	1.000							
Length of fruit (cm)	.565**	.452**	0.152	.813**	1.000						
Diameter of fruit (cm)	.831**	.847**	.809**	.880**	.548**	1.000					
Yield (ton/ha)	.918**	.902**	.854**	.898**	.524**	.934**	1.000				
Total water use(mm)	.822**	.801**	.662**	.843**	.535**	.821**	.844**	1.000			
Water use efficiency(kg/ha/mm)	.830**	.816**	.845**	.779**	.419**	.844**	.933**	.612**	1.000		
Dry matter production at harvesting (g/m2)	.901**	.861**	.733**	.904**	.608**	.904**	.930**	.924**	.789**	1.000	
Crop growth rate (g/day/m2)	.580**	.551**	.454**	.536**	.365**	.653**	.568**	.573**	.466**	.705**	1.000

** Correlation is significant at the 0.01 level (2-tailed).

Table 9.Results of step wise regression analysis involving yield as dependable variable and all other variables as predictors

Variable	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	1.576	1.517		1.039	0.000
K (kg/ha)	0.074	0.006	0.986	13.350	0.000
Organic Carbon (%)	4.753	0.662	0.186	7.175	0.000
EC	-0.376	0.119	-.098	-3.169	0.002
N(kg/ha)	-0.093	0.031	-.227	-3.053	0.003

Dependent Variable: Tomato yield

R	R Sq	Adj R Sq	SE(est)		
0.99	0.98	0.98	0.539		

** Coefficients are significant at the 0.01 level.

4.1.5. Soil moisture use and moisture use efficiency of tomato:

Periodical soil moisture content in percentage due to pitcher + tillage treatment in soils growing with tomato was monitored by weekly basis; the results are presented in Table 6 and figures. Consistence variation has been observed in the soil under different treatment. Highest moisture percentage was found in saline water (25%) + sweet water (75%) + mulch tillage (T_8).and lowest water use found in saline water (75%) + sweet water (25%) + conventional tillage (T_3).Average values for the results of each year also show similar trends as shown in figures. Results also revealed that total moisture use by plant in the following order i.e T_8 (544.16 mm) > T_7 (542.05 mm) > T_2 (538.26mm) > T_1 (537.19 mm) > T_6 (525.63mm) > T_5 (5523.89mm) > T_4 (443.84mm) > T_3 (442.52mm) (Table5). Response of total water use over saline water (75%) + sweet water (25%) + conventional tillage (T3)due to each treatment were 101.64(22.96%), 99.53(22.49%), 95.74(21.63%), 94.67(21.39%), 83.11(18.78%), 81.37(18.38%) and 1.32(2.98%) respectively in treatments (T_8), (T_7), (T_2), (T_1), (T_6), (T_5) and (T_4)

The total water use of tomato crop significantly increased with the application of blending of saline and sweet water in pitcher pot for pitcher irrigation with different type of tillage. Result further reveals that total water use is positively and significantly correlated, with plant height (r = 0.822), number of branch (r = 0.801), number of fruit / plant (r = 0.662), fruit weight (r = 0.843), length of fruit (r = 0.535), diameter of fruit (r = 0.821), yield (r = 0.844), moisture use efficacy (r = 0.612),dry matter production (r = 0.924) and crop growth rate (r = 0.573) at 1% level of significance (Table8).

The moisture use efficiency significantly increased ($P<0.05$) with the application of each of the different types of blending of saline and sweet water in pitcher pot for pitcher irrigation with different type of tillage over control. Result further reveals that water use efficiency is positively and significantly correlated with plant height (r = 0.830), number of branch (r = 0.816), number of fruit / plant (r = 0.845), fruit weight (r = 0.779, diameter of fruit (r = 0.844), yield (r = 0.933), total water use (r = 0.612) and dry matter production (r = 0.789), at 1% level of significance (Table 8).

Therefore, it is apparent form the present study that saline water (25%) + sweet water (75%) + mulch tillage (T_8).can serves as better for tomato crop and thus improves the yield and yield attributes of tomato by the influence of adequate soil moisture and optimum thermal condition leading to favourable nutrient supply to crops.

The highest total and marketable fruit yields were obtained from clay pot irrigation combined with application of nitrogen fertilizer with irrigation water irrespective of difference in plant population. The clay pot irrigation had seasonal water use of up to 143.71 mm, which resulted in significantly higher water use efficiency (33.62 kg m-3) as compared to the furrow irrigation. This experiment carried out by (Tesfaye *et al.,* 2011).

The results of this study are in agreement with Mitra *et al.*, (2012) A field study was carried out during the winter season of 2003-2004 and 2004-2005 , India, to evaluate the effect of irrigation frequencies and mulches on evapotranspiration rate from tomato crop field as well as leaf area index (LAI), fruit yield and WUE of crops.

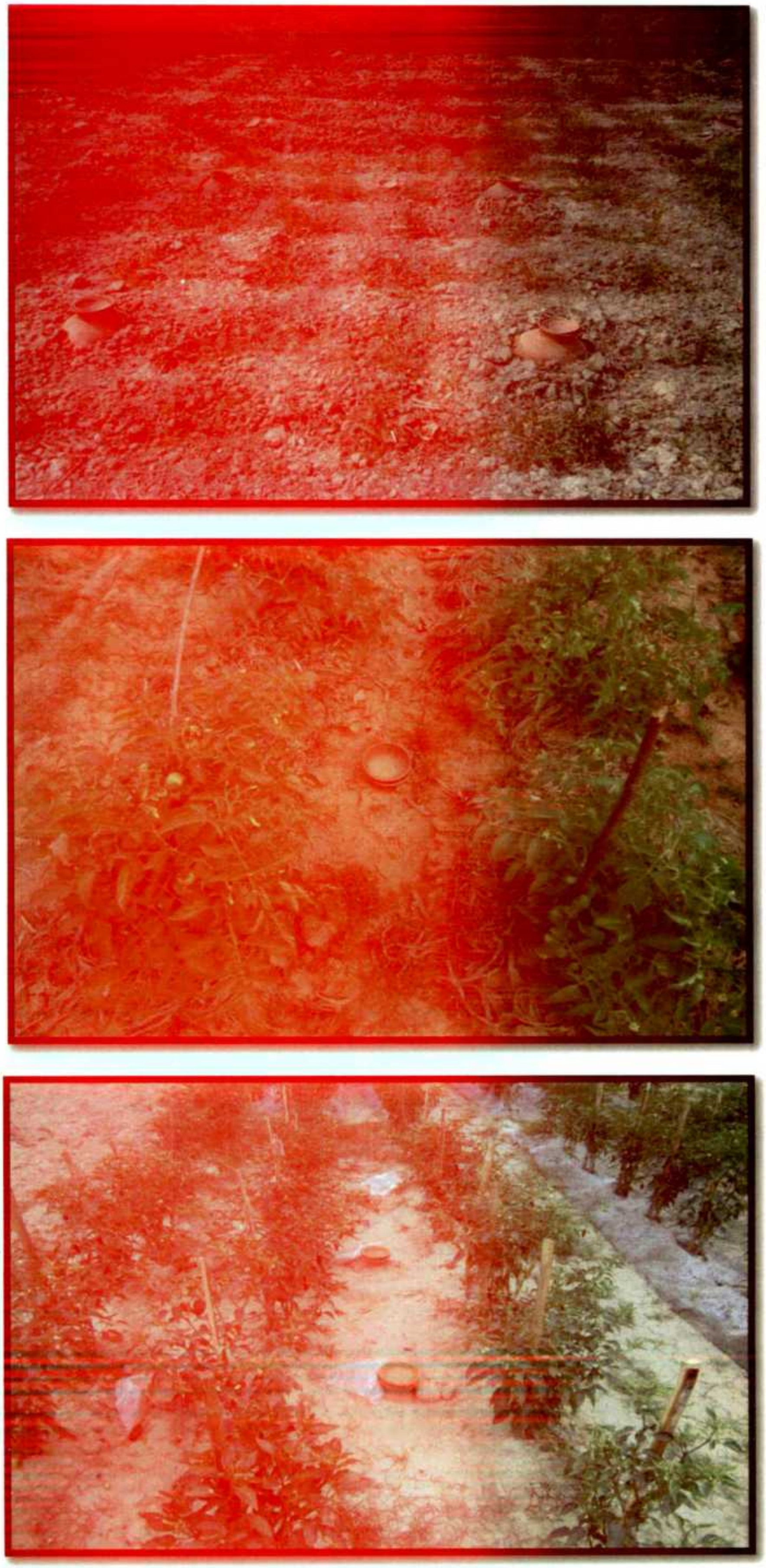

Plate 1: Pitcher pot with tillage in tomato and chilli plot.

4.2. Effect of different blending of saline and sweet water in pitcher pot and tillage on chilli.

4.2.1. Yield and yield attributes of chilli:

The results (Table 10) of pooled data on yield of chilli grown in 2012 and 2013 during summer seasons showed variation with the application of blending of saline and sweet water in pitcher pot for pitcher irrigation with different type of tillage. Highest fruit yield (8.81 t/ha) was recorded in plots received in saline water (25%) + sweet water (75%) + mulch tillage (T_8) and lowest yield (4.04 t /ha) was recorded in plots received in saline water (75%) + sweet water (25%) + conventional tillage (T_3). The fruit yields of chilli were recorded as 8.81t/ha, 8.74 t/ha, 6.67 t/ha, 6.46 t/ha 5.96 t/ha 5.28 t/ha 4.10 t/ha and 4.04 t/ha respectively in the plots of saline water(25%) + sweet water (75%)+ mulch tillage (T_8), saline water (25%)+sweet water(75%) + conventional tillage (T_7), pitcher (Sweet water) + mulch tillage (T_2), pitcher (Sweet water)+ conventional tillage (T_1),saline water(50%)+Sweet water(50%) + mulch tillage (T_6), saline water(50%)+ sweet water(50%) + conventional tillage (T_5), saline water(75%)+sweet water(25%) + mulch tillage (T_4) and saline water (75%) +sweet water (25%) + conventional tillage (T_3).The effect of pooled data for 2012 and 2013 also resembles with findings (fig.10). Significantly highest fruit yield was recorded in plots received in saline water (25%) + sweet water (75%) + mulch tillage (T_8).Response of chilli yield over saline water(75%)+ sweet water(25%)+ conventional tillage(T3)due to each other treatment were 4.77 t/ha (118.06%), 4.7 t/ha (116.33%), 2.63 t/ha (65.09%). 2.42t/ha (59.90%) , 1.92 t/ha (47.52%), 1.24 t/ha (30.69%) and0.06 t/ha (1.48%) respectively in saline water (25%) + sweet water (75%) + mulch tillage (T_8), saline water (25%)+sweet water(75%) + conventional tillage (T_7), pitcher (Sweet water) + mulch tillage (T_2), pitcher (Sweet water)+ conventional tillage (T_1),saline water(50%)+Sweet water(50%) + mulch tillage (T_6), saline water(50%) + sweet water(50%) + conventional tillage (T_5) and saline water(75%) + sweet water(25%) + mulch tillage (T_4).

The data also reveals that chilli yield due to application of treatment for each of the year, however, the performances of yields were much better in the second year for each of the treatments. The variations of chilli yield in different year were significant at each of the treatments. Result further reveals that yield is positively and significantly correlated with height of plant ($r = 0.933$), number of branch ($r = 0.944$), number of fruit / plant (r = 0.999), weight of fruit (r = 0.969), length of fruit (r = 0.946), diameter of fruit (r = 0.868), total water use (r = 0.899), moisture use efficacy (r = 0.993), crop growth rate (r = 0.869) at 1% level of significant (Table 15). Further analysis using step wise multiple regression technique revealed that Water holding capacity (WHC %) is only significant predicator to predict yield. The regression equation consisting with water holding capacity (WHC %) as independent variable can predict the yield of chilli with 52.8% variability (Table 16).

Table 10. Effect of different blending of saline and sweet water in pitcher pot and tillage onyield, yield components and benefit cost ratio of chilli.

Treatment		No of fruit / plant			Fruit Weight (gm.)			Yield (ton/ha)			Benefit Cost Ratio (B:Cratio)		
		1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled
T_1 = Pitcher (Sweet water)+ Conventional tillage		250.59	252.39	251.49	2.57	2.56	2.56	6.44	6.48	6.46	3.4:1	3.4:1	3.4:1
T_2 = Pitcher (Sweet water) + Mulch tillage		252.81	264.72	258.76	2.57	2.58	2.57	6.51	6.83	6.67	3.3:1	3.3:1	3.3:1
T_3 = Saline water(75%)+Sweet water(25%)+ Conventional tillage		178.07	179.65	178.85	2.25	2.26	2.25	4.02	4.06	4.04	3.2:1	3.2:1	3.2:1
T_4 = Saline water(75%)+Sweet water(25%)+ Mulch tillage		179.55	181.50	180.52	2.27	2.27	2.27	4.09	4.12	4.10	3.3:1	3.3:1	3.3:1
T_5 = Saline water(50%)+Sweet water(50%)+ Conventional tillage		213.69	224.48	219.08	2.41	2.41	2.41	5.15	5.41	5.28	3.4:1	3.4:1	3.4:1
T_6 = Saline water(50%)+Sweet water(50%) + Mulch tillage		239.84	246.27	243.06	2.45	2.45	2.45	5.88	6.04	5.96	3.3:1	3.3:1	3.3:1
T_7 = Saline water(25%)+Sweet water(75%)+ Conventional tillage		321.98	329.56	325.77	2.67	2.67	2.67	8.60	8.38	8.74	3.6:1	3.6:1	3.6:1
T_8 = Saline water(25%)+Sweet water(75%) + Mulch tillage		338.56	314.53	326.55	2.73	2.66	2.70	9.20	8.42	8.81	3.5:1	3.5:1	3.5:1
Irrigation	SE(m)	1.592	5.608	3.002	0.000	0.011	0.007	0.034	0.177	0.093	0.00	0.00	0.00
	CD(0.05)	4.729	16.663	8.545	0.000	0.033	0.020	0.100	0.526	0.264	0.00	0.00	0.00
Tillage	SE(m)	0.545	2.188	1.435	0.002	0.002	0.001	0.014	0.064	0.043	0.00	0.00	0.00
	CD(0.05)	2.452	9.846	6.459	0.009	0.011	0.004	0.062	0.289	0.195	0.00	0.00	0.00
Irrigation * Tillage	SE(m)			4.245			0.010			0.131	0.00	0.00	0.00
	CD(0.05)			12.085			0.028			0.373	0.00	0.00	0.00

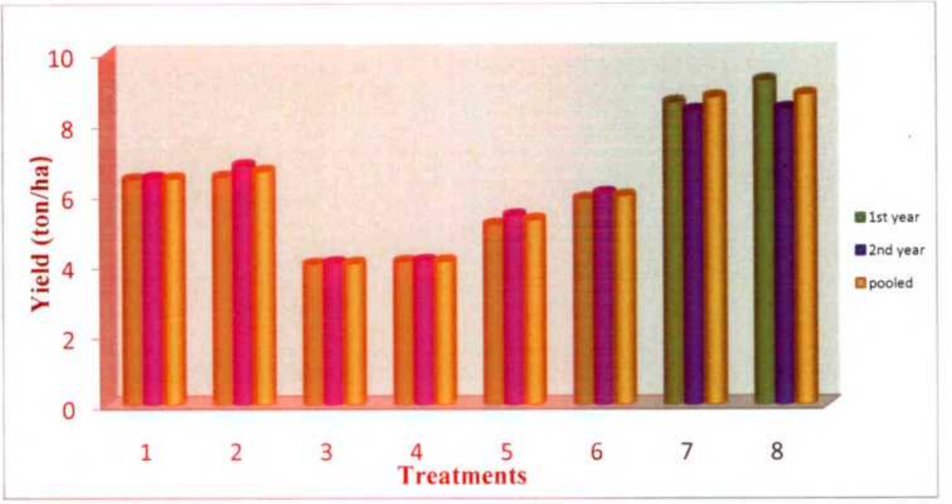

Fig. 10: Effect of various blending of saline and sweet water in pitcher pot with different type of tillage on yield of chilli.

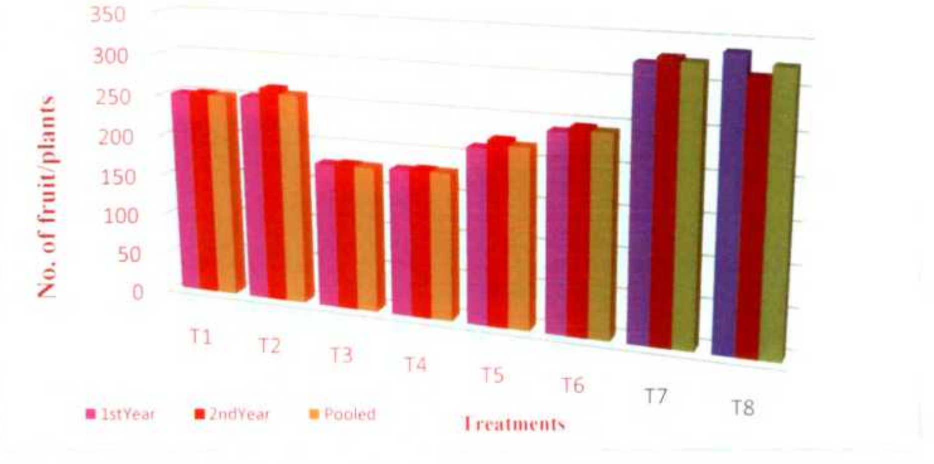

Fig. 11: Effect of various blending of saline and sweet water in pitcher pot with different type of tillage on no. of fruit/plant of chilli.

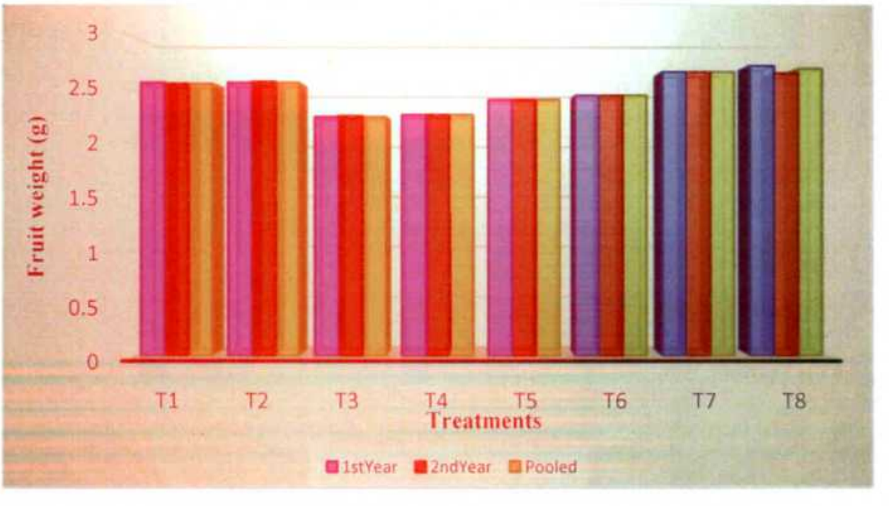

Fig. 12: Effect of various blending of saline and sweet water in pitcher pot with different type of tillage on fruit weight of chilli.

The number of fruit / plant of chilli pooled data also show that 251.49, 258.78, 178.85, 180.52, 219.08, 243.06, 325.77 and 326.55 (Table 10) respectively in the plots of (T1), (T2), (T3), (T4), (T5), (T6), (T7) and (T8). Significantly highest number of fruit / plant was recorded saline water (25%) + sweet water (75%) + mulch tillage (T_8). The effect of pooled data for 2012 and 2013 also resembles with findings (fig.11). The results reveals that response of number of fruit / plant over saline water (75%) + sweet water (25%) + conventional tillage (T_3),due to each treatment were 72.64(40.61%), 79.91 (44.67%), 1.67 (0.93%)40.23(22.49%), 64.21 (35.90%), 146.92(82.11%) and147.77 (82.58%) respectively in the plots (T_8), (T_7), (T_2), (T_1), (T_6), (T_5) and (T_4). The number of fruit / plant of chilli significantly increased with the application of each of the different types of treatments over saline water (75%) + sweet water (25%) + conventional tillage (T_3).

The data also shows that variation of number of fruit / plant of chilli crop due to application treatment for each of the year, however, the performances of yields were better in the second year for each of the treatments. The variations of number of fruit / plant of chilli crop in different year were significant at each of the treatments. Result further reveals that number of fruit / plant is positively and significantly correlated with number of plant height (r = 0..948), number of branch (r = 0..937), fruit weight (r = 0.961), diameter of fruit (r = 0.938), yield (r = 0..969) total water use (r = .944), moisture use efficacy (r = 0.951) crop growth rate (r= 938), at 1% level of significance (Table 15).

The results of fruit weight also showed similar trend of results as observed for the earlier results number of fruit / plant. Highest values (61.77 gm) are observed for the treatments of pitcher saline water(25%) + sweet water (75%)+ mulch tillage (T_8),followed by the treatments of pitcher saline water (25%)+sweet water(75%) + conventional tillage (T_7) (60.25 gm), pitcher (Sweet water) + mulch tillage (T_2) (57.01g), pitcher (Sweet water)+ conventional tillage (T_1) (57.79g),), saline water(50%)+Sweet water(50%) + mulch tillage (T_6) (55.75g)saline water(50%)+ sweet water(50%) + conventional tillage (T_5) (54.75g),saline water(75%)+sweet water(25%) + mulch tillage (T_4) (50.09g) and saline water (75%) +sweet water (25%) + conventional tillage (T_3) (49.36). The effect of pooled data for 2012 and 2013 also resembles with findings (Table 10 & figure 12). The response of fruit weight over pitcher saline water (75%) +sweet water (25%) + conventional tillage (T3)due to each treatment were 0.45 (20.00%), 0.42(18.66%), 0.32(14.22%) ,7.650.31(14.00%), 0.20(8.88%), 0.16(7.11%) and 0.02(0.8%)respectively in the plots received the treatments(T_8), (T_7), (T_2), (T_1), (T_6), (T_5) and (T_4). Result further reveals that fruit weight is positively and significantly correlated with plant height (r = 0.985), number of branch (r = 0.988), number of fruit / plant (r = 0.961), length of fruit (r = 0.973), diameter of fruit (r = 0.902), yield (r = 0.969), total water use (r = 0.944), moisture use efficacy (r = 0.951) and crop growth rate (r = 0.938) at 1% level of significance (Table 15).

The results of the effect of pitcher pot irrigation with various tillage on the length of fruit of chilli crop are presented in Table 11. The results of length of fruit of chilli were observed as 5.76, 5.65, 5.50, 5.40, 5.13, 5.10, 4.87 and 4.68 cm respectively in the treatments (T_8), (T_7), (T_2), (T_1), (T_6), (T_5), (T_4) and (T_3). The pool data of the two year analysis follow the similar trend of result. The results also found that response length of fruit of chilli over pitcher saline water (75%) + sweet water (25%) + conventional tillage (T_3)due to each treatment were 1.08(23.07%),0.97(20.72%), 0.82(17.52%), 0.72(15.38%), 0.45(9.61%), 0.42(8.97%), and 0.19(4.05%) respectively in (T_8), (T_7), (T_2), (T_1), (T_6), (T_5) and (T_4) treatments.

The length of fruit of chilli also showed positive and significant correlation with plant height (r = 0.969), number of branch (r = 0.973), No. of fruit/plant (r=938), fruit weight (r = 0.973), diameter of fruit (r = 0.899),yield (r = 0.946), total water use (r = 0.938), moisture use efficacy (r = 0.925),and crop growth rate (r = 0.918) at 1% level of significance (Table 8). The minimum length of fruit of chilli is also found under the saline water (75%)+ sweet water (25%) + conventional tillage (T_3) plot in the each of year. The variations of number of fruit / plant of chilli crop in different year were not significant at each of the treatments.

The result of the diameter of fruit of the chilli crop as influence by various applied treatments is shown in the table 11. The significantly highest diameter of fruit of chilli crop was observed in saline water (25%) + sweet water (75%) + mulch tillage (T_8) both the year. Diameter of fruit varies with the variation of treatments and values are obtained as 1.91, 1.78, 1.73, 1.63, 1.57, 1.63, 1.32 and 1.23cm in respectively of in (T_8), (T_7), (T_2), (T_1), (T_6), (T_5), (T_4) and (T_3). The effect of pooled data for 2012 and 2013 also resembles with findings (Fig 14).

The data further showed diameter of fruit is positive and significant correlation with plant height (r = 0.919), number of branch (r = 0.895), number of fruit / plant (r = 0.863), fruit weight (r = 0.902), length of fruit (r = 0.899), yield (r = 0.868), total water use (r = 0.887), moisture use efficacy (r = 0.857) and crop growth rate (r = 0.900) at 1% level of significance (Table 15).

Application of pitcher pot irrigation with various tillage caused to increase chilli yield along with yield attributes than (T_3). pitcher pot of saline water (25%) + sweet water (75%) + mulch tillage (T_8).found to be most effective in increasing number of fruit/plant, length of fruit, diameter of fruit, weight of fruit and chilli yield than the other treatments. Variations in results of yields and yield attributes of chilli due to application various blending of saline and sweet water in pitcher pot for pitcher irrigation with different type of tillage may be attributes to the variations of favourable soil condition more precisely by the increasing availability of nutrients in soils.

The results of the study find agreement with the illustration made by Tesfaye *et al.,* (2011). A field experiment was conducted to determine irrigation water and fertilizer use efficiency, growth and yield of chilli under clay pot irrigation at the experimental site of Sekota Dryland Agricultural Research Center, Lalibela, Ethiopia in 2009/10. The experiment comprised of five treatments including furrow irrigated control and clay pot irrigation with different plant population and fertilization methods. The highest total and marketable fruit yields were obtained from clay pot irrigation combined with application of nitrogen fertilizer with irrigation water irrespective of difference in plant population. Thus, clay pot irrigation with 33,333 plants ha-1 and nitrogen fertilizer application with irrigation water in clay pots was the best method for increasing the yield of chilli while economizing the use of water and nitrogen fertilizer in a semiarid environment.

The results agree with Vikram*et al.,* (1999)described this trial was conducted in Jobner (Rajasthan) in 1989 using the chilli [Capsicum] cultivar Pusa Jwala irrigated by the pitcher method (which has relatively low evaporation and leaching losses compared with other methods, and also uses less water). The lateral and vertical movement of moisture and soluble salts in the soil profile was monitored and the method was concluded to be very effective for chillies. It was also recommended that when using saline water, salt-resistant and shallow rooted crop such as chillies could be grown near the pitcher for effective utilization of saline and high residual sodium carbonate (RSC) water in sandy loam soil of arid and semiarid regions.

According to Setiawan,-B-I *et al.,* (1998) conducted to determine an appropriate technology option for irrigation in water-short areas in Indonesia is presented. The pitcher irrigation system utilizes a bottle-like emitter made of baked clay, sand and ash. Water level is maintained constant inside the pitcher and permeates the pitcher wall to supply crops in the surrounding soil. The system has been applied successfully to horticultural products such as chillies, chillies, grapes and mangos, in greenhouse as well as in the field.

Table 11. Effect of different blending of saline and sweet water in pitcher pot and tillage on Physiological parameter and yield components of chilli.

Treatment		Plant height(cm)			No of Branch			Length of fruit (cm)			Diameter of fruit (cm)		
		1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled
T_1 = Pitcher (Sweet water)+ Conventional tillage		58.62	58.40	58.51	20.18	20.23	20.20	5.45	5.35	5.40	1.67	1.60	1.63
T_2 = Pitcher (Sweet water) + Mulch tillage		60.24	59.74	59.99	20.56	20.56	20.56	5.55	5.45	5.50	1.77	1.70	1.73
T_3 = Saline water(75%)+Sweet water(25%)+ Conventional tillage		48.99	49.37	49.18	14.83	14.98	14.90	4.72	4.65	4.68	1.27	1.20	1.23
T_4 = Saline water(75%)+Sweet water(25%)+ Mulch tillage		49.15	49.63	49.39	15.25	15.25	15.25	4.90	4.85	4.87	1.35	1.20	1.32
T_5 = Saline water(50%)+Sweet water(50%)+ Conventional tillage		55.30	55.03	55.17	17.59	17.58	17.58	5.12	5.07	5.10	1.62	1.65	1.63
T_6 = Saline water(50%)+Sweet water(50%) + Mulch tillage		56.01	55.70	55.85	18.02	18.02	18.02	5.15	5.13	5.13	1.57	1.57	1.57
T_7 = Saline water(25%)+Sweet water(75%)+ Conventional tillage		62.41	61.16	61.78	21.33	21.15	21.23	5.65	5.65	5.65	1.80	1.77	1.78
T_8 = Saline water(25%)+Sweet water(75%) + Mulch tillage		64.05	62.50	63.27	22.34	21.59	21.96	5.85	5.68	5.76	1.95	1.87	1.91
Irrigation	SE(m)	0.120	0.447	0.229	0.094	0.124	0.078	0.019	0.032	0.018	0.022	0.034	0.019
	CD(0.05)	0.356	1.329	0.652	0.278	0.368	0.221	0.058	0.094	0.050	0.066	0.100	0.053
Tillage	SE(m)	0.133	0.148	0.076	0.064	0.052	0.061	0.014	0.011	0.011	0.008	0.008	0.008
	CD(0.05)	NS	0.668	0.340	0.287	0.233	0.276	0.062	0.050	0.051	0.036	0.036	0.035
Irrigation * Tillage	SE(m)			0.324			0.110			0.025			0.027
	CD(0.05)			0.923			0.312			0.071			0.076

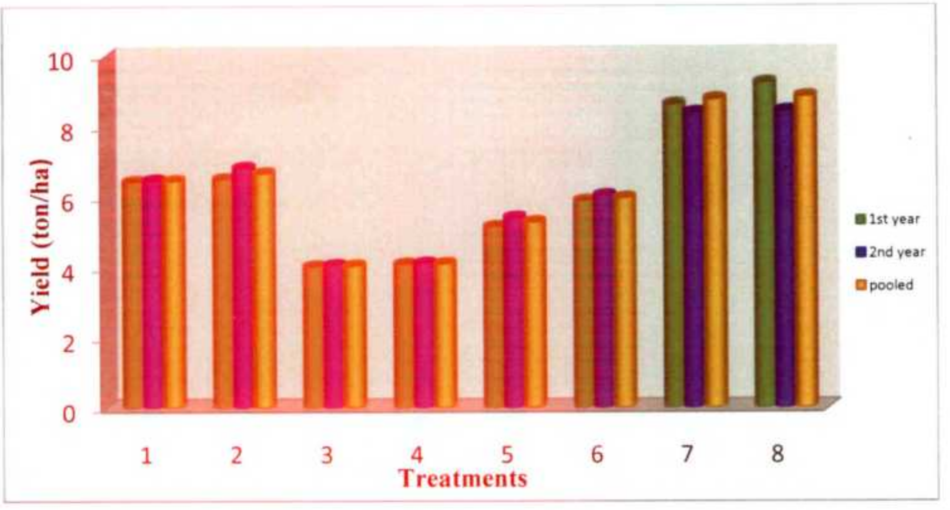

Fig. 10: Effect of various blending of saline and sweet water in pitcher pot with different type of tillage on yield of chilli.

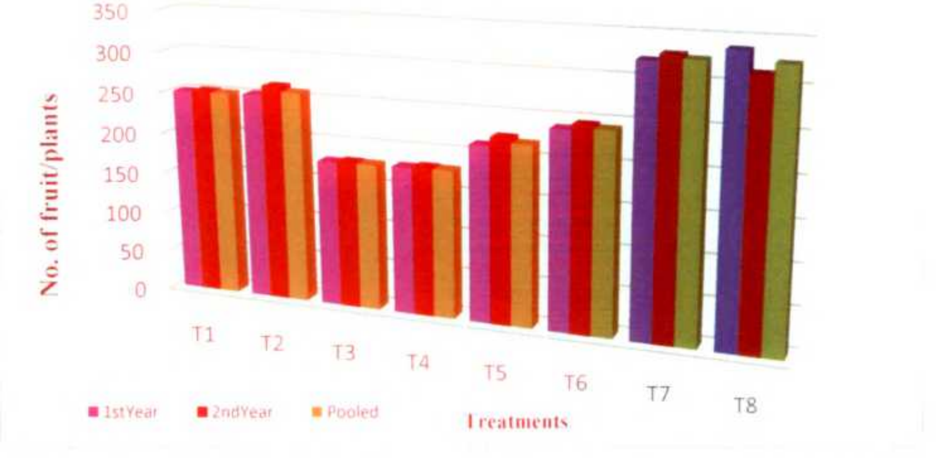

Fig. 11: Effect of various blending of saline and sweet water in pitcher pot with different type of tillage on no. of fruit/plant of chilli.

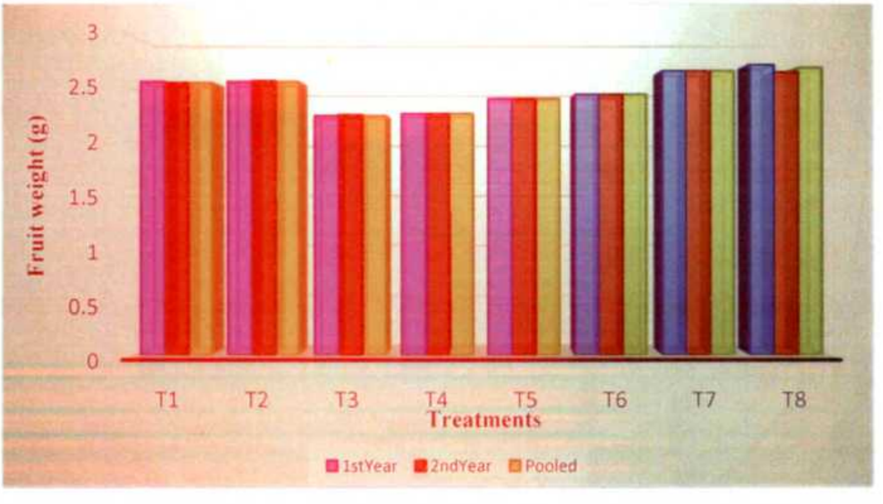

Fig. 12: Effect of various blending of saline and sweet water in pitcher pot with different type of tillage on fruit weight of chilli.

4.2.2. Physiological parameter of chilli:

The result of physical parameters inducing growth of chilli crop presented in (Table 11) by application of blending of saline and sweet water with various tillage. The results of the effect of blending saline and sweet water with various tillage on the plant height of chilli crop are summarized fig13. The highest plant height of chilli crop were observed in pitcher pot of saline water (25%) + sweet water (75%) + mulch tillage (T_8).both the year. The results found that plant height were recorded as63.27, 61.78, 59.99, 58.51, 55.85, 55.17, 49.39, and 49.18 cm respectively in treatments (T_8), (T_7), (T_2), (T_1), (T_6), (T_5), (T_4) and (T_3). The results also found that response plant height of chilli over pitcher saline water(75%) + sweet water(25%) + conventional tillage(T_3)due to each treatment were 14.09(28.64%), 12.60 (25.62%), 10.81 (21.98%) ,9.33 (18.97%), 6.67(13.56%), 5.99(12.17%) and 0.21(4.27%) respectively in (T_8), (T_7), (T_2), (T_1), (T_6), (T_5) and (T_4).The data also showed variation plant height of chilli due to application treatment for each of the year. The minimum plant heights are also found under the pitcher pot of saline water (75%) + sweet water(25%) + conventional tillage(T_3)plot in the both years (fig 13).Result further shows that plant height is positively and significantly correlated with number of branch ($r = 0.987$), number of fruit / plant ($r = 0.948$), fruit weight ($r = 0.985$), length of fruit ($r = 0.969$), diameter of fruit ($r = 0.919$), yield ($r = 0.953$), total water use ($r = 0.942$),Total water use ($r=0.942$), moisture use efficacy ($r = 0.936$) and crop growth rate ($r = 0.957$) at 1% level of significance (Table.15).The plant height of chilli showed significant variation ($P<0.05$) for application of each types of treatments over pitcher saline water (75%) + sweet water (25%) + conventional tillage(T_3)and there were 1% level of significance at each of the treatments variations in different year.

Similarly the number of branch of chilli crop effect of various tillage with different pitcher irrigation combinations are summarized in Table 4.The results found that numbers of branch initiation pool data were recorded as21.96, 21.23, 20.56, 20.20, 18.02, 17.58, 15.25 and 14.90 cm respectively in treatments (T_8), (T_7), (T_2), (T_1), (T_6), (T_5), (T_4) and (T_3)(Table 11).

Application of pitcher pot irrigation with various tillage caused to increase physiological parameter of chilli in pitcher pot of saline water (25%) + sweet water (75%) + mulch tillage treatment (T8) than saline water(75%) + sweet water(25%) + conventional tillage(T_3).

Cost benefit ratio which is define at the ratio between total economic return and total cost of cultivation were also influence by pitcher irrigation with various type of tillage (Table 10 & fig 17). Cost benefit ratio (1:3.6) is highest in of saline water (25%) + sweet water (75%) + mulch tillage (T_8) treatment and lowest (1:3.2) in of saline water (75%) + sweet water (25%) + conventional tillage (T_3) treatment.

According to the Saha *et al.*, (2005) conducted an experiment with pumpkin (C. moschata) during the early summer of 2001/02 and 2002/03 in Canning, West Bengal, India, involving 3 methods of irrigation (drip irrigation by direct pitcher, drip irrigation by pipe from pitcher and basin system of irrigation). The direct pitcher method recorded significantly higher values for vine length, number of nodes per vine, stem girth and significantly lower values for internode length compared to the other two methods of irrigation in both years at all stages of plant growth. The values for number of branches per plant, number of fruits per plant as well as polar length, diameter, weight and yield of fruits were highest under the direct pitcher method followed by the pipe from pitcher method; the basin method recorded the lowest values for these characters. The direct pitcher method was found to be the best method to obtain higher crop yield of pumpkin.

Table 12. Effect of different blending of saline and sweet water in pitcher pot and tillage on crop growth rate and moisture use efficiency of chilli.

Treatment		Dry matter production at harvesting (g/m^2)			Crop growth rate (g/day/m^2)			Total water use(mm)			MUE (kg/ha/mm)		
		1stYear	2ndYear	Pooled	1stYear	2ndYear	Pooled	1stYear	2ndYear	Pooled	1stYear	2ndYear	Pooled
T_1 = Pitcher (Sweet water)+ Conventional tillage		407.75	382.32	395.53	3.48	3.49	3.48	524.85	520.18	522.51	12.27	12.46	12.36
T_2 = Pitcher (Sweet water) + Mulch tillage		409.25	382.25	395.75	3.51	3.51	3.51	525.35	520.78	523.05	12.39	13.10	12.74
T_3 = Saline water(75%)+Sweet water(25%)+ Conventional tillage		374.62	350.22	362.42	3.06	3.06	3.06	476.67	446.91	461.79	8.41	9.06	8.73
T_4 = Saline water(75%)+Sweet water(25%)+ Mulch tillage		375.95	351.51	363.74	3.11	3.11	3.11	480.47	449.35	464.91	8.48	9.15	8.76
T_5 = Saline water(50%)+Sweet water(50%)+ Conventional tillage		391.15	366.85	379.00	3.38	3.38	3.38	498.30	500.91	499.60	10.33	10.79	10.56
T_6 = Saline water(50%)+Sweet water(50%) + Mulch tillage		392.25	367.75	380.00	3.40	3.42	3.41	499.89	501.77	500.83	11.76	12.03	11.89
T_7 = Saline water(25%)+Sweet water(75%)+ Conventional tillage		414.85	388.50	401.67	3.52	3.52	3.52	534.25	537.95	536.10	16.09	16.50	16.30
T_8 = Saline water(25%)+Sweet water(75%) + Mulch tillage		416.25	389.30	402.77	3.57	3.55	3.56	537.17	535.19	536.18	17.80	16.63	17.21
Irrigation	SE(m)	0.658	0.861	1.217	0.002	0.000	0.000	0.682	1.257	1.778	0.137	0.382	0.540
	CD (0.05)	NS	2.558	NS	0.007	0.000	0.000	3.071	3.736	NS	0.616	1.134	NS
Tillage	SE(m)	0.000	0.000	0.000	0.001	0.002	0.003	0.227	0.383	0.542	0.021	0.040	0.057
	CD (0.05)	0.000	0.000	0.000	0.003	0.007	0.010	1.021	1.138	NS	0.094	0.120	NS
Irrigation * Tillage	SE(m)			0.611			0.005			2.905			0.268
	CD (0.05)			NS			NS			NS			NS

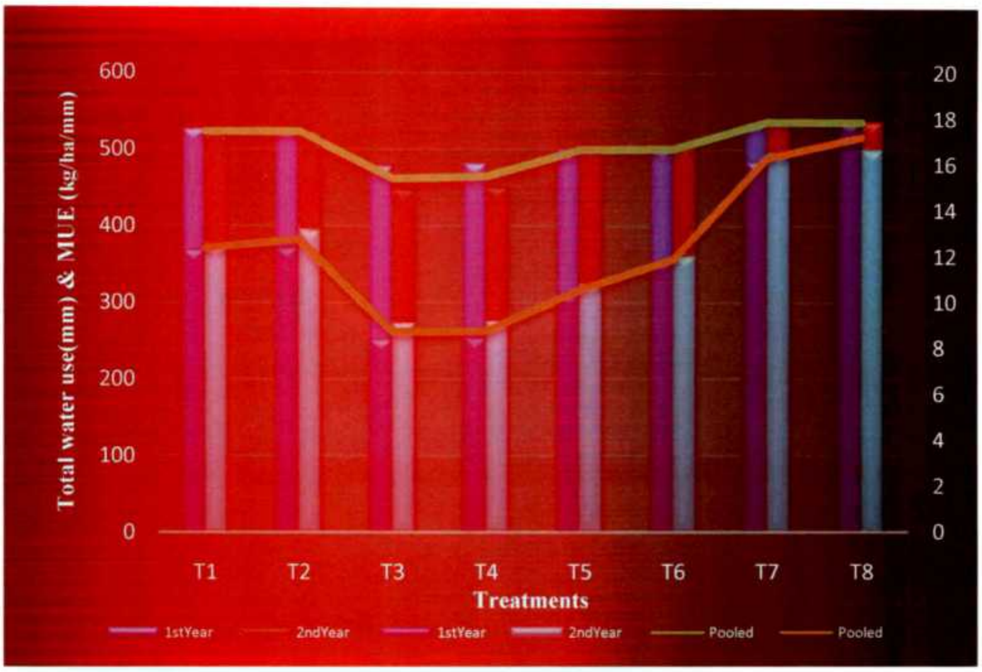

Fig. 16: Effect of various blending of saline and sweet water in pitcher pot with different type of tillage on total water use & MUE of chilli.

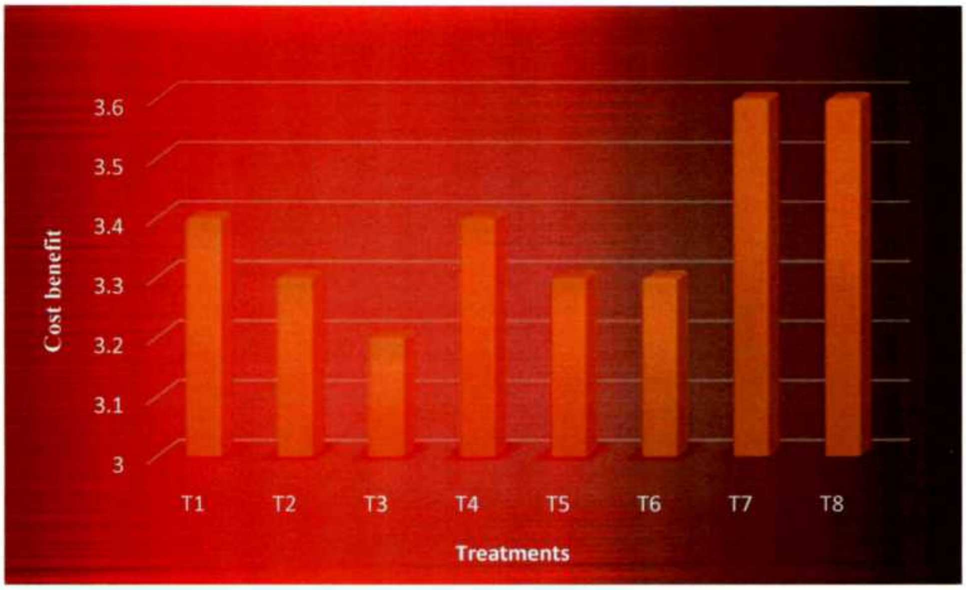

Fig. 17: Effect of various blending of saline and sweet water in pitcher pot with different type of tillage on cost benefit ratio of chilli.

4.2.3. Growth and crop growth rate of chilli:

The result in the (table 12) shows that the dry matter accumulation of the crop progressively increase with increasing period after sowing at each of the treatment in each year. The dry matter production found highest in saline water (25%) + sweet water (75%) + mulch tillage (T8) in both years. The results reveal that total dry matter weight 402.72, 402.85, 395.75, 395.53, 380.0, 379.0, 363.74 and 362.42gm/m^2 respectively(T8), (T7), (T2), (T1), (T6), (T5), (T4) and (T3) treatments. Response of dry matter production over pitcher saline water (75%) + sweet water (25%) + conventional tillage(T3)due to each treatment were40.30(11.11%), 40.43(11.15%), 33.33(9.19%) 33.11(9.13%), 17.58(4.85%), 16.58(4.57%), 1.32(3.64%)and respectively in treatments (T_8), (T_7), (T_2), (T_1), (T_6), (T_5) and (T_4)on the total dry matter weight of the chilli crop. Result further reveals that crop growth rate is positively and significantly correlated with yield and its attribute and other plant parameter at 1% level of significance (Table 15).The variations of dry matter accumulation of chill in interaction with tillage and blending of saline, sweet water different year were not significant at each of the treatments.

Similarly result of crop growth rates of the chilli as influenced by various applied treatments are showed in the Table 12.Crop growth rate was found 3.56, 3.52, 3.51, 3.48, 3.41, 3.38, 3.11 and 3.06g/day/m^2 and increased over saline water (75%) + sweet water (25%) + conventional tillage(T_3)by0.50(16.33%), 0.46(15.03%), 0.45(14.70%), 0.42(13.72%), 0.35(11.43%), 0.32(10.45%) and 0.05(1.63%)in respectively in treatments(T_8), (T_7), (T_2), (T_1), (T_6), (T_5) and (T_4).The effect of pooled data for 2012 and 2013 also resembles with findings (figure 14). The significantly highest crop growth rates of chilli crop were observed in saline water (25%) + sweet water (75%) + mulch tillage (T_8) both the years.

The minimum crop growth rates of chilli are also found under the T_3 plot in the both years. The effect of pooled data for 2012 and 2013 also resembles with findings (figure 14). Result further shows that crop growth rate is positively and significantly correlated with plant height (r = 0.957), number of branch (r = 0.957), number of fruit / plant (r = 0.868), fruit weight (r = 0.938), diameter of fruit (r = 0.900), yield (r = 0.869), total water use (r = 0.939) and moisture use efficacy (r = 0.838)at 1% level of significance (Table15).The variations of crop growth rate of chilli in different year were no significant different at each of the treatments.

The results of the study find agreement with the illustration made by Ashrafuzzaman*et al.* (2011) reported that Effect of plastic mulch on growth and yield of chilli (*Capsicum annuum* L.). In this work a field study was conducted to evaluate the effect of coloured plastic mulch on growth and yield of chilli from October 2005 to April 2006. The plastic mulches were transparent, blue, and black and bare soil was the control. Mulching produced the fruits with the highest chlorophyll-a, chlorophyll-b and total chlorophyll contents and also increased the number of fruits per plant and yield.

Table 13.Changes of soil moisture % from 0-15 cm soil depth during growing period of chilli.

1st Year

Treatment	Standard Meteorological Week													
	47	48	49	50	51	52	1	2	3	4	5	6	7	8
	Rainfall (mm)													
	0.0	0.0	0.0	24.4	0.0	0.9	8.0	0.0	0.0	0.0	0.0	0.0	5.8	0.0
T_1 = Pitcher (Sweet water)+ Conventional tillage	29.73	26.92	24.57	35.83	26.39	29.94	32.41	3073	28.52	27.17	25.69	24.26	32.84	30.59
T_2 = Pitcher (Sweet water) + Mulch tillage	28.16	26.78	27.43	27.39	26.27	28.88	31.86	32.94	32.38	33.89	32.57	30.91	32.33	30.27
T_3 = Saline water(75%)+Sweet water(25%)+ Conventional tillage	20.96	20.83	23.74	23.65	24.91	25.17	27.56	29.74	29.43	31.12	30.64	29.48	30.17	28.16
T_4 = Saline water(75%)+Sweet water(25%)+ Mulch tillage	21.28	21.15	24.38	23.93	25.07	25.41	27.60	29.85	29.56	31.22	30.17	29.79	30.19	28.20
T_5 = Saline water(50%)+Sweet water(50%)+ Conventional tillage	23.28	23.15	26.38	26.23	25.37	27.91	31.55	32.29	31.24	33.22	31.47	30.29	31.19	29.75
T_6 = Saline water(50%)+Sweet water(50%) + Mulch tillage	23.75	23.98	26.85	28.60	27.15	28.54	31.96	33.22	32.16	33.95	31.65	31.02	31.64	30.22
T_7 = Saline water(25%)+Sweet water(75%)+ Conventional tillage	28.16	26.78	27.43	27.39	26.27	28.88	31.86	32.94	32.38	33.89	32.57	30.91	32.33	30.27
T_8 = Saline water(25%)+Sweet water(75%) + Mulch tillage	29.73	26.92	24.57	35.83	26.39	29.94	32.41	3073	28.52	27.17	25.69	24.26	32.84	30.59

Contd……

2st Year

Treatment	Standard Meteorological Week													
	9	10	11	12	13	14	15	16	17	18	19	20	21	22
	Rainfall (mm)													
	0.0	0.0	0.0	0.0	0.0	0.0	4.5	0.0	53.0	0.0	0.0	0.0	0.0	0.0
T_1 = Pitcher (Sweet water)+ Conventional tillage	26.24	25.92	25.77	27.15	28.18	26.63	26.37	26.24	27.11	27.29	26.27	26.11	26.94	26.67
T_2 = Pitcher (Sweet water) + Mulch tillage	26.66	26.23	25.74	27.38	28.69	27.22	26.73	26.38	27.47	27.21	26.59	26.34	27.17	27.29
T_3 = Saline water(75%)+Sweet water(25%)+ Conventional tillage	23.35	22.97	22.58	23.9	24.36	24.15	23.77	23.49	23.83	23.78	23.29	23.2	23.14	23.87
T_4 = Saline water(75%)+Sweet water(25%)+ Mulch tillage	25.7	25.34	25.18	26.56	27.48	26.41	26.28	25.87	26.75	26.93	25.84	25.47	26.29	25.75
T_5 = Saline water(50%)+Sweet water(50%)+ Conventional tillage	26.11	25.26	24.92	25.32	25.05	25.85	28.47	26.44	26.12	25.91	25.54	24.87	24.35	24.16
T_6 = Saline water(50%)+Sweet water(50%) + Mulch tillage	26.24	25.92	25.77	27.15	28.18	26.63	29.37	26.24	27.11	27.29	26.27	26.11	26.94	26.67
T_7 = Saline water(25%)+Sweet water(75%)+ Conventional tillage	26.66	26.23	25.74	27.38	28.69	27.22	29.73	26.38	27.47	27.21	26.59	26.34	27.17	27.29
T_8 = Saline water(25%)+Sweet water(75%) + Mulch tillage	26.92	26.37	26.96	27.55	29.14	27.73	31.38	26.84	27.96	27.43	26.9	26.38	27.62	27.39

Table 14. Total water use (mm) from 0-15 cm soil depth during growing period of chilli.

1st Year

Treatment	Standard Meteorological Week													
	48	49	50	51	52	1	2	3	4	5	6	7	8	Total water use
T_1 = Pitcher (Sweet water)+ Conventional tillage	34.27	36.46	42.38	49.46	42.54	45.56	44.86	41.56	39.54	41.37	42.56	39.3	33.24	524.85
T_2 = Pitcher (Sweet water) + Mulch tillage	34.59	37.78	42.45	50.32	42.68	47.86	45.69	42.67	40.65	40.42	38.43	37.42	33.45	525.35
T_3 = Saline water(75%)+Sweet water(25%)+ Conventional tillage	29.05	30.43	35.22	39.19	38.52	34.36	34.02	33.82	39.08	35.35	33.46	35.68	27.15	476.67
T_4 = Saline water(75%)+Sweet water(25%)+ Mulch tillage	29.05	30.43	35.22	40.19	38.52	34.36	34.02	33.82	39.08	35.25	33.46	36.68	27.15	480.47
T_5 = Saline water(50%)+Sweet water(50%)+ Conventional tillage	33.24	38.46	42.03	49.46	42.75	43.56	44.87	41.56	39.54	39.17	38.96	39.3	33.24	498.30
T_6 = Saline water(50%)+Sweet water(50%) + Mulch tillage	34.65	38.46	42.03	49.46	42.76	43.56	44.94	41.56	39.54	39.17	38.96	39.41	33.75	499.89
T_7 = Saline water(25%)+Sweet water(75%)+ Conventional tillage	34.82	38.78	43.52	50.15	43.46	47.46	45.77	42.46	41.65	40.42	39.29	39.42	33.45	534.25
T_8 = Saline water(25%)+Sweet water(75%) + Mulch tillage	34.9	38.86	43.56	50.75	43.46	47.56	45.85	42.62	41.81	40.6	39.45	39.53	33.55	537.17

Contd.......

2st Year

Treatment	Standard Meteorological Week													
	9	10	11	12	13	14	15	16	17	18	19	20	21	Total water use
T_1 = Pitcher (Sweet water)+ Conventional tillage	34.27	36.46	42.38	49.46	42.54	45.56	44.86	41.56	39.54	41.37	42.56	39.3	33.24	520.18
T_2 = Pitcher (Sweet water) + Mulch tillage	34.59	37.78	42.45	50.32	42.68	47.86	45.69	42.67	40.65	40.42	38.43	37.42	33.45	520.78
T_3 = Saline water(75%)+Sweet water(25%)+ Conventional tillage	29.05	30.43	35.22	39.19	38.52	34.36	34.02	33.82	39.08	35.35	33.46	35.68	27.15	446.91
T_4 = Saline water(75%)+Sweet water(25%)+ Mulch tillage	29.05	30.43	35.22	40.19	38.52	34.36	34.02	33.82	39.08	35.25	33.46	36.68	27.15	449.35
T_5 = Saline water(50%)+Sweet water(50%)+ Conventional tillage	33.24	38.46	42.03	49.46	42.75	43.56	44.87	41.56	39.54	39.17	38.96	39.3	33.24	500.91
T_6 = Saline water(50%)+Sweet water(50%) + Mulch tillage	34.65	38.46	42.03	49.46	42.76	43.56	44.94	41.56	39.54	39.17	38.96	39.41	33.75	501.77
T_7 = Saline water(25%)+Sweet water(75%)+ Conventional tillage	34.82	38.78	43.52	50.15	43.46	47.46	45.77	42.46	41.65	40.42	39.29	39.42	33.45	537.95
T_8 = Saline water(25%)+Sweet water(75%) + Mulch tillage	34.9	38.86	43.56	50.75	43.46	47.56	45.85	42.62	41.81	40.6	39.45	39.53	33.55	535.19

Table 15.Correlation metrics involving yield andyield attributes characters of chilli.

	Plant hight	No of branch	No of fruit / plant	Fruit Weight (gm.)	Length of fruit (cm)	Diameter of fruit (cm)	Yield (ton/ha)	Total water use(mm)	MUE(kg/ha/mm)	Dry matter production at harvesting (g/m2)	Crop growth rate (g/day/m2)
Plant hight	1.00										
No of branch	.987(**)	1.00									
No of fruit / plant	.948(**)	.937(**)	1.00								
Fruit Weight (gm.)	.985(**)	.988(**)	.961(**)	1.00							
Length of fruit (cm)	.969(**)	.973(**)	.938(**)	.973(**)	1.00						
Diameter of fruit (cm)	.919(**)	.895(**)	.863(**)	.902(**)	.899(**)	1.00					
Yield (ton/ha)	.953(**)	.944(**)	.999(**)	.969(**)	.946(**)	.868(**)	1.00				
Total water use(mm)	.942(**)	.949(**)	.893(**)	.944(**)	.938(**)	.887(**)	.899(**)	1.00			
MUE(kg/ha/mm)	.936(**)	.920(**)	.992(**)	.951(**)	.925(**)	.857(**)	.993(**)	.856(**)	1.00		
Dry matter production at harvesting (g/m2)	.420(**)	.417(**)	.367(**)	.412(**)	.398(**)	.473(**)	.375(**)	.441(**)	.348(**)	1.00	
Crop growth rate (g/day/m2)	.957(**)	.957(**)	.868(**)	.938(**)	.918(**)	.900(**)	.869(**)	.939(**)	.838(**)	.401(**)	1.00

** Correlation is significant at the 0.01 level (2-tailed).

Table 16.Results of step wise regression analysis involving yield as dependable variable and all other variables as predictors

Variable	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	-40.601	5.042		-8.053	0.000
WHC (%)	1.068	0.115	0.763	9.299	0.000

Dependent Variable: Chilli yield

R	R Sq	Adj R Sq	SE(est)		
0.763	0.582	0.576	1.147		

** Coefficients are significant at the 0.01 level.

4.2.4. Soil moisture use and moisture use efficiency of chilli:

Periodical soil moisture content in percentage due to pitcher + tillage treatment in soils growing with chilli was monitored by weekly basis; the results are presented in Table 12 and (figures.16). Consistence variation has been observed in the soil under different treatment. Highest moisture percentage was found in saline water (25%) + sweet water (75%) + mulch tillage (T_8)and lowest water use found in saline water (75%) +sweet water (25%) + conventional tillage (T_3).Average values for the results of each year also show similar trends as shown in figures. Results also revealed that total moisture use by plant in the following order i.e saline water(25%) + sweet water (75%)+ mulch tillage (T_8) (536.18 mm) >saline water (25%) + sweet water(75%) + conventional tillage (T_7) (536.10 mm) > pitcher (Sweet water) + mulch tillage (T_2) (523.05mm) >pitcher (Sweet water)+ conventional tillage (T_1) (522.51 mm) > saline water(50%)+Sweet water (50%) + mulch tillage (T_6) (500.83mm) > saline water(50%)+ sweet water(50%) + conventional tillage (T_5) (499.60mm)>saline water(75%)+sweet water(25%) + mulch tillage (T_4) (464.91mm)>saline water (75%) +sweet water (25%) + conventional tillage (T_3) (461.79mm) (Table 12). Response of total water use over T_3 due to each treatment were 74.39(16.10%), 74.31(16.09%), 61.26(13.26%), 60.72(13.14%), 39.04(8.78%), 37.81(8.18%) and 3.12(6.75%) respectively in (T_8), (T_7), (T_2), (T_1), (T_6), (T_5) and (T_4).The total water use of chilli crop significantly increased ($P<0.05$) with the application of each of the pitcher with various type of tillage over saline water (75%) +sweet water (25%) + conventional tillage (T_3).Result further reveals that total water use is positively and significantly correlated, with plant height (r = 0.942), number of branch (r = 0.949), number of fruit / plant (r = 0.839), fruit weight (r = 0.944), length of fruit (r = 0.938), diameter of fruit (r = 0.887), yield (r = 0.899), moisture use efficacy (r = 0.856),and crop growth rate (r = 0.939) at 1% level of significance (Table15).

The moisture use efficiency significantly increased ($P<0.05$) with the application of each of the different types of irrigation and tillage control. Result further reveals that water use efficiency is positively and significantly correlated with plant height (r = 0.936), number of branch (r = 0.920), number of fruit / plant (r = 0.992), fruit weight (r = 0.951), diameter of fruit (r = 0.857), yield (r = 0.993), total water use (r = 0.856) and crop growth rate (r = 0.838), at 1% level of significance (Table 15).

Therefore, it is apparent form the present study that blending of saline water (25%) + sweet water (75%)+ mulch tillage (T_8) for chilli crop and thus improves the yield and yield attributes of chilli by the influence of adequate soil moisture and may maintained electrical conductivity (EC) condition leading to favourable nutrient supply to crops.

The results of this study are in agreement with Naik *et al.,* (2008),that pitcher irrigation in saline water condition was studied in laboratory conditions in terms of flow behavior of pitcher, soil moisture distribution, wetting front advance and distribution of salt concentration in the soil using different pitcher making material.

4.3. Effect of different blending of saline and sweet water in pitcher pot for pitcher irrigation with different type of tillage on soil properties.

4.3.1. Soil physical properties of soil

4.3.1.1. Bulk Density:

The result of changes of various physical properties in soil due to application of blending of saline and sweet water in pitcher pot for pitcher irrigation with different type of tillage are presented in (Table 17).The data reveals that changes of bulk density, porosity and water holding capacity in soil due to variation of treatment combinations. At each of the pitcher irrigation treatment the values of bulk density found to decrease over control (T_3). The values are lowest in the soil treated with sweet water (100%) + mulch tillage (T_2.)Bulk density showed to change with the following order.(T_2) > (T_8) > (T_1) > (T_7) > (T_6) > (T_5) > (T_4) > (T_3). The effect of pooled data for 2012 and 2013 also resembles with findings (figure 18).The reductions of bulk density is found to be significant over control (T_3),at each of the applied treatments. Decrease of bulk density over the year may be indicative to better results in subsequent year due to application of different type of tillage with blending of saline and sweet water in pitcher pot for pitcher irrigation. Result further reveals that bulk density is negatively and significantly correlated with porosity (r = -0.811), water holding capacity (r = -0.780), EC(r=-0.589), pH (r= -0.728),organic carbon (r = -0.855), available nitrogen (r = -0.833), available phosphorus (r = -0.811), available potassium (r = -0.790), mean weight diameter (MWD) (r= -0.810), structural coefficient (r = -0.805), geometric mean diameter (r = -0.812), yield of tomato (r = -0.885) and yield of chilli (r = -0.650)at 1% level of significance (Table21).

Table 17: Effect of different blending of saline and sweet water in pitcher pot and tillage on physical properties of soil.

Treatment	Cropping Sequence	BD (g/cc)			Porosity (%)			WHC (%)		
		Year1	Year2	Pooled	Year1	Year2	Pooled	Year1	Year2	Pooled
T_1	Tomato	1.26	1.25	1.26	45.15	45.33	45.33	47.20	47.28	47.24
	Chilli	1.26	1.25	1.26	45.28	45.45	44.99	47.33	47.35	47.34
	Total	**1.26**	**1.25**	**1.26**	**45.21**	**45.39**	**45.16**	**47.26**	**47.31**	**47.29**
T_2	Tomato	1.26	1.25	1.25	45.20	45.45	47.24	47.30	47.38	47.34
	Chilli	1.26	1.25	1.23	45.08	44.90	45.36	47.23	47.83	47.53
	Total	**1.26**	**1.25**	**1.23**	**45.14**	**45.17**	**46.30**	**47.26**	**47.60**	**47.43**
T_3	Tomato	1.30	1.28	1.29	42.30	42.55	42.43	45.50	45.65	45.68
	Chilli	1.29	1.28	1.28	42.33	42.55	42.44	45.63	45.88	45.73
	Total	**1.29**	**1.25**	**1.28**	**43.93**	**43.90**	**42.43**	**46.37**	**46.39**	**45.70**
T_4	Tomato	1.30	1.28	1.29	42.40	42.65	42.53	45.80	45.90	45.85
	Chilli	1.29	1.28	1.27	42.43	42.65	42.54	45.75	45.70	45.73
	Total	**1.29**	**1.28**	**1.28**	**43.65**	**43.67**	**42.53**	**46.26**	**46.29**	**46.36**
T_5	Tomato	1.27	1.26	1.27	42.55	42.73	42.64	45.60	45.75	45.58
	Chilli	1.27	1.24	1.26	42.70	43.30	43.0	45.88	46.60	45.75
	Total	**1.27**	**1.25**	**1.26**	**42.62**	**43.05**	**42.82**	**45.74**	**46.17**	**46.49**
T_6	Tomato	1.27	1.26	1.25	43.15	43.43	43.29	46.50	46.65	46.58
	Chilli	1.25	1.24	1.26	43.70	45.34	44.53	46.68	47.30	46.99
	Total	**1.26**	**1.25**	**1.25**	**43.42**	**44.38**	**43.91**	**46.59**	**46.97**	**46.78**
T_7	Tomato	1.26	1.25	1.26	44.40	44.65	44.53	46.50	46.65	46.58
	Chilli	1.26	1.25	1.26	44.58	44.96	44.77	46.70	46.98	46.84
	Total	**1.26**	**1.25**	**1.26**	**44.49**	**44.80**	**44.65**	**46.6**	**46.51**	**46.71**
T_8	Tomato	1.25	1.24	1.25	44.75	44.93	44.84	46.90	47.01	46.95
	Chilli	1.24	1.23	1.24	44.15	42.45	43.30	46.55	45.60	46.80
		1.24	**1.23**	**1.24**	**44.74**	**44.35**	**44.41**	**46.65**	**46.61**	**46.77**
		SEm	**LSD%**		**SEm**	**LSD%**		**SEm**	**LSD%**	
Tillage		0.000	**0.002**		0.000	**NS**		0.011	0.050	
Irrigation		0.003	**0.005**		0.000	**NS**		0.016	0.047	
Tillage*irrigation		0.002	**0.008**		0.000	**NS**		**0.022**	**0.066**	

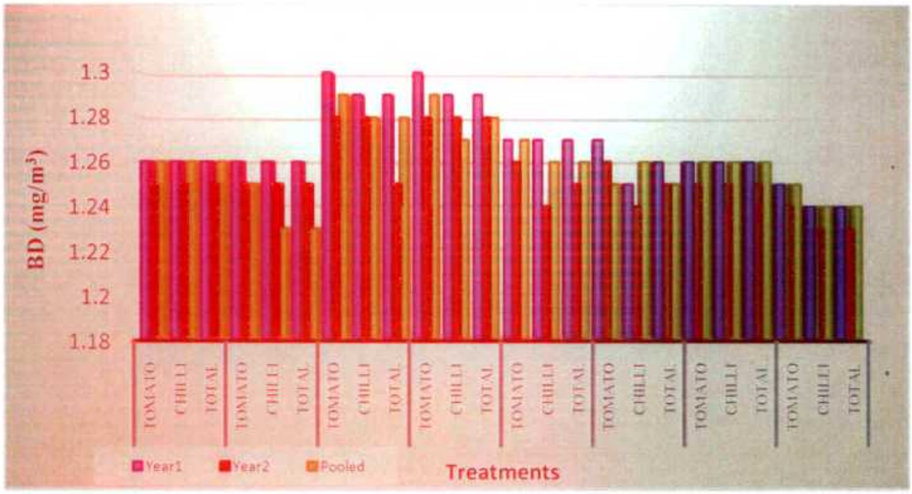

Fig. 18: Effect of various blending of saline and sweet water in pitcher pot with different type of tillage on bulk density of soil.

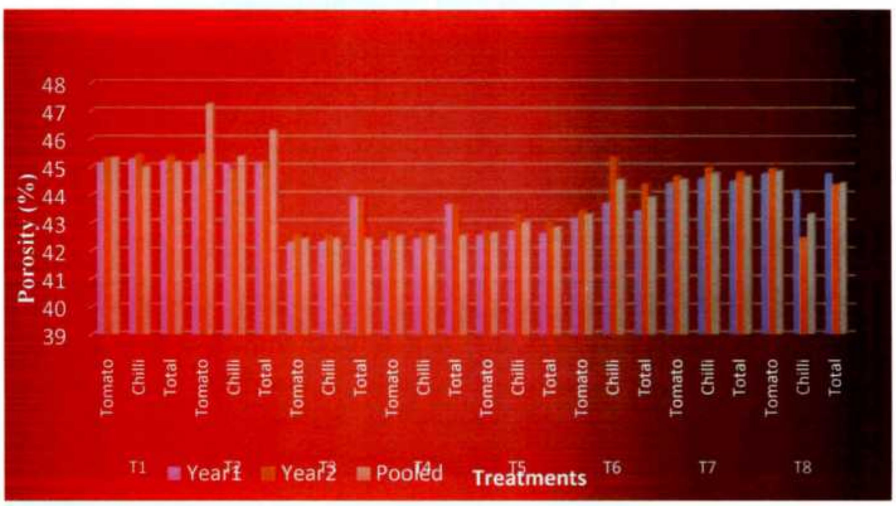

Fig. 19: Effect of various blending of saline and sweet water in pitcher pot with different type of tillage on porosity of soil.

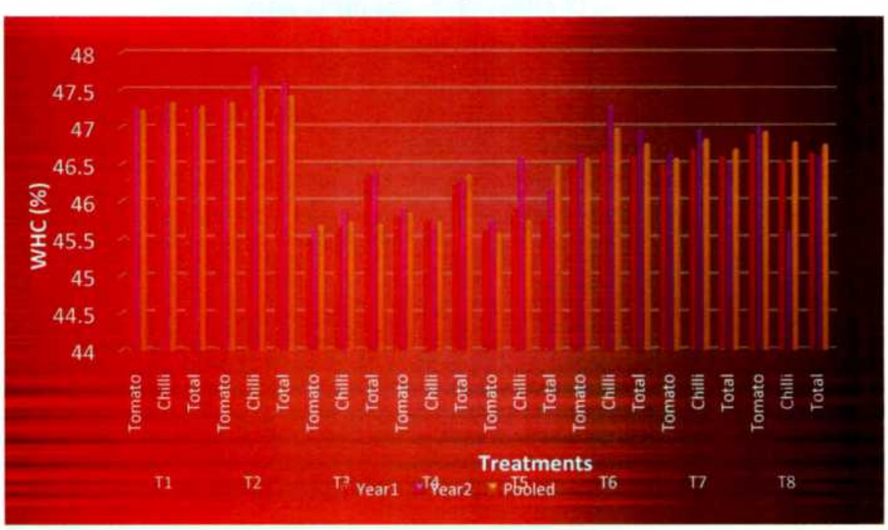

Fig. 20: Effect of various blending of saline and sweet water in pitcher pot with different type of tillage on water holding capacity of soil.

Further analysis using step wise multiple regression technique revealed that Water holding capacity (%)is only significant predicator to predict chilli yieldwith 57.6% variability, other step wise multiple regression technique revealed that Potassium. Organic carbon, EC and Nitrogen are only significant predicator to predict yield of tomato with 98.0 % variability Table 22. The findings of Hangarge *et al* (2002) showed that application of organic wastes and organic manures in the form of FYM reduced the bulk density finds conformity of the results of the present investigation.

4.3.1.2. Porosity:

The results of porosity showed reverse trend of bulk density as it increases due to application of each treatments over control. Highest values are observed in the soil treated with pitcher (sweet water 100%) + mulch tillage (T_2) under tomato and chilli in every year (Table 17). Porosity showed to change with the following order. (T_2) > (T_8)> (T_1) > (T_7) > (T_6) > (T_5) > (T_4).Increase values over control (T_3) due to each treatment were 3.87 (9.12%), 2.73 (6.43%), 2.22 (5.23%), 1.98 (4.68%), 1.48(3.48%), 0.39(0.91%) and 0.10(0.23%) respectively for pitcher (sweet water 100%) + mulch tillage (T_2), saline water (25%) + sweet water (75%) + mulch tillage (T_8), pitcher (sweet water 100%)+ conventional tillage (T_1), saline water (25%) + sweet water(75%) + conventional tillage (T_7), saline water(50%)+ sweet water(50%) + mulch tillage (T_6), saline water(50%)+ sweet water(50%) + conventional tillage (T_5), saline water(75%)+ sweet water(25%)+ mulch tillage (T_4).The increase of porosity due to each treatment over control was found significant at 1% level of significance. The effect of pooled data for 2012 and 2013 also resembles with findings (figure19). However the data have the tendency of slight increase in the subsequent years indicating the tendency of porosity in subsequent years due to application of different type of application of blending of saline and sweet water in pitcher pot for pitcher irrigation with different type of tillage. Increase of porosity may be due to higher organic carbon content in soil decrease bulk density due to more space and better soil aggregation.

Result further reveals that porosity is positively/negatively and significantly correlated with water holding capacity (r = 0.956), EC (r= -0.844), pH (r= -0.709), organic carbon (r = 0.800), available nitrogen (r = 0.893), available phosphorus (r = 0.848), available potassium (r = 0.919), mean weight diameter (MWD) (r= 0896), structural coefficient (r = 0.892), geometric mean diameter (r = 0.798), yield of tomato (r

= -0.938), yield of chilli (r = 0.722)at 1% level of significance (Table 35). Such variations of results on porosity resembles with the observations of Choudhury *et al*, (1985) and Cater and Ball, (1993).

4.3.1.3. Water holding capacity:

The water holding capacity in soil also shows to vary significantly with the application of blending of saline and sweet water in pitcher pot for pitcher irrigation with different type of tillage in the both years. The water holding capacity in soil also found similar results of porosity. At each of the application of blending of saline and sweet water in pitcher pot for pitcher irrigation with different type of tillage treatment the values of water holding capacity found to increase over control (T_3). Highest values are observed in the pitcher (sweet water 100%) + mulch tillage (T_2), under tomato - chilli in both cropping sequence (Table 19).Increase of water holding capacity over control due to each treatment were1.73 (3.70%), 1.59 (3.47%), 1.07 (2.34%), 1.01 (2.21%), 1.01(2.21%), 0.79(1.72%), 0.66(1.44%) respectively pitcher (sweet water 100%) + mulch tillage (T_2), saline water (25%) + sweet water (75%) + mulch tillage (T_8), pitcher (sweet water 100%)+ conventional tillage (T_1), saline water (25%) + sweet water(75%)+ conventional tillage (T_7), saline water(50%)+ sweet water(50%) + mulch tillage (T_6), saline water(50%)+ sweet water(50%) + conventional tillage (T_5), saline water(75%)+ sweet water(25%)+ mulch tillage (T_4). The effect of pooled data for 2012 and 2013 also shows similar findings (figure20).Significantly highest water holding capacity was recorded in plots received pitcher (sweet water 100%) + mulch tillage (T_2). The water holding capacity significantly increased with the application of each of the application of blending of saline and sweet water in pitcher pot for pitcher irrigation with different type of tillage control (T_3).However the data have the tendency of slight increase in the subsequent years due to application of different type of tillage. Increase of water holding capacity may be due to higher organic carbon content in soil, decrease bulk density and increase porosity due to more space and better soil aggregation. Result further reveals that water holding capacity is positively and significantly correlated with organic carbon (r = 0.696), available nitrogen (r = 0.931), available phosphorus (r = 0.881), available potassium (r = 0.978), mean weight diameter (MWD) (r= 0.953), structural coefficient (r = 0.948), geometric mean diameter (r = 0.793), yield of tomato (r = 0.968), yield of chilli (r = 0.763) at 1% level of significance (Table 35). Such variation of results on water holding capacities are the reflection of changes of bulk density and corroborates with the findings of Choudhury *et al,* (1985) and Cater and Ball, (1993). Significant negative correlations of water holding capacity with bulk density (r = -0.870), EC (r= -0.843) and pH(r= -0.729)in the present investigation also finds conformity of the above views.

Step wise multiple regression analysis revealed that water holding capacity is the only significant predicator to predict yield of Chilli with 58.20% variability, however, step wise multiple regression involving EC can predict yield of tomato with 98.0% variability (Table 22). The findings of similar results also evidence by Hangarge *et al* (2002) and Booth *et al.* (2005) that lowering bulk density and increasing the porosity and water holding capacity (WHC%). A significant positive correlation (r = 0.523) between water holding capacity and organic carbon content in soils finds agreements from the investigations reported by Bablulkar *et al* (2000) and Bhattacharya (2004) with the views that the application of organic manures helped to increase the water holding capacity of soil over control.

Table 18: Effect of different blending of saline and sweet water in pitcher pot and tillage on pH and Electrical conductivity (EC) of soil.

Treatment	Cropping Sequence	pH			EC		
		Year1	Year2	Pooled	Year1	Year2	Pooled
T_1	Tomato	6.70	6.80	6.76	5.80	5.60	4.10
	Chilli	6.90	6.90	6.90	6.45	5.35	4.50
	Total	**6.8**	**6.85**	**6.83**	**6.12**	**5.47**	**4.20**
T_2	Tomato	6.70	6.83	6.75	4.20	4.10	4.15
	Chilli	6.95	6.90	6.80	6.05	5.95	4.0
	Total	**6.82**	**6.86**	**6.77**	**5.12**	**5.02**	**4.10**
T_3	Tomato	7.45	7.38	7.51	7.20	7.05	5.13
	Chilli	7.25	7.50	7.50	7.93	7.55	5.74
	Total	**7.35**	**7.44**	**7.50**	**7.56**	**7.3**	**5.43**
T_4	Tomato	7.45	7.50	7.48	6.80	6.55	5.56
	Chilli	7.18	7.43	7.40	7.60	7.53	5.68
	Total	**7.31**	**7.46**	**7.44**	**7.2**	**7.04**	**5.32**
T_5	Tomato	6.95	6.90	6.93	6.80	6.60	4.70
	Chilli	7.05	7.05	7.06	7.73	7.13	5.28
	Total	**7.0**	**6.97**	**6.99**	**7.26**	**6.86**	**4.90**
T_6	Tomato	6.95	6.90	6.93	6.10	5.90	4.0
	Chilli	7.10	7.10	7.10	7.08	6.93	5.0
	Total	**7.02**	**7.0**	**7.01**	**6.59**	**6.41**	**4.5**
T_7	Tomato	6.73	6.80	6.76	5.90	5.75	5.83
	Chilli	6.83	6.95	6.95	6.78	6.25	6.51
	Total	**6.78**	**6.87**	**6.85**	**6.34**	**6.0**	**4.47**
T_8	Tomato	6.78	6.85	6.81	4.40	4.33	4.36
	Chilli	6.83	6.93	6.90	6.35	6.23	4.48
		6.80	**6.89**	**6.85**	**5.37**	**5.28**	**4.42**
		SEm	**LSD%**		**SEm**	**LSD%**	
Tillage		0.000	**NS**		0.0000	**NS**	
Irrigation		0.045	**0.133**		0.000	**NS**	
Tillage*irrigation		0.000	**NS**		0.000	**NS**	

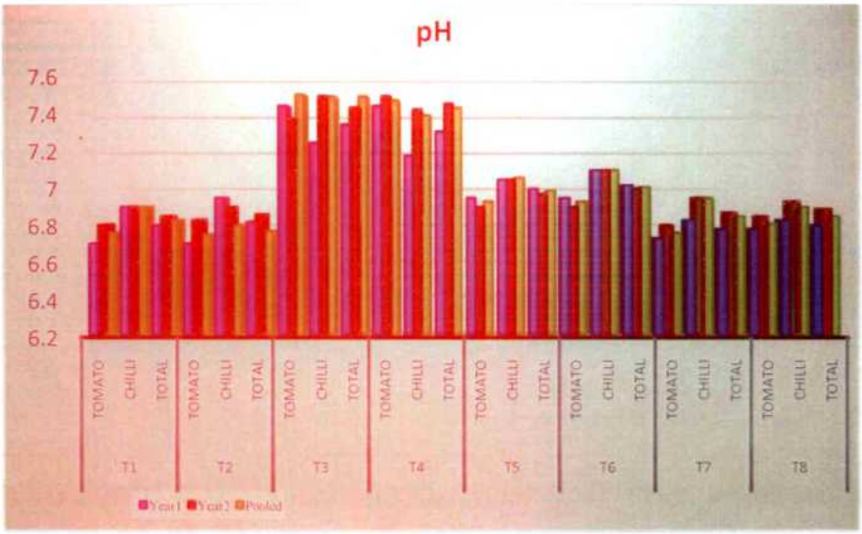

Fig. 21: Effect of various blending of saline and sweet water in pitcher pot with different type of tillage on pH of soil.

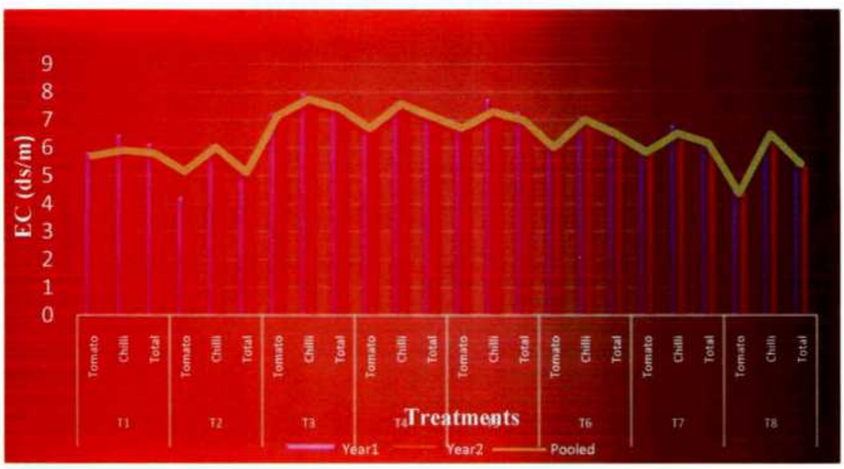

Fig.22: Effect of various blending of saline and sweet water in pitcher pot with different type of tillage on EC of soil.

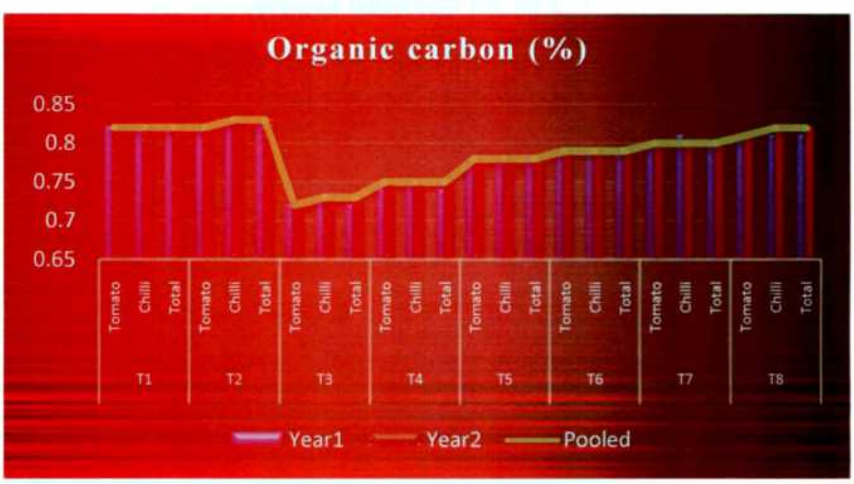

Fig.23: Effect of various blending of saline and sweet water in pitcher pot with different type of tillage on organic carbon of soil.

4.3.1.4: pH and Electrical Conductivity.

The pH and EC in soil also shows to vary significantly with the application of blending of saline and sweet water in pitcher pot for pitcher irrigation with different type of tillage in the both years. At each of the pitcher with tillage treatment the values of pH and EC found to decrease over control (T_3). Lowest value is observed in the sweet water (100%) + mulch tillage (T_2.), under tomato - chilli in both cropping sequence (Table 19). Decrease of pH over control (T_3) due to each treatment were 0.73 (9.73%), 0.67 (8.93%), 0.65 (8.66%), 0.66 (8.76%), 0.49 (6.53%), 0.51(6.80%) and 0.06 (0.80%) respectively pitcher (sweet water 100%) + mulch tillage (T_2), pitcher (sweet water 100%)+ conventional tillage (T_1),saline water (25%) + sweet water (75%) + mulch tillage (T_8), saline water (25%) + sweet water(75%) + conventional tillage (T_7), saline water(50%)+ sweet water(50%) + mulch tillage (T_6), saline water(50%)+ sweet water(50%) + conventional tillage (T_5), saline water(75%)+ sweet water(25%)+ mulch tillage (T_4). The effect of pooled data for 2012 and 2013 also shows similar findings(figure21).Significantly highest ECwas recorded in plots received saline water(75%)+ sweet water (25%) + mulch tillage(T_3). The EC significantly decreased with the application of each of the different types of blended saline and sweet water with different tillage over control(T_3)due to each treatment were 1.33 (24.49%), 1.23 (22.65%), 1.01 (18.60%), 0.96 (17.67%), 0.93 (17.12%), 0.53(9.76%) and 0.11 (2.02%) respectively in pitcher (sweet water 100%) + mulch tillage (T_2), pitcher (sweet water 100%)+conventional tillage (T_1),saline water (25%) + sweet water (75%) + mulch tillage (T_8), saline water (25%) + sweet water(75%) + conventional tillage (T_7), saline water(50%)+ sweet water(50%) + mulch tillage (T_6), saline water(50%)+ sweet water(50%) + conventional tillage (T_5), saline water(75%)+ sweet water(25%)+ mulch tillage (T_4). However the data have the tendency of slight decrease in the subsequent years due to application of different type of tillage. Decrease of EC means lowering the salt concentration in soil. Result further reveals pH significantly negatively correlated with organic carbon (r = -0.638), available nitrogen (r =- 0.881), available phosphorus (r = -0.901), available potassium (r = -0.820), mean weight diameter (MWD) (r=-0.852), structural coefficient (r = -0.879), geometric mean diameter (r = -0.907), yield of tomato (r = -0.802), yield of chilli (r = -0.453) at 1% level of significance (Table 21), (Fig 22).

Result further reveals EC negatively and significantly correlated with organic carbon (r = 0.696), available nitrogen (r = 0.931), available phosphorus (r = 0.881), available potassium (r = 0.978), mean weight diameter (MWD) (r= 0.953), structural coefficient (r = 0.948), geometric mean diameter (r = 0.793), yield of tomato (r = 0.968), yield of chilli (r = 0.763) at 1% level of significance (Table 21).However, step wise multiple regression involving EC can predict yield of tomato with 98.0% variability (Table 22).

Bhingardeve, S. D. *et al* (2006) studied the influence of saline, canal water and n-fertilizer level through drip irrigation on pH, ECe of soil and plant height at different growth stages of brinjal. At harvest plant height was maximum (78.94 cm) due to canal water than saline water treatment. It further showed that subsequent irrigations of saline water added salts to soil in surface and subsurface layer of soil. Hence, pH and ECe of soil increased, that means ECe is directly proportional to the pH of soil.

Mondal *et al.,* (1992) experimented pitchers when water for irrigation is saline. They buried baked earthern pitchers up to the neck in soil. Six week old brinjal and 4 week old cauliflower seedlings were planted around the pitchers retaining 3 and 4 plants/pitcher, respectively. The pitchers were filled with saline water of electrical conductivity 4, 8, 12 or 15 dS/m. Tubewell water (EC 0.4 dS/m) was used as a control. Brinjal yield showed a 20% decrease at 12 dS/m compared with the control but was not adversely affected below this level of salinity. Pitcher irrigation is considered more efficient than surface, drip and sprinkler irrigation and produces yields even when saline water is used.

4.3.1.4. Soil structural indices:

Soil aggregation is an important indicator of soil structure associated with various major functions in relation to soil management system. Stabilization of soil aggregates is often used as a measurement of soil structure, which mediates many important biological, chemical and physical processes in soil. The extent of aggregation within a soil acts as the controlling factor of maintenance of bulk density, porosity and water retention capacities. Many indices of soil structure are in employed to evaluate the conditions of soil structure. Changes of some of such indicate like mean weight diameter, geometric mean diameter, aggregates stability percentage and structural coefficient under the influence of tillage are presented in Table 33. The results clearly indicate that all the indices of soil structure and the stability of aggregation shows much variation due to variation of treatment.

4.3.1.4.1. Mean weight diameter (MWD):

The mean weight diameter gives an estimate weighted percentage of average sizes of all aggregates and used as an important index for characterizing the structure of whole soil by integrating the aggregate class size distribution into one number. It is also used to indicate the effect of application of blending of saline and sweet water in pitcher pot for pitcher irrigation with different type of tillage and soil structure. Mean weight diameter shows to change with due to applied treatments with the following order:(T_8) > (T_7) > (T_2) > (T_1) > (T_6) > (T_5) > (T_4) > (T_3).The increase of mean weight diameter over control due to each treatment were 1.29 (189%), 1,26 (185%), 1,11 (163%), 0.97 (142%), 0.81(119%), 0.56(82.3%), 0.10(14.7%) respectively for saline water(25%) + sweet water (75%) + mulch tillage, saline water (25%) + sweet water(75%) + conventional tillage, pitcher (sweet water 100%) + mulch tillage pitcher (sweet water 100%)+ conventional tillage, saline water(50%)+ sweet water(50%) + mulch tillage, saline water(50%)+ sweet water(50%) + conventional tillage, saline water(75%)+ sweet water(25%)+ mulch tillage(Table 19). The represents the effect of pooled data for 2012 and 2013 and shows similar trends of result. Significantly highest of mean weight diameter has been recorded in plots received saline water (25%) + sweet water (75%) + mulch tillage (T_8).The mean weight diameter increases ($P<0.05$) significantly increases with the application of each of the different types tillage with irrigation over control (T_3). Increase of mean weight diameter over the year may be indicative to better results in subsequent year due to application of different type of tillage. Result further reveals that mean weight diameter correlates positively and significantly with porosity ($r = 0.896$), water holding capacity ($r = 0.953$), organic carbon ($r = 0.742$), available nitrogen ($r = 0.983$), available phosphorus ($r = 0.973$), available potassium ($r = 0.981$), structural coefficient ($r = 0.987$), geometric mean diameter ($r = 0.910$), yield of tomato ($r =0.962$), yield of chilli ($r = 0.719$)at 1% level of significance (Table 35). The result of mean weight diameter negatively and significantly correlates with BD ($r= -0.902$), EC($r= -0.788$), pH($r= -0.852$) at 1% level of significance.

Higher mean weight diameter due to application irrigation with tillage may be ascribed by favouring the organic inputs to anchor the soil properties towards binding together and also stimulates the soil microbial activity for decaying of organic residues associated with higher secretion of microbial polysaccharides thus lead to better aggregation as per opinions made by Lal and Mathur (1989) also observed that application of FYM gradually increased the mean weight diameter 0.3 to 1.3 in red loam soil. The result also agrees with the observations of Boyle (1989) who pointed out that organic matter through its effect of binding soil particles improved soil aggregation.

Table 19. Effect of different blending of saline and sweet water in pitcher pot and tillage on soil structure and their stabilization.

Treatment	Cropping Sequence	S.coefficient(%)			GMD(mm)			MWD(mm)		
		Year1	Year2	Pooled	Year1	Year2	Pooled	Year1	Year2	Pooled
T_1	Tomato	0.93	0.93	0.74	0.71	0.76	0.74	1.71	1.78	1.71
	Chilli	0.93	0.93	0.76	0.73	0.79	0.76	1.46	1.68	1.46
	Total	**0.93**	**0.75**	**0.75**	**0.72**	**0.77**	**0.75**	**1.58**	**1.73**	**1.58**
T_2	Tomato	0.93	0.93	0.81	0.79	0.83	0.81	1.80	1.87	1.83
	Chilli	0.85	0.83	0.84	0.65	0.73	0.69	1.78	1.71	1.75
	Total	**0.89**	**0.88**	**0.82**	**0.72**	**0.78**	**0.75**	**1.79**	**1.79**	**1.79**
T_3	Tomato	0.53	0.53	0.53	0.23	0.27	0.45	0.68	0.75	0.71
	Chilli	0.54	0.57	0.48	0.26	0.35	0.51	0.69	0.70	0.65
	Total	**0.53**	**0.55**	**0.50**	**0.24**	**0.31**	**0.48**	**0.68**	**0.72**	**0.68**
T_4	Tomato	0.57	0.57	0.57	0.35	0.39	0.47	0.72	0.79	0.75
	Chilli	0.60	0.61	0.56	0.44	0.49	0.51	0.85	0.75	0.80
	Total	**0.58**	**0.59**	**0.56**	**0.40**	**0.44**	**0.49**	**0.78**	**0.77**	**0.78**
T_5	Tomato	0.71	0.71	0.71	0.69	0.73	0.71	1.21	1.28	1.24
	Chilli	0.72	0.74	0.69	0.69	0.69	0.69	1.23	1.27	1.25
	Total	**0.71**	**0.72**	**0.70**	**0.69**	**0.71**	**0.70**	**1.22**	**1.27**	**1.24**
T_6	Tomato	0.74	0.74	0.74	0.69	0.74	0.71	1.27	1.34	1.30
	Chilli	0.79	0.83	0.76	0.72	0.79	0.76	1.44	1.32	1.68
	Total	**0.76**	**0.78**	**0.75**	**0.71**	**0.76**	**0.73**	**1.35**	**1.33**	**1.49**
T_7	Tomato	0.94	0.94	0.94	0.79	0.83	0.81	1.92	1.99	1.95
	Chilli	0.94	0.93	0.85	0.80	0.81	0.80	1.93	1.95	1.94
	Total	**0.94**	**0.93**	**0.89**	**0.79**	**0.82**	**0.80**	**1.92**	**1.97**	**1.94**
T_8	Tomato	0.96	0.96	0.96	0.81	0.85	0.83	1.96	2.04	2.0
	Chilli	0.95	0.96	0.90	0.79	0.84	0.85	1.93	1.97	1.95
	Total	**0.95**	**0.96**	0.93	**0.80**	**0.84**	**0.84**	**1.95**	**2.0**	**1.97**
		SEm	**LSD%**		**SEm**	**LSD%**		**SEm**	**LSD%**	
Tillage		0.000	**0.001**		0.000	**0.001**		0.002	**0.008**	
Irrigation		0.000	**0.001**		0.000	**0.001**		0.003	**0.007**	
Tillage*irrigation		0.000	**0.001**		0.000	**0.001**		**0.004**	**0.011**	

4.3.1.4.2. Geometric mean diameter (GMD):

The results of changes of geometric mean diameter due to application of blending of saline and sweet water in pitcher pot for pitcher irrigation with different type of tillage are presented in (Table 19). It shows that geometric mean diameter changes due to applied treatments with the following order: (T_8) > (T_7) > (T_2) > (T_1) > (T_6) > (T_5) > (T_4) > (T_3).The increase of geometric mean diameter over control (T_3). due to each treatment were 0.36 (75.0%), 0.32 (66.66%), 0.28 (58.33%), 0.27 (56.25%), 0.25(52.08%), 0.22(45.83%) and 0.01(2.08%)respectively for saline water(25%) + sweet water (75%) + mulch tillage (T_8), saline water (25%) + sweet water(75%) + conventional tillage (T_7), pitcher (sweet water 100%) + mulch tillage (T_2), pitcher (sweet water 100%)+ conventional tillage (T_1), saline water(50%)+ sweet water(50%) + mulch tillage (T_6), saline water(50%)+ sweet water(50%) + conventional tillage (T_5) and saline water(75%)+ sweet water(25%)+ mulch tillage (T_4).The table 21 represents effect of pooled data for 2012 and 2013and also shows similar trends of results. Highest of geometric mean diameter has been recorded in plots received saline water (25%) + sweet water (75%) + mulch tillage (T_8). The geometric mean weight diameter significantly increased with the application of each of the different types of blended saline and sweet water with tillage over control(T_3). Increase of geometric mean diameter over the year may be indicative to better results in subsequent year due to application of different types of blended saline and sweet water with tillage. Result further reveals that geometric mean diameter positively and significantly correlates with porosity ($r = 0.798$), water holding capacity ($r = 0.793$), organic carbon ($r = 0.773$), available nitrogen ($r = 0.942$), available phosphorus ($r = 0.972$), available potassium ($r = 0.862$), mean weight diameter ($r = 0.910$), structural coefficient ($r = 0.912$), yield of tomato ($r = 0.861$), yield of chilli ($r = 0.514$)at 1% level of significance (Table 21). The result of geometric mean diameter negatively and significantly correlates with BD ($r = -0.853$), EC($r = -0.742$), pH($r = -0.907$)at 1% level of significance.

4.3.1.4.3. Structural coefficient (SC):

Structural coefficient (SC) is also acts as useful indicators for evaluating soil structure and measures by the ratio between the differences of particles less than 0.25 mm in diameter as determined by mechanical analysis of soil and that obtained by weight sieving method. Higher the values of structural coefficient represent the better soil structure. Structural coefficient (%) shows to change due to applied treatments with the following order, saline water(25%) + sweet water (75%) + mulch tillage (T_8) >saline water (25%) + sweet water(75%) + conventional tillage (T_7) > pitcher (sweet water 100%) + mulch tillage (T_2) > pitcher (sweet water 100%)+ conventional tillage (T_1) > saline water(50%)+ sweet water(50%) + mulch tillage (T_6) > saline water(50%)+ sweet water(50%) + conventional tillage (T_5) > saline water(75%)+ sweet water(25%)+ mulch tillage (T_4) > saline water(75%)+ sweet water(25%) + conventional tillage(T_3). Such increase of structural coefficient (%)over control(T_3) due to each treatment were0.43 (86%), 0.39 (78%), 0.32 (64%), 0.25 (50%), 0.25 (50%),0.20(40%), 0.06(12%) respectively(T_8), (T_7), (T_2), (T_1), (T_6), (T_5) and (T_4) (Table 19).The effect of pooled data for 2012 and 2013 also shows similar results as given in table 19.Similar to mean weight and geometric mean diameter the highest value of structural coefficient (%)was observed in plots received in tomato field with 75% sweet water and mulch tillage than chilli. The structural coefficient (%) significantly increased ($P<0.05$) with the application of each of the different types of pitcher irrigation and tillage over control (T_3). Increase of structural coefficient (%) over the year follows the same reason as described in mean weight and geometric mean diameter. Structural coefficient (%)furnished positive and significant correlation with porosity ($r = 0.892$), water holding capacity ($r = 0.948$), organic carbon ($r = 0.692$), available nitrogen ($r = 0.983$), available phosphorus ($r = 0.966$), available potassium ($r = 0.984$), mean weight diameter ($r = 0.987$), GMD(r=912) yield of tomato ($r =0.960$), yield of chilli ($r = 0.703$) at 1% level of significance (Table 21).The Structural coefficient (%) also furnished negative and significant correlation with BD ($r= -0.860$), EC($r= -0.829$), pH($r= -0.877$) at 1% level of significance.

4.3.2. Chemical properties of soil:

The results of the effects of application of blending of saline and sweet water in pitcher pot for pitcher irrigation with different type of tillage on the changes of chemical properties and nutrient availabilities in soils are presented in (Table 20).

The organic carbon content in soil shows much variation with application of blending of saline and sweet water in pitcher pot for pitcher irrigation with different type of tillage. The data also showed variation due to application treatment for each of the year, however, the performances of organic carbon were much better in the second year for each of the treatments (Table 20figure23).Highest organic carbon was recorded in plots received pitcher (sweet water) + Mulch tillage (T2). Response of organic carbon over control (T3) due to each treatment were0.10 (13.69%), 0.09(12.32%),0.09(12.32%), 0.07(9.58%), 0.06(8.12%), 0.05(6.84%), 0.02(2.73%) respectively in (T_2), (T_8), (T_1), (T_7), (T_6), (T_5), (T_4). The organic carbon significantly increased with the application of each of the different types of pitcher irrigation and tillage over control (T_3).Generally the organic carbon content in soils found more in the second year than the previous year. Application of mulch in tillage may stimulate the soil microbial activity for decaying of roots and other tissues associated with higher secretion of microbial polysaccharides that leads to better aggregation of soils. Similar options are also available from the results of Sudhier and Siddaramappa (1995) and Varalashmi*et al.,* (2005) also observed increase of organic carbon content in NPK over NP due to significant important of active fraction of soil organic carbon.

Results further reveal that organic carbon content is positively and significantly correlated with porosity (r = 0.800), water holding capacity (r = 0.696), available nitrogen (r = 0.749), available phosphorus (r = 0.759), available potassium (r = 0.722), mean weight diameter (r = 0.742), structural coefficient (%) (r = 692), geometric mean diameter (r = 0.773), yield of tomato (r =0.738), yield of chilli (r = 0.612) and negatively correlated with bulk density (r = -0.781), EC(r= -0.537), pH(r= -0.638) at 1% level of significance (Table 35). Such relationships are indicative of favourable physical environment leading to better growth, development as well as yield of tomato and chilli.

Table 20: Effect of different blending of saline and sweet water in pitcher pot and tillage on chemical properties of soil.

Treatment	Cropping Sequence	Organic Carbon (%)			Nitrogen (kg/ha)			Phosphorus (kg/ha)			Potassium (kg/ha)		
		Year1	Year2	Pooled	Year1	Year2	Pooled	Year1	Year2	Pooled	Year1	Year2	Pooled
T_1	Tomato	0.82	0.81	0.82	83.90	87.10	85.50	35.38	36.88	36.13	362.00	367.0	364.50
	Chilli	0.82	0.82	0.82	80.55	64.50	72.28	32.78	31.20	27.14	338.50	361.0	294.75
	Total	**0.82**	**0.81**	**0.82**	**82.22**	**75.8**	**78.89**	**34.08**	**34.04**	**31.63**	**350.25**	**364.0**	**329.6**
T_2	Tomato	0.82	0.82	0.82	83.50	86.68	85.09	35.13	36.63	35.88	357.50	361.0	359.25
	Chilli	0.83	0.83	0.83	85.63	85.90	85.76	36.18	34.90	35.54	363.0	362.50	362.75
	Total	**0.83**	**0.83**	**0.83**	**84.56**	**86.29**	**85.42**	**33.65**	**37.76**	**35.71**	**360.25**	**361.75**	**361.0**
T_3	Tomato	0.72	0.72	0.72	62.50	64.65	63.58	21.75	22.50	22.13	251.50	255.0	253.25
	Chilli	0.73	0.73	0.73	64.0	65.0	64.50	22.05	21.90	21.98	254.0	255.50	255.0
	Total	**0.72**	**0.72**	**0.73**	**63.25**	**64.82**	**64.04**	**21.9**	**22.2**	**22.05**	**252.75**	**255.25**	**254.12**
T_4	Tomato	0.74	0.75	0.75	63.50	64.95	64.23	22.15	22.90	22.53	255.75	258.0	257.15
	Chilli	0.75	0.75	0.75	67.78	75.10	71.44	24.70	21.50	27.95	266.50	251.50	279.15
	Total	**0.74**	**0.75**	**0.75**	**65.64**	**70.02**	**67.83**	**23.42**	**22.2**	**25.24**	**261.12**	**254.75**	**268.15**
T_5	Tomato	0.78	0.77	0.78	75.60	75.30	75.45	31.45	32.18	31.81	296.25	298.0	297.25
	Chilli	0.78	0.78	0.78	75.50	77.70	76.60	32.28	31.50	31.89	320.0	312.0	251.0
	Total	**0.78**	**0.78**	**0.78**	**75.55**	**76.5**	**76.02**	**31.86**	**31.84**	**31.85**	**308.12**	**305**	**274.25**
T_6	Tomato	0.79	0.79	0.79	76.20	78.40	77.30	31.75	32.65	32.20	291.75	295.0	293.63
	Chilli	0.79	0.79	0.79	79.53	88.00	83.76	33.50	36.25	34.88	295.75	296.0	295.50
	Total	**0.79**	**0.79**	**0.79**	**77.86**	**83.2**	**80.53**	**32.62**	**34.45**	**33.54**	**293.75**	**295.5**	**294.5**
T_7	Tomato	0.80	0.80	0.80	86.50	88.73	87.61	36.50	37.55	37.03	381.50	385.0	383.25
	Chilli	0.81	0.80	0.80	87.98	88.90	88.44	37.25	37.25	37.25	386.50	387.0	386.75
	Total	**0.80**	**0.80**	**0.80**	**87.24**	**88.18**	**88.02**	**36.87**	**37.4**	**37.14**	**384.0**	**386.0**	**385.0**
T_8	Tomato	0.81	0.81	0.81	87.58	89.60	88.59	37.50	38.60	38.05	386.75	391.0	388.50
	Chilli	0.81	0.82	0.82	87.93	87.03	87.48	37.28	35.58	36.43	381.50	366.0	384.50
	Total	**0.81**	**0.82**	**0.82**	**87.75**	**88.31**	**88.03**	**37.39**	**37.09**	**37.24**	**384.12**	**378.50**	**386.5**
		SEm	**CD%**		**SEm**	**CD%**		**SEm**	**CD%**		**SEm**	**CD%**	
Tillage		0.002	**0.008**		0.031	**0.138**		0.008	**0.036**		0.088	**0.398**	
Irrigation		0.00	**NS**		0.043	**0.129**		0.118	**0.352**		0.284	**0.844**	
Tillage*irrigation		0.000	**NS**		0.061	**0.182**		0.167	**0.497**		0.402	**1.194**	

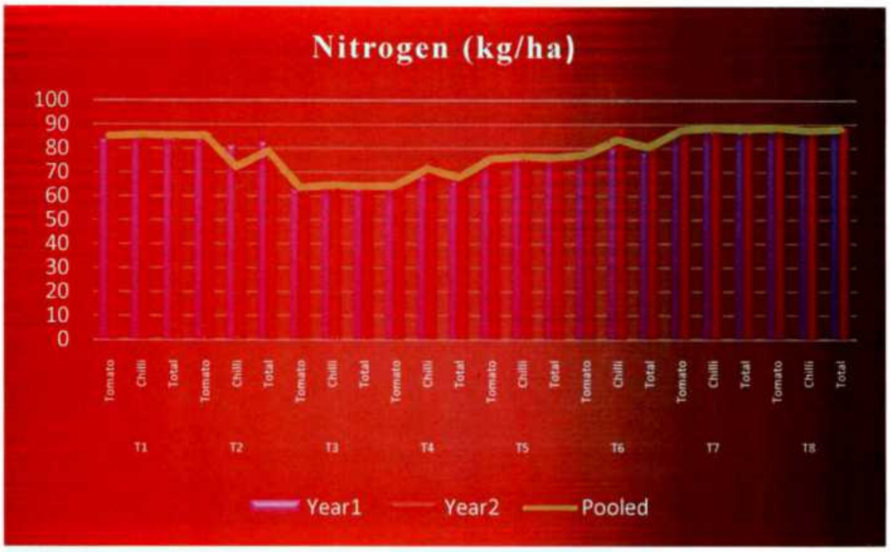

Fig. 24: Effect of various blending of saline and sweet water in pitcher pot with different type of tillage on nitrogen of soil.

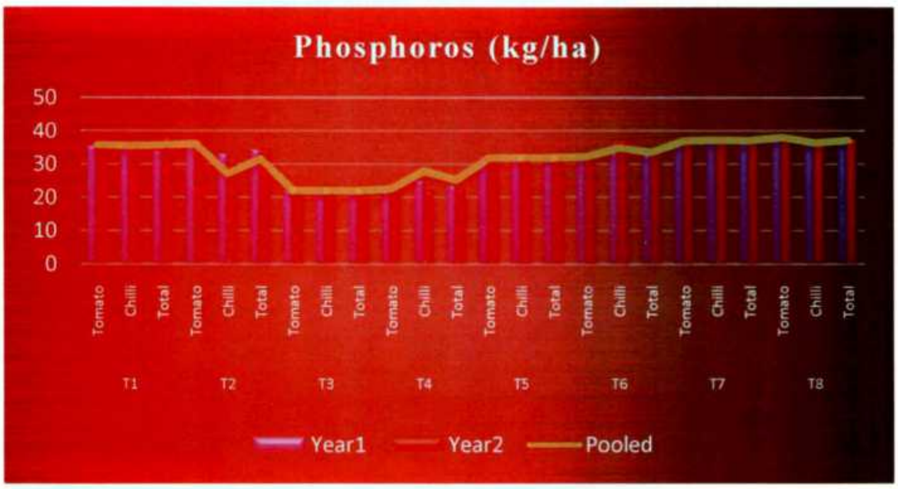

Fig.25: Effect of various blending of saline and sweet water in pitcher pot with different type of tillage on phosphorus of soil.

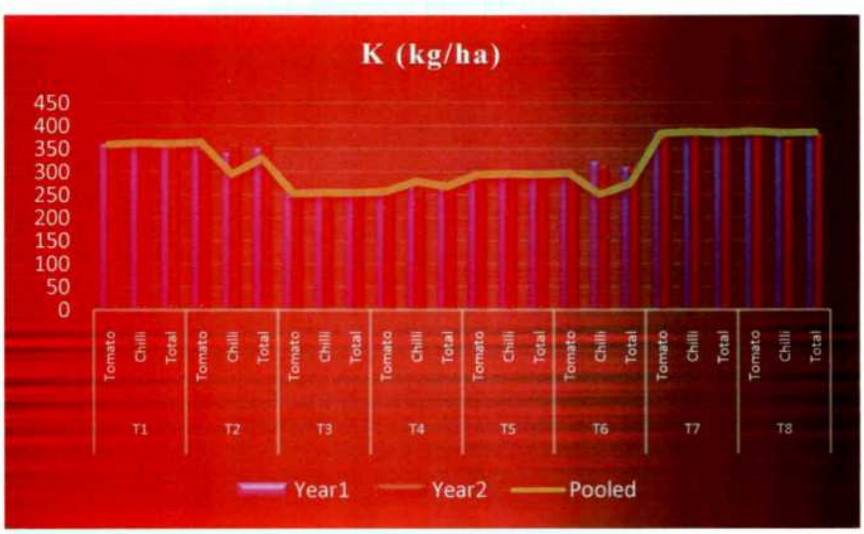

Fig.26: Effect of various blending of saline and sweet water in pitcher pot with different type of tillage on yield of soil.

Table. 21:Correlation metrics involving yield of tomato, chilli and physical and chemical properties of soil .

	BD(g/cc	Porosity (%)	WHC (%)	EC(tomato)	pH	OC (%)	N (kg/ha)	p (kg/ha)	K (kg/ha)	MWD	Structural coeft	GMD	WAS>0.25	WAS<0.25
BD(g/cc)	1.000													
Porosity (%)	-.846(**)	1.000												
WHC (%)	-.870(**)	.955(**)	1.000											
EC(tomato)	.735(**)	-.844(**)	-.843(**)	1.000										
pH	.705(**)	-.709(**)	-.729(**)	.654(**)	1.000									
OC (%)	-.781(**)	.800(**)	.696(**)	-.537(**)	-.638(**)	1.000								
N (kg/ha)	-.903(**)	.893(**)	.931(**)	-.806(**)	-.881(**)	.749(**)	1.000							
p (kg/ha)	-.897(**)	.848(**)	.881(**)	-.776(**)	-.901(**)	.759(**)	.982(**)	1.000						
K (kg/ha)	-.883(**)	.919(**)	.978(**)	-.823(**)	-.820(**)	.722(**)	.970(**)	.936(**)	1.000					
MWD	-.902(**)	.896(**)	.953(**)	-.788(**)	-.852(**)	.742(**)	.983(**)	.972(**)	.981(**)	1.000				
Struc. coeft	-.860(**)	.892(**)	.948(**)	-.829(**)	-.879(**)	.692(**)	.983(**)	.966(**)	.984(**)	.987(**)	1.000			
GMD	-.853(**)	.798(**)	.793(**)	-.742(**)	-.907(**)	.773(**)	.942(**)	.972(**)	.864(**)	.910(**)	.912(**)	1.000		
WAS>0.25	-.890(**)	.875(**)	.866(**)	-.691(**)	-.814(**)	.924(**)	.924(**)	.927(**)	.913(**)	.926(**)	.897(**)	.904(**)	1.000	
WAS<0.25	.889(**)	-.875(**)	-.865(**)	.693(**)	.816(**)	-.925(**	-.924(**)	-.926(**)	-.913(**)	-.925(**	-.897(**)	-.904(**	-1.000(**)	1.000
Yield Tomato	-0885**	-.938**	.968**-	-.827**	-.802**	.738**	.950**	.920**	.983**	.962**	.960**	.861**	.936**	-.935**
Yield Chilli	-.650**	.722**	.763**	-.539**	-.437**	.612**	.689**	.638**	.744**	.719**	.703**	.514**	.670**	-.669**

** Correlation is significant at the 0.01 level (2-tailed).

Table. 22: Results of step wise regression analysis involving yield of tomato, chilli as dependable variable and all other variables (soil properties) as predictors.

Variable	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	-40.601	5.042		-8.053	0.000
WHC(%)	1.068	0.115	0.763	9.299	0.000

a Dependent Variable: Yield of Chilli

R	R Sq	Adj R Sq	SE(est)		
0.763	0.582	0.567	1.147		

Variable	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	1.576	1.517		1.039	0.000
K (kg/ha)	0.074	0.006	0.986	13.350	0.000
Organic Carbon (%)	4.753	0.662	0.186	7.175	0.000
EC	-0.376	0.119	-.098	-3.169	0.002
N(kg/ha)	-0.093	0.031	-.227	-3.053	0.003

a Dependent Variable: Yield of Tomato

R	R Sq	Adj R Sq	SE(est)		
0.99	0.98	0.98	0.539		

.The results on the effects of application of blending of saline and sweet water in pitcher pot for pitcher irrigation with different type of tillage on the changes of availabilities of nitrogen, phosphorus and potassium after harvesting of crops every year are presented in Table 34. Availability of nitrogen, phosphorus and potassium found more in the soils received saline water(75%)+ sweet water(25%) + conventional tillage(T_3) than the other treatments. Highest availability of nitrogen, phosphorus and potassium was recorded in plots received saline water (25%) + sweet water (75%) + mulch tillage (T_8) treatment. Presence of available nitrogen over control (T_3) due to each treatment were23.99 kg/ha (37.46%), 23.98 kg/ha (37.44%), 21.38 kg/ha (33.38%), 14.85 kg/ha(23.18%), 16.69 kg/ha (25.74%), 11.98 kg/ha (18.70%) and 3.79 kg/ha (05.18%),respectively(T_8), (T_7), (T_2), (T_1), (T_6), (T_5) and (T_4) treatments (Table 20andfigure24). The available nitrogen significantly increased with the application of each of the different types of pitcher irrigation over control (T_3). The available nitrogen in different year was not significant at each of the treatments. Available nitrogen is positively and significantly correlated with porosity (r = 0.893), water holding capacity (r = 0.931), organic carbon (r = 0.749), available phosphorus (r = 0.982), available potassium (r = 0.970), mean weight diameter (r = 0.983), structural coefficient (%) (r = 983), geometric mean diameter (r = 0.942), yield of tomato(r =0.950), yield of chilli (r = 0.689) and negatively correlated with bulk density (r = -0.903),EC(r= -0.806), pH(r= -0.881) at 1% level of significance (Table 22).

Increase of phosphorus content in soils over control (T_3) due to each treatment were15.19 kg/ha (68.89%), 15.09 kg/ha (68.43%), 13.66 kg/ha (61.25%), 11.49 kg/ha (52.10%), 9.80 kg/ha (44.44%), 9.58 kg/ha (43.44%), 3.19 kg/ha (14.46%)respectively in saline water(25%) + sweet water (75%) + mulch tillage (T_8), saline water (25%) + sweet water(75%) + conventional tillage (T_7), pitcher (sweet water 100%) + mulch tillage (T_2), saline water(50%)+ sweet water(50%) + mulch tillage (T_6), saline water(50%)+ sweet water(50%) + conventional tillage (T_5), pitcher (sweet water 100%)+ conventional tillage (T_1) and saline water(75%)+ sweet water(25%)+ mulch tillage (T_4)(Table 20 and figure 25).The results of available phosphorus content in soils at each treatments lacks consistent variations in different years. It exhibits significant and positive correlations with porosity (r = 0.848), water holding capacity (r = 0.881), organic carbon (r = 0.759), available nitrogen (r = 0.982), available potassium (r = 0.936), mean weight diameter (r = 0.972), structural coefficient (%) (r = 966), geometric mean diameter (r = 0.972), yield of tomato (r =0.920), yield of chilli (r = 0.638) and negative correlation with bulk density (r = -0.897),EC(r= -0.776), pH(r= -0.901) at 1% level of significance (Table 35).Increase of potassium availability in soil over control (T_3) were134.34 kg/ha (53.30%), 132.88 kg/ha (52.70%), 108.89 kg/ha (43.18%), 77.48 kg/ha (30.73%) 42.38 kg/ha (16.80%), 22.13 kg/ha (8.78%), 16.03 kg/ha (06.35%)respectively due to(T_8), (T_7), (T_2), (T_1), (T_6), (T_5) and (T_4)(Table 20 and figure 26).It increased significantly with the application of each of the different types of pitcher irrigation and tillage over control. The changes of available potassium in soil show no consistency in different year at each of the treatments. Available potassium is positively and significantly correlated with porosity (r = 0.919), water holding capacity (r = 0.978), organic carbon (r = 0.722), available nitrogen (r = 0.970), available phosphorus (r = 0.936), mean weight diameter (r = 0.981), structural coefficient (%) (r = 984), geometric mean diameter (r = 0.864), yield of tomato (r =0.983), yield of chilli (r = 0.744) and negatively correlated with bulk density (r = -0.883) EC(r= -0.823), pH(r= -0.820)at 1% level of significance (Table 35). Changes in the availability of N and P due to application of treatments found more effective than the availability of K.

The data further reveals that application of blending of saline and sweet water in pitcher pot for pitcher irrigation with different type of tillagemarkedly increases the availability of N, P and K over control (T_3). Availability of N and P found more in the soils received 75% sweet water + 25% saline water with mulch tillage treatment(T_8), than the application other treatments. The availability of K was maximum in the soils under 75% sweet water+ 25%saline water treatment than others. Changes in the availability of N and P due to application of treatments found more effective than the availability of K.

Mondal *et al.,* (1992) worked on use of pitchers when water for irrigation is saline. Baked earthern pitchers were buried up to the neck in soil. Six-week-old brinjal [aubergine]. Curd yield of cauliflower was not adversely affected by irrigation with saline water. The highest curd yield (6.2 kg/pitcher) was obtained with 12 dS/m irrigation water. Pitcher irrigation is considered more efficient than surface, drip and sprinkler irrigation and produces yields even when saline water is used.

Srinivas *et al.,* (1991) studied with the chilli [Capsicum sp.] cv. Byadagi compared 5 irrigation treatments during the kharif season in 1987 and 1988. Treatments consisted of (1) non-saline canal water only, (2) 2 applications of non-saline water alternating with one of saline water, (3) alternations of non-saline and saline water, (4) one application of non-saline alternating with 2 of saline water, and (5) saline (well) water only. The highest dry chilli yields (8.12 and 20.78 q/ha in 1987 and 1988, respectively) were obtained with treatment (1), followed by (2) with 7.30 and 20.38 q/ha respectively. Plants in treatment (5) yielded 3.99 and 11.72 q/ha respectively, which represented yield reductions of 50.8 and 43.6%, compared with (1). The most promising treatment for using saline water to supplement the limited supply of canal water appeared to be (2).

The results of present study lead to suggest that application of blending of saline and sweet water in pitcher pot for pitcher irrigation with different type of tillage increases growth and yield of tomato in rabi and chilli in summer crop. It also helps to improve physical properties in soil particularly the structural status of soil and also enhance the water use efficiency of the crop. Besides, each of the applied treatment facilitates to decrease electrical conductivity and increase soil organic carbon and build up soil fertility.

The results of present study lead to suggest that application of various combinations of saline and sweet water through pitcher pot irrigation with tillage increases growth and yield of tomato and chilli crop. Increasing application of sweet water in conjunction with saline water caused to decrease the electrical conductivity in soil.. Therefore application of 25% saline water + 75% sweet water with mulch tillage may be useful for ameliorating the salinity constraints for tomato and chilli production in the above area. The similar results also reflected for the improvement soil physical properties and favouring increasing availabilities of nutrients in soil influencing the yield of crops.

Chapter 5

Summary and Conclusion

SUMMARY AND CONCLUSIONS

Indiscriminate use of saline irrigation water in absence of proper management of water –crop- soil poses a grave risk of endangering to the development of salt effected soils accompanying with serious crop damage.Thus developing traditional, low-cost, water saving technology for sustainable crop production, particularly in saline soil area remains a major change in science and engineering, one that has been ignored by most international development programs. A notable example of such a neglected traditional method is pitcher irrigation.The proposed programme, thus envisaged to assess the effectiveness of tomato and chilli crop production by pitcher pot irrigation with tillage in different season and conserving water towards increasing of crop productivity in this region.

The result of the effects of blending of saline and sweet water in pitcher pot for pitcher irrigation with different type of tillage involving on the yield and yield components of tomato during rabi and chilli during summer crop as well as the changes of soil physical and chemical properties and soil moisture are presented in this section.

The data reveals that yields of tomato were recorded as 27.86 t/ha, 26.82 t/ha, 25.01t/ha, 23.90 t/ha 20.78t/ha 19.95 t/ha 17.66t/ha and 16.83t/ha respectively in the plots of saline water(25%) + sweet water (75%)+ mulch tillage (T_8), saline water (25%)+sweet water(75%) + conventional tillage (T_7), pitcher (Sweet water) + mulch tillage (T_2), pitcher (Sweet water)+ conventional tillage (T_1),saline water(50%)+Sweet water(50%) + mulch tillage (T_6), saline water(50%)+ sweet water(50%) + conventional tillage (T_5), saline water(75%)+sweet water(25%) + mulch tillage (T_4) and saline water (75%) +sweet water (25%) + conventional tillage (T_3) during rabi season. Significantly highest tomato yield was recorded in plots saline water (25%) + sweet water (75%) + mulch tillage (T_8). Responses of tomato yield over control (T_3) due to each treatment were 11.03 t/ha (65.53%), 9.99 t/ha (59.35%), 8.18 t/ha (48.60%) and 7.07 t/ha (42.00%) , 3.95 t/ha (23.46%), 3.12 t/ha (18.53%), 0.83 t/ha (4.93%) respectively in saline water (25%) + sweet water (75%) + mulch tillage (T_8), saline water (25%)+sweet water(75%) + conventional tillage (T_7), pitcher (Sweet water) + mulch tillage (T_2), pitcher (Sweet water)+ conventional tillage (T_1), saline water(50%)+Sweet water(50%) + mulch tillage (T_6) , saline water(50%) + sweet water (50%) + conventional tillage (T_5) and saline water(75%) + sweet water(25%) + mulch tillage (T_4). The yield of tomato significantly increased with the application of each of the different types of treatments over pitcher pot Saline water (75%) + Sweet water (25%) + Conventional tillage (T_3). Similar trend found under number of fruit/plant, length of fruit, diameter of fruit, weight of fruit. Application of blending of saline and sweet water in pitcher pot for pitcher irrigation with different type of tillage caused to increase tomato yield along with yield attributes than saline water (75%) + sweet water (25%) + mulch tillage (T_3). Pitcher pot of saline water (25%) + sweet water (75%) + mulch tillage (T_8) found to be most effective in increasing number of fruit/plant, length of fruit, diameter of fruit, weight of fruit and tomato yield as well as benefit cost ratio than the other treatments. Variations in results of yields and yield attributes of tomato due to application various blending of saline and sweet water with different tillage may be attributed to the variations of favourable soil condition mainly decreased soil salinity and more precisely by the increasing availability of nutrients in soils.

The results also reveals that weight a mature green chilli were recorded as 8.81 t/ha, 8.74 t/ha, 6.67 t/ha, 6.46 t/ha 5.96 t/ha 5.28 t/ha 4.10 t/ha and 4.04 t /ha respectively in the plots of saline water(25%) + sweet water (75%)+ mulch tillage (T_8), saline water (25%)+sweet water(75%) + conventional tillage (T_7), pitcher (Sweet water) + mulch tillage (T_2), pitcher (Sweet water)+ conventional tillage (T_1),saline water(50%)+Sweet water(50%) + mulch tillage (T_6), saline water(50%)+ sweet water(50%) + conventional tillage (T_5), saline water(75%)+sweet water(25%) + mulch tillage (T_4) and saline water (75%) +sweet water (25%) + conventional tillage (T_3).The yield and yield attributes of chilli also significantly increased with the application of blending of saline and sweet water in pitcher pot for pitcher irrigation with different type of tillageover control(T_3).Same result found under number of fruit/plant, length of fruit, diameter of fruit, weight of fruit. Pitcher pot of saline water (25%) + sweet water (75%) + mulch tillage (T_8) found to be most effective in increasing number of fruit/plant, length of fruit, diameter of fruit, weight of fruit and tomato yield as well as benefit cost ratio than the other treatments. Variations in results of yields and yield attributes of tomato due to application various blending of saline and sweet water with different tillage may be attributed to the variations of favourable soil condition mainly decreased soil salinity and more precisely by the increasing availability of nutrients in soils.

The result of changes of various physical properties also changes with the application of pitcher irrigation with different combinations of sweet water and saline water. The reduction of B.D. over control due to each treatment were following order (T_2)>(T_8) >(T_1) >(T_7) >(T_6) >(T_5) >(T_4).Reverse order also formed in cause of soil porosity that follows the order. Increase porosity over control in each treatment was 3.87 (9.12%), 2.73 (6.43%), 2.22 (5.23%), 1.98 (4.68%), 1.48(3.48%), 0.39(0.91%) and 0.10(0.23%) respectively in (T_2), (T_1), (T_8), (T_7), (T_6), (T_5) and (T_4).Variations of B.D. occur non-significantly but that of porosity occurs significantly increases in sweet water (100%) + mulch tillage (T_2.) saline water treatment over the control. The water holding capacity in soil also found similar results of porosity. Thus it may indicate that the different types of pitcher irrigation management has influenced on the reducing bulk density and reverse effect in porosity as well as WHC were noted.

The results clearly indicate that all the indices of soil structure and the stability of aggregation shows much variation due to variation of treatments. The mean weight diameter is an important index for characterizing the structure of whole soil by integrating the aggregate class size distribution into one number. It is also used to indicate the effect of different pitcher irrigation management practice and soil structure. It reveals significantly difference between control and pitcher (sweet water 100%) + mulch tillage (T_2) treatment. Increase of values of MWD and GMD due to application of different pitcher irrigation methods is clearly an indicative of improvement of soil structure.

Results of the present study reveals that soil moisture increases with the different treatment in the following order i.e. saline water(25%) + sweet water (75%)+ mulch tillage (T_8) > saline water (25%)+sweet water(75%) + conventional tillage (T_7) > pitcher (Sweet water) + mulch tillage (T_2) > pitcher (Sweet water)+ conventional tillage (T_1) > saline water(50%) + sweet water(50%) + mulch tillage (T_6)>saline water(50%)+ sweet water(50%) + conventional tillage (T_5) > saline water(75%)+sweet water(25%) + mulch tillage (T_4) > saline water (75%) + sweet water (25%) + conventional tillage (T_3). Results also reveal that total water use pattern was also increased in the above mentioned order. Variation of changes of soil moisture content as various treatments may be reflected by the variations of BD and porosity caused due to application of treatments in soil.

The result also revealed that the changes of chemical properties like pH, EC, Organic Carbon and available N, P, K content in soil are influenced by various type of pitcher irrigation method in tomato and chilli crop. Soil pH and EC values decreases with the treatments of pitcher (Sweet water) + mulch tillage (T_2), pitcher (Sweet water)+ conventional tillage (T_1), saline water(25%) + sweet water (75%)+ mulch tillage (T_8), saline water (25%)+sweet water(75%) + conventional tillage (T_7), saline water(50%)+Sweet water(50%) + mulch tillage (T_6),saline water(50%)+ sweet water(50%) + conventional tillage (T_5), saline water(75%)+sweet water(25%) + mulch tillage (T_4) than the control(T_3). Lowest value of pH (6.77) and EC (4.10mmhos/cm) were found in the pitcher (sweet water) + mulch tillage (T_2) and highest value i.e 7.50 and 5.43mmhos/cm are found in the control (T_3) plot respectively. Differences of values of pH and EC for each of the treatment and control were found significant but no significant difference of the values occurred within the treatments. The results showed significant difference in organic carbon content under each treatment over control.

The data further reveals that application of each pitcher irrigation markedly increases the availability of N, P and K over control. Availability of N and P found more in the soils received saline water (25%) + sweet water (75%)+ mulch tillage (T_8) treatment than the application other treatments. Changes in the availability of N, P and K due to application of treatments found more effective. The results of present study lead to suggest that application of each of the pitcher irrigation increases growth and yield of tomato and chilli crop.

Chapter 6

Future Scope of Research

FUTURE SCOPE OF RESEARCH

The present investigation on the effect of various pitcher irrigation management and tillage on crop productivity under rabi season tomato and summer chilli crop has been conducted as carefully as possible. There are several research gaps which deserve due attention in order to increasing the tomato and chilli productivity. However some more investigations need to be studied in future to interpret in a better way on this aspect, by conducting this type of experiment under different Agronomic condition. The present experiment needs further investigation in respect of the following points.

1. The application of pitcher irrigation mainly with different combinations of sweet water and saline water are needed to be investigated for different cereal, vegetable, pulses, fruits and plantation crops.
2. Location specific sustainable and economically viable low cost research should be needed.
3. Long term experiment is necessitated to study the effect of integrated pitcher irrigation management on crop production.
4. Use of pitcher irrigation with integrated nutrient management.
5. The experiment should be conducted with other chilli varieties to be sure about the response of chilli to the pitcher irrigation with different combinations of sweet water and saline water.

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